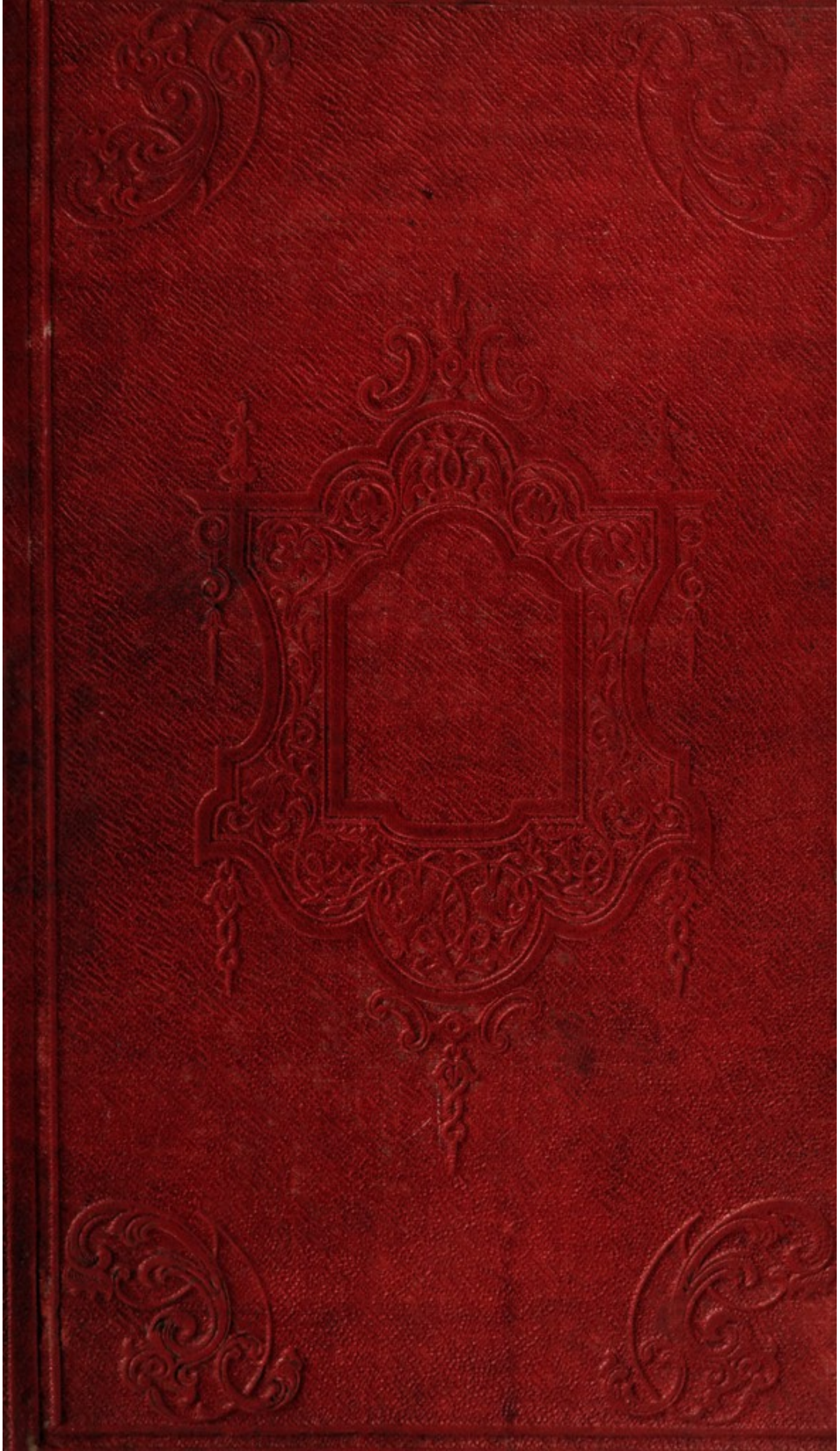
Views of the architecture of the heavens / By J.P. Nichol.



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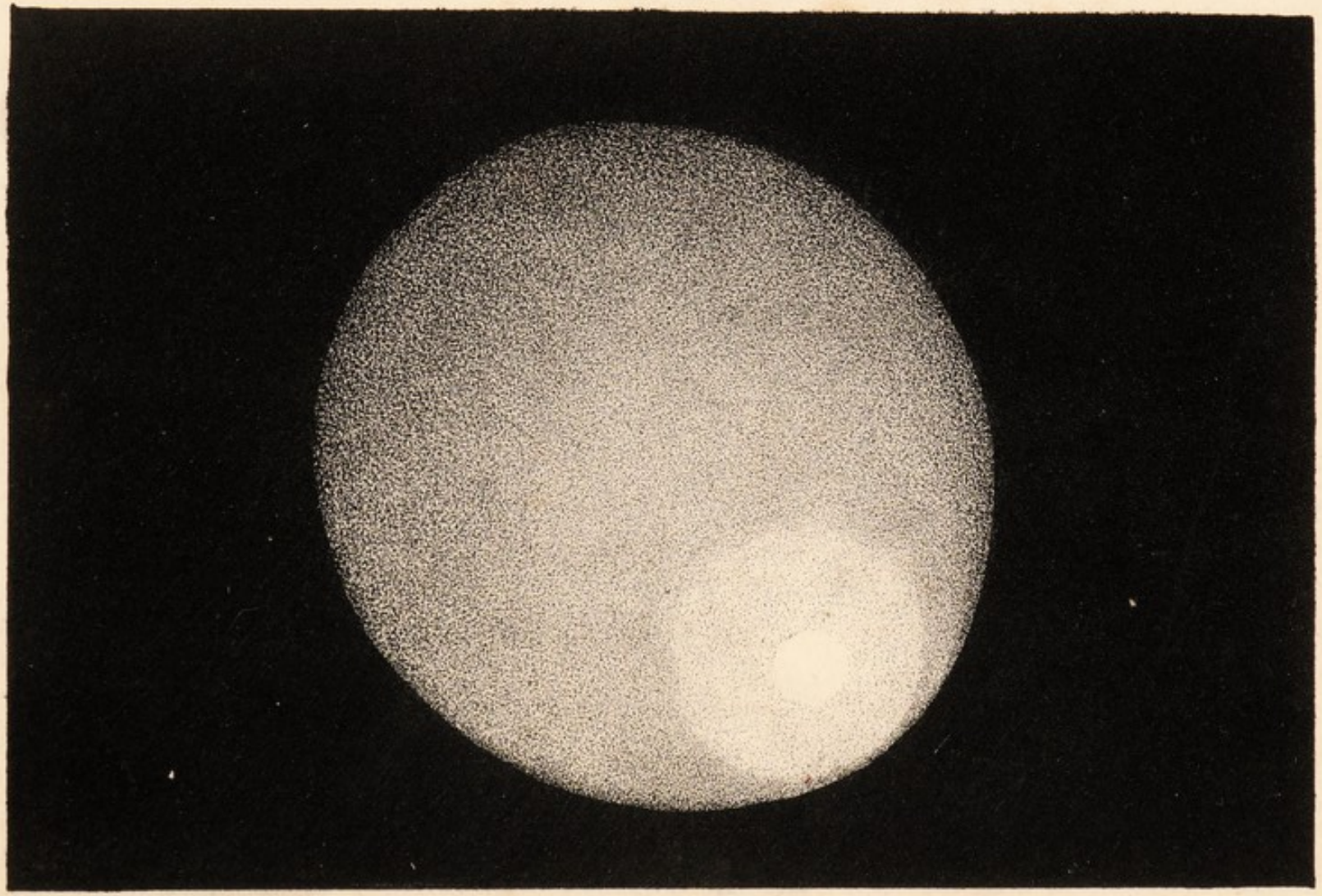
THE

ARCHITECTURE

OF THE

HEAVENS.

HOW MANIFOLD, O GOD, ARE THY WORKS; IN WISDOM THOU HAST MADE THEM ALL.



ENCKE'S COMET.

VIEWS

OF THE

ARCHITECTURE

OF THE

HEAVENS.

By J. P. NICHOL, LL.D.,
Professor of Practical Astronomy in the University of Glasgow.

FOURTH EDITION.

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PREFACE

TO THE FOURTH EDITION.

When this volume was written, some years ago, I had no further design than to lay before the mass of my countrymen a statement, in the plainest language, of those views regarding the general outline of the Universe, which recent discovery and speculation in Astronomy appeared to unfold, and which I believed fitted to assist many sound moral influences. The remarkable favour with which my effort has been received, shows that this opinion was not wrong; for a work, on a branch of science not bearing upon practical inquiries, can hardly obtain extensive acceptance unless the subjects it treats of are felt

to be, in some degree, connected with those lofty, though obscure aspirations, by which so much of Man's better life is sustained.

Encouraged by the seeming realisation of fervent hopes, I have resolved, should legitimate leisure prove adequate, to arrange, in a similar form, thoughts accumulated during years of various study, in reference to other illustrations of the Unity of that Creation within which we live, and the Order regulating its progress. Beginning with this volume, which circumscribes the most general class of relations yet discerned by science, my succeeding treatise is naturally occupied with the special phenomena of the Solar System—a volume some time ago published independently, but now adjusted to its place in the projected series. The third volume will discuss those larger cosmical actions passing on the surface or within the outer crust of our Globe, by which the existing epoch of its History—so singular in its character and promise—appears to be determined; and in three others, it is my hope to trace and unfold—in the play of the various physical

agencies, among the complex and correlated phenomena of Life, and in the harmonies of Man with his sublunary position—that all-pervading presence of the Beautiful and the Good, which assures us that we belong to a firm and beneficent ORDER, although its beginning is unseen, and mystery still enshrouds its course and close.

The present volume had, at first, the form of Letters. As it is now related to other treatises, such a form would be incongruous and inconvenient; and to retain it were, besides, an empty ceremony,—the lovely and honoured Spirit, to whom my words were addressed, having gone to the Blessed.

J. P. N.

OBSERVATORY, GLASGOW,
10*th April*, 1843.

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Page 48, line 16, *for* remot *read* remote.
— 88, — 1, — illustrations *read* illustrious.
— 107, — 17, — bonds *read* bounds.
— 143, — 26, *dele* of.

PART I.

THE EXISTING FORMS AND ACTIVITIES OF THE STELLAR UNIVERSE

CHAPTER I.

CONSIDERATIONS ON THE DISTRIBUTION OF THE FIXED STARS—SHAPE OF THAT CLUSTER OR GALAXY WITHIN WHICH OUR SUN IS PLACED—OPENING OF A WIDER INQUIRY.

No careful observer can have looked often at the Heavens, without discerning that the brilliant bodies which adorn them are not all of one character. Even the Chaldæans knew that the few which wander among the others, are bound together in a separate system; and that, although they shine with remarkable brilliance, they are yet dark like the earth—receiving their light from the sun. Small as well as opaque, they revolve around that orb in stated courses—being almost portions of himself; and tho' the intervals which divide them, if reckoned in those

units by which we measure terrestrial magnitudes, appear to be exceeding vast—so trifling are they in presence of the celestial spaces, that the whole orbit of Uranus might, if viewed by our best telescope from the nearest of the fixed stars, seem covered by the breadth of a spider's thread.

Passing, then, in the meantime, from consideration of these subsidiary orbs, what guess can we adventure concerning those myriads of stars, except that we are amidst Immensity:—is it possible, beneath such Vastness, to think of more than that Man is overwhelmed? Subdued by the presence of grandeurs which shrivelled our great system into a point, it is no wonder that the inquirer was long disposed to imagine that the bounds of knowledge had here been reached, and that limit attained at which Reason must give place to Awe; and accordingly, before the close of last century, no greater problem was started, nor had any fact or speculation been adduced, as rational ground for supposing that we could arrive at definite notions concerning the arrangements of the Fixed Stars. This period, however, was distinguished by two events, which could not occur together without ensuring important results. The TELESCOPE,

formerly of limited range, suddenly assumed a capability of sounding profundities never reached before; and the Man in whose hands it took on this new efficiency, was possessed of a genius to which all opportunities could be entrusted, for it was adequate to the highest. The rise of Sir William Herschel marks the first, and still the greatest epoch of the modern Astronomy. He was struck for a discoverer in the finest mould. Mingling boldness with a just modesty, a thirsting after large and general views with a peculiar sensitiveness in regard of *existing* analogies, and a habit of most scrupulous and dutiful obedience to their intimations—he was precisely the man first to quit paths which, through familiarity, were common and safe, and to guide us into regions, dim and remote, where the mind, as a lamp to itself, must walk entirely by lights which stream from internal fountains.

There is one infallible mark of the rise of an original mind. When you see a man in the midst of his contemporaries, not contesting opinions—not quarrelling—but quietly, and without either ostentation or fear, proceeding to resolve, by reason, subjects which had hitherto been in possession of "common belief,"—be certain that a signal

access of knowledge is awaiting us; for the freshest stamp of divinity is upon that man. Herschel's first remarkable paper gave a promise of this description, and abundantly was it soon fulfilled. It seems to have early occurred to him, that the usual notions concerning the relation of our firmament,* or whole heavens, to the Universe, or rather to Infinite Space, rest on no better foundation than many long-discarded conceptions which found easy acceptance in less-advanced epochs of astronomy. The inference, from the aspects of the sky, had hitherto always been, that *our* skies are infinite, or that stars, as we see them, stretch through all space; which is, perhaps, only a repetition of the old fallacy, that what is great to *us*, must be great absolutely, and to all Beings—that a system must be infinite—occupying and constituting creation, merely because *we* cannot descry its boundaries, or reckon up its magnitudes by the dimensions of our narrow abode. The firmament, with its countless and glorious

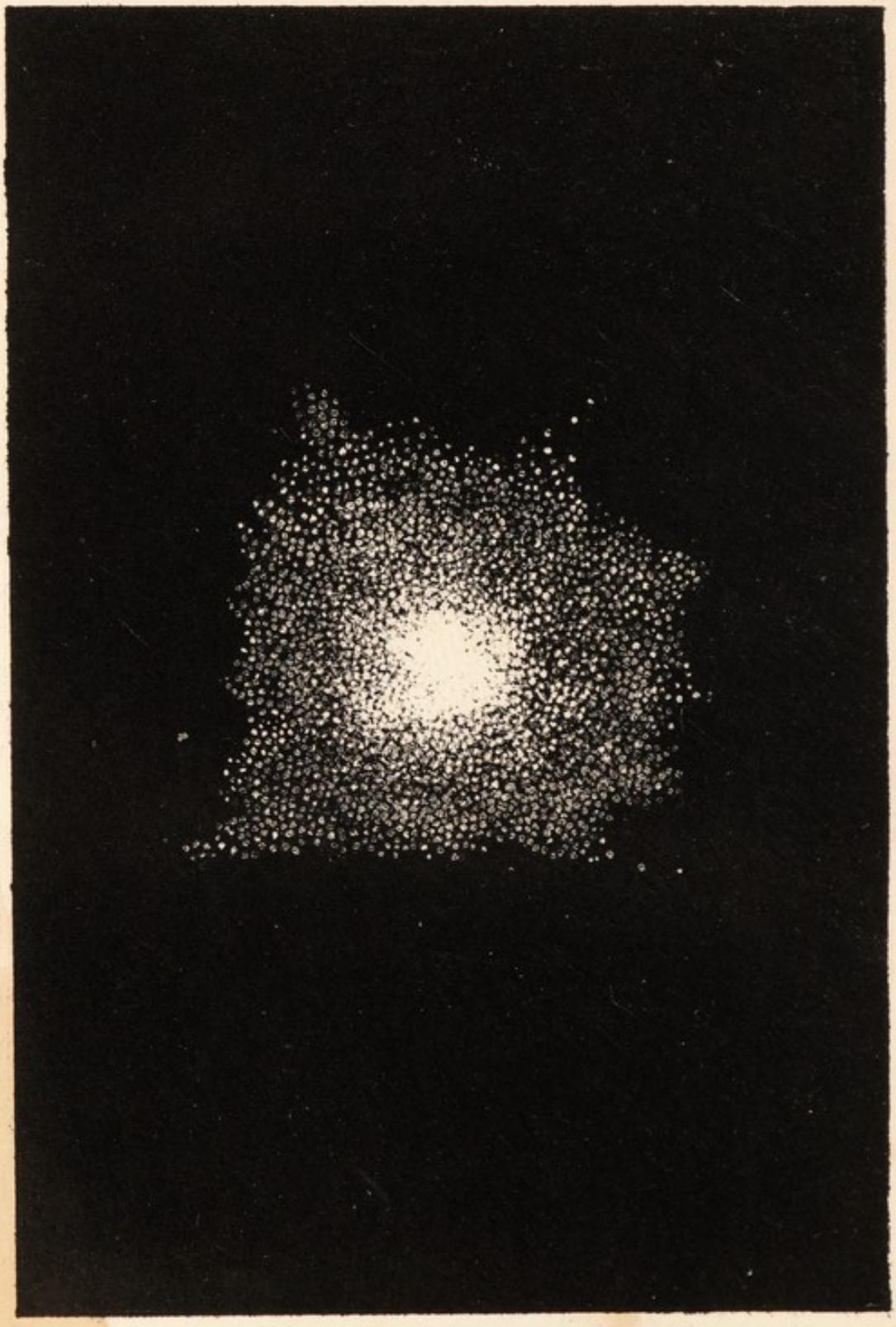
* Once for all, and to prevent ambiguity, let me state, that in speaking of *our firmament*, I mean, not the solar system, but that entire mass of stars, of which what we see in a clear night is the nearest portion. It will be seen in the sequel, that the proper name for this mass is, *our cluster*.

orbs, is doubtless vast; but, calmly placing the utmost sphere within our possible sight, beside the idea of what is really infinite,—or comparing the vision of man with the reach of an Almighty eye—it flashes instantly upon us that we cannot have any positive ground for the assertion that our stars are diffused through all existence. Herschel proceeded to refute systematically this common delusion, and to unfold the true scheme of the universe.

The subject now opened is unusual, and most apt to bewilder and overwhelm; so that we shall best enter it by aid of illustration: and one occurs which may exhibit, with some precision, the progress of our Discoverer's thoughts.—Call up an Indian of that old America, when civilisation had not yet disturbed the sombre twilight of its forests; suppose him of a tribe whose wanderings had been confined far within the interior of a range of primæval pines,—how natural for his untutored thought to conceive the forest of his nativity infinite, or that *space* is all occupied with *trees!* His eye had never lighted upon one external object,—the forms of his infancy were the forms to which his manhood had been alone ac-

customed; trees had always environed him, and hemmed in his prospect; so that, on being informed by an instructed traveller, of the existence of free and wide savannahs, he must have seemed to hear of something unintelligible and against nature, and have gazed with that very incredulity which fills our minds at the idea of the great firmament being limited like a Forest—of *our* Infinite being comprehended within Form. But lo! in his stray wanderings—at a time when his gods smiled upon him—the Indian arrives at a mountain, which rears its summit above the gigantic pines. He attempts it, overcomes its precipices, and descries—a new world! The forest of his dwelling is mighty, and stretches far; but America is mightier, and numbers of forests equal to his luxuriate on its plains. Seldom, indeed, is this mountain found. Men wander through centuries, in ancient ignorance, without reaching or scaling an elevation capable of showing them beyond it; but in propitious hour, and after long preparation, genius and industry descry it, and straightway the scales fall from our sight. It was the TELESCOPE which in this case pierced the skies, and revealed the contents of outer regions hitherto unseen by man. And most splendid that

Pl. I.



perspective! Divided from our firmament and each other by measureless intervals, numerous FIRMAMENTS, glorious as ours, float through immensity, doubtless forming one stupendous system, bound together by fine relationships. These remarkable masses are located so deep in space, that to inferior telescopes they seem like faint streaks or spots of milky light upon the blue of the sky; but the instruments which had just been summoned into being resolve their mystery, and disclose their myriads of stars. One of these objects, perhaps the most brilliant apparent in the heavens, is represented in Plate I.: it is in the constellation Hercules.* After all, how easy the belief to *its* indwellers, that a mass thus surpassingly gorgeous is—infinite. What wonder although the inhabitant of a planet revolving around one of its central suns, should have mistaken his own magnificent heavens for the universe, and needed the distant and dim vision of our firmament, appearing to his telescopes as a starry speck, to remove the veil from his mind, and give him juster notions of the majesty of Creation!

* No Plate can give a fitting representation of this magnificent cluster. Perhaps no one ever saw it for the first time through a telescope, without uttering a shout of wonder.

There are truths which, although startling at first, are found so much in harmony with the scheme of Nature, that we are chiefly astonished because they never occurred to us before: and I can conceive circumstances in which the Indian, after the foregoing revelation had been made to him, would not fail to descry among the *internal* aspects of his forest, not only distinct intimations of its limitude, but also of its *peculiar shape*, and even *approximate dimensions*. Think of the appearances, which would be marked by an observant man, as characteristic of his position, were the forest infinite or very extensive. In his immediate vicinity the surrounding trees would be well defined, and of the largest proportions; behind these he would see another range, smaller, but also well defined, and so on through many gradations of size and distinctness, until individual trees could no longer be distinguished, and the view would terminate in an unnamed and vague appearance, which I may be permitted to call a diffused *woodiness*. But if this peculiar background were not seen in every direction, the light of the sky appearing through the trees in different places, the conclusion would be just and manifest,—*that the forest had not the characteristics*

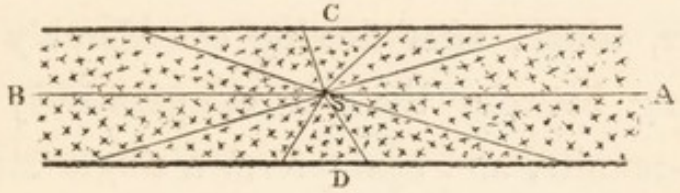
of one stretching out indefinitely or even equally on all sides,—that in some directions its edges were nearer than in others, or that it was merely a *group or stripe of trees, having boundaries, and of a particular and ascertainable shape*. With these fresh lights turn again to the heavens, asking what is the case with them? Were we in the interior of an infinite and regular stratum, appearances would necessarily be similar all around—the aspect of the sky on one side would be almost its picture on every other side. The same, or nearly the same number of visible bodies would, as in the infinite forest, be found everywhere; and there would come from behind in all directions, through those recesses in which no single star could be descried, something of the same amount of whitish or milky illumination, arising from the combined effulgence of luminaries individually unseen. *But this does not agree with actual phenomena*, which rather correspond with the second form of our illustration. It is only when we look towards the MILKY WAY, that those bodies seem to retire indefinitely, and finally to be lost in a diffused *starriness;* and in all other places the intervals between the luminaries are nearly quite dark, *as if there we were closer on the edges of our bed of*

stars, and therefore saw through it into the external and obscure vacancies of space. The opinion is thus forced on us anew, that what we term our Firmament is merely a *group* or *cluster* of stars, and, moreover, that it is a group of peculiar configuration, *narrow, but greatly elongated in the line of the Milky Way.* Is it not strange that an inference so natural, so palpable, flowing so easily from the phenomena of our brilliant zone, was never drawn before ; and that, notwithstanding of that zone shining there, and speaking since "creation's dawn" most invitingly to reason, it should have been left for Herschel, even to so late a day, to rescue it from mythology and mystery, and teach us to look at its countless orbs with emotions loftier than an exciting but useless wonder !

Starting with the foregoing general ideas, let us attempt to ascertain, with definiteness, the shape and character of that great cluster in which we are. I shall endeavour to approach the truth in what remains of this chapter.

1. Our group, I have said, is certainly an elongated one. A simple diagram will explain how

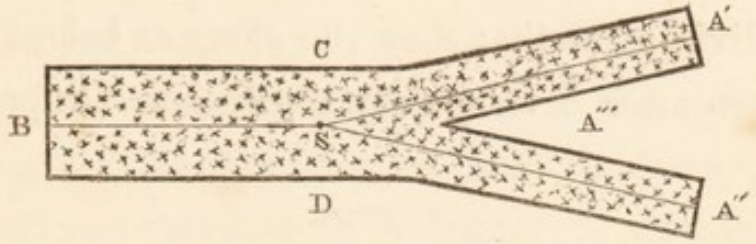
existing appearances are *generally* accounted for by this hypothesis; and the same illustration will indicate the first rude modification necessary to bring it into a more perfect and *minute* consistency with appearances. If a spectator were in a world S in the midst of a stratum or bed of stars, bounded as beneath by the lines C and D, *i. e.* narrow, or, at least measurable in breadth, or in the directions, SC, SD, but indefinitely



prolonged towards A and B, he would manifestly be engirt by heavens having the general aspect of ours; for, on looking along any line from S towards C or D, he might see through the cluster, and the regions in that quarter would therefore all appear comparatively dark ground, bespangled with multitudes of distinguishable luminaries; while in the directions SA and SB—before and behind him—his eyes would fail, as ours do when turned to the Milky Way, in separating the individual bodies, or in recognising the existence of the remoter masses, otherwise than in the silvery

twilight coming from their aggregation. Were our milky zone one regular belt, we would, it is thus evident, require no modification of the previous hypothesis; for the supposition that the firmament is a regular oblong stratum, would in that case clearly explain and account for its whole more prominent phenomena: but the Milky Way *is not a regular belt.* An attentive inspection of it, on any favourable night, may show, that through one-third of its entire course it *divides into two branches*, which, after flowing considerably apart —leaving between them a comparatively dark space—reunite, and again form a single stream; so that a new hypothetical figure is required, which will explain why, in looking before one to any part of that region where the stream is divided, the prospect terminates, not in *one* milky spot, but in *two*, separated by a considerable breadth of space which has no greater number of stars, and not much more general illumination, than the *sides* of the cluster. Now this peculiarity will be accounted for, if we suppose our cluster an OBLONG, *divided at one of its extremities;* for if the sun, S, were in such a cluster as below, a spectator in it would manifestly see one bright spot towards B; *two* equally bright spots, A′ and

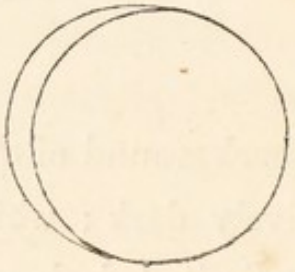
A″, in the opposite direction; and towards C and



D, as before, the background of the heavens would appear comparatively dark; while he would observe a *third*, but limited dark space, of precisely the same character, towards the vacuity A‴, which separates the divergent branches.

The foregoing figure may thus be taken as a first, but rude approximation to a section of our vast firmament; and even as such, I should think it cannot be viewed with an ordinary interest. Perhaps, however, there is difficulty in apprehending what our firmament really is, or in inferring its entire shape from its chart in *section*; I shall, therefore, without departing from the very general mode of illustration I have adopted, endeavour to construct its complete or solid form. My reader knows a common grindstone? Suppose, first, that the rim is split in the middle, along the line of the rim, and through about one-third of its circumference; which split, however, does not reach so far down

as the centre of the grindstone: also let the divided parts be somewhat separated towards the middle of the division, so that they run along as below, and reënter after a temporary separation. Suppose,

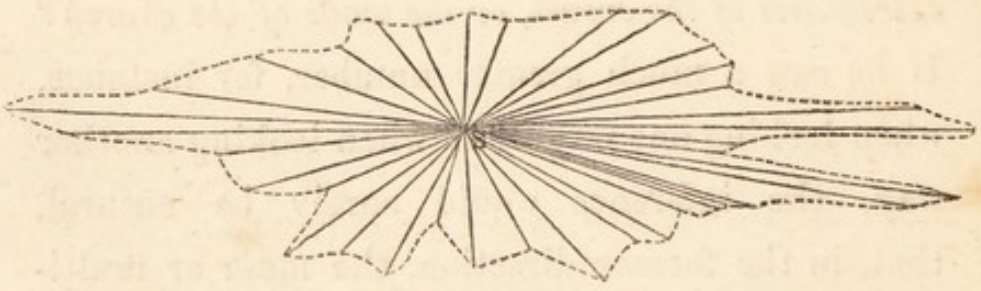


secondly, that the sandstone is considerably more porous than stone is,—then let its minute atoms represent stars, the pores or intervals being the interstellar spaces; and observe what an inhabitant of a sun or world near the centre of a cluster of such configuration would perceive in his heavens. *It would seem exactly like our own celestial vault.* Towards the sides of this mass the view would be comparatively unadorned—dark space looming from beyond the visible stars; while, in the direction of the circumference, a countless throng of small remote stars would, although separately unseen, illume the sky, forming a splendid zone, divided like our Milky Way through part of its shadowy course. Is it repulsive to compare our magnificent universe to an object so ordinary, so

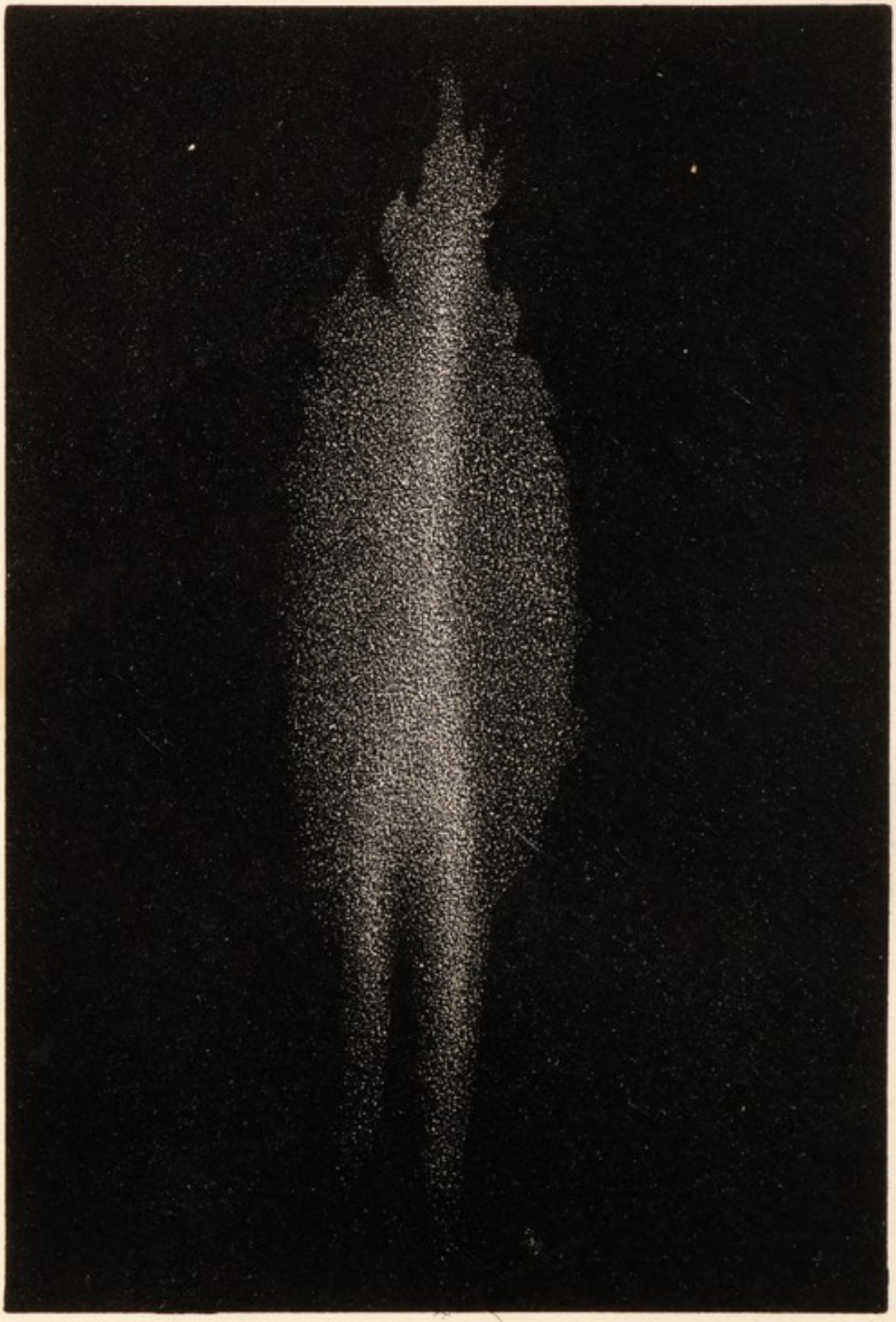
trifling? Alas! endow it once with *Form*, and, whatever its actual dimensions, beside the vastness of the Infinity which environs it, all are shrivelled up, and their majesty disappears! We can speak of our cluster only as of a limited object, a speck, —one individual of an unnumbered throng; we think of it, in comparison with Creation, only as we were wont to think of one of its own stars.

II. Hitherto we have used merely the eye—now we take up the telescope. Herschel employed this wonderful instrument to show him the minute irregularities of our firmament, upon a principle easily understood. Suppose one somewhere in a crowd—say, in a church filled with people—would he not, on turning and looking around in different directions, *see a number of persons somehow proportionate to his distance from the extremities of the crowd, or the walls of the church?* If he saw a much greater number, for instance, when looking one way, than when looking another way, the inference would surely be natural, that, in the former direction, the mass or multitude of people extended farther than in the latter; and it will be quite conceivable that an arithmetical rule might be found, by which to *compute* his

relative distances in the two cases, from the ends or limits of the assembly. The rule does exist, and is not complex; nevertheless, I am satisfied here if its *possibility* be recognised. Take then a large telescope, capable of piercing deeply through space—turn it in all directions, count the number of stars in its field in each position, calculate upon this basis its corresponding distance from the extremities of the cluster, and the means are provided to a certain extent of accurately charting the firmament. Herschel was fired by this idea. He termed the process a gaging or sounding the heavens—casting out lines, as we do at sea, to fathom and record its profundities. With his peculiar ardour and perseverence, he accomplished at least 700 observations with a view to determine the elements of a suitable and *accurate* sketch:—



Then supposing S the position of the Sun, and drawing, in the due directions, lines, determined

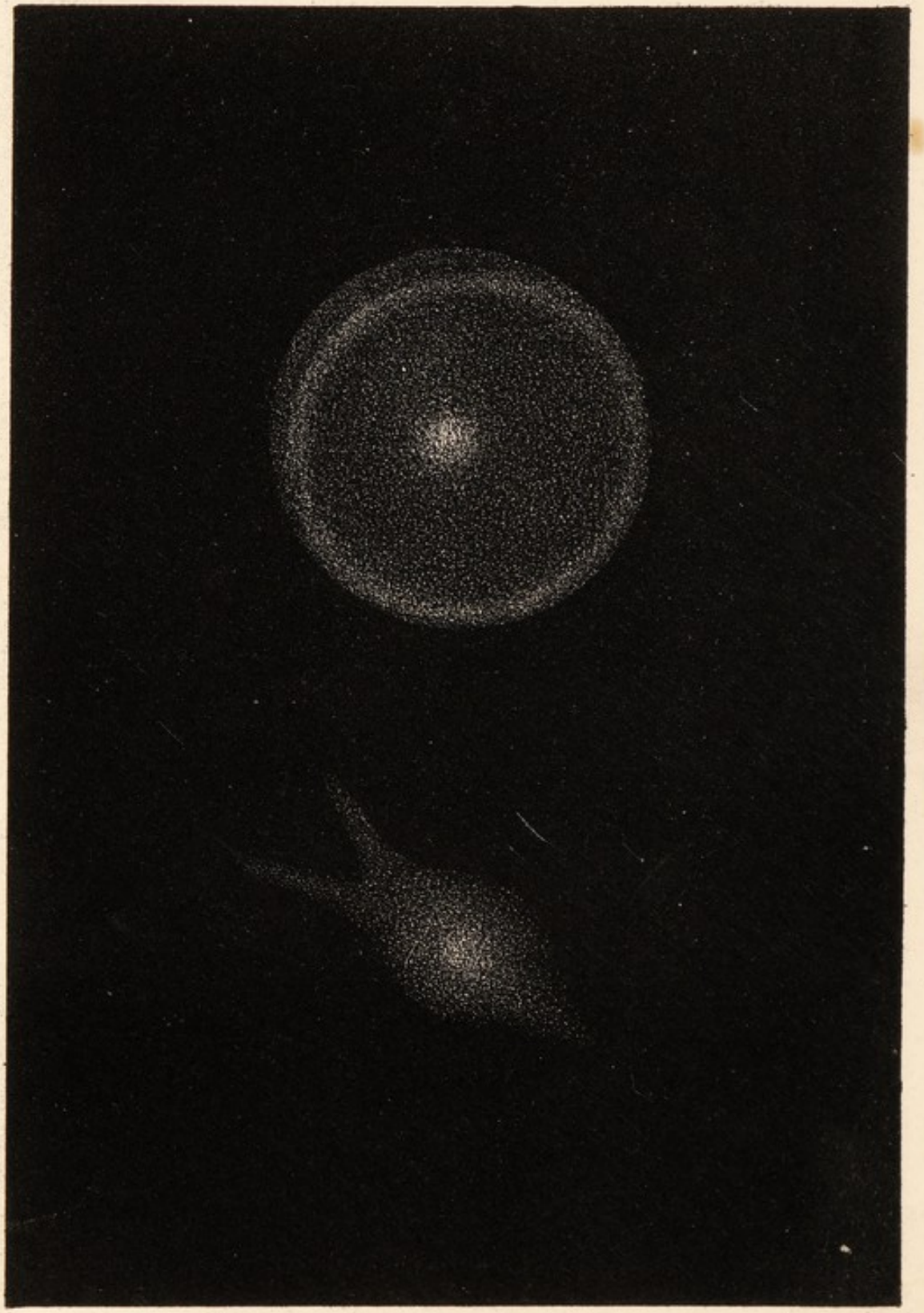


in length by the arithmetical rule spoken of, as corresponding to depths indicated by the quantity of stars in each *gage*, the mere joining of the extremities of these lines gave him the section required. The above wood-cut is purely imaginary, and only intended to exhibit the rationale of Herschel's *method;* the result actually obtained by him is shown in Plate II. It has the aspect, and is larger than the size under which that firmament—so magnificent to us—may appear to spectators in remote clusters, situated in a line, passing through the Milky Way, and nearly over our heads;—spectators who, perhaps, are even now marvelling, as they descry it through their telescopes, what that sprawling spot may be, which just somewhat, and only in one trifling point, interrupts the dark azure of their heavens!

—There are obvious sources of error in Herschel's sketch. His two fundamental postulates, viz., as to the equable size and the equable distribution of the stars, may be found inaccurate. In truth neither is accurate; and it is at this point of our inquiry that the weight of the objections, thence arising, ought to be ascertained. With regard to the size of the stars, our Observer

never had the idea that a real equality existed, or that, in the case of *an individual orb*, smallness of appearance established magnitude of distance: he felt it enough to suppose, that whatever the varying sizes of these bodies, they were yet strewn indiscriminately—the large and the small together; so that, in reference to the different districts of space, he might assume a common *average magnitude*—and that diminution of size would indicate increase of distance in respect of *masses*. Everything we yet know confirms this idea; and it is the same with the supposed *equable distribution* of the stars. It is not to be imagined that Herschel overlooked the existence—nay the prevalence of close clusters—such as the Pleiades, or Præsepe, or even Orion; but he assumed that such clusters are scattered on all sides with apparent indifference, and therefore that they did not affect the grand outline. The discussion of the minute details and modifications depending on the residual errors of his first principles, our Astronomer was constrained to leave to after ages.

III. I have now to state a remarkable circumstance, perhaps the strangest and most unexpected which modern astronomy has revealed. Although



the telescope has not yet laid down the plan of our cluster, from *interior* surveys, it exhibits what seems its very *picture*, hung up in external space! Look at plate III. It represents an object resting near the outermost range of telescopic observation, not resolved, but doubtless a great scheme of stars,—*the fac-simile of that to which we belong!* It has its surrounding ring of the precise form we have been inclined to attribute to our zone; and its section, figured in the same plate, or the aspect it would take on to a spectator at a vast distance, looking from the direction of the white line in the margin, has the closest general resemblance to Herschel's sketch.* Nor is that resemblance only general and faint. Even as in that sketch—that shadow of a distant and gorgeous scheme of being—there is no question that the central mass of stars with us is separated from the surrounding ring by a space comparatively vacant. Nay, it has been said by Sir John Herschel, that we have

* It adds considerably to the interest attached to this cluster that a spectator in it must see ours, precisely as we see it, *i. e. sideways;* so that our firmament will have, to the inhabitants of its stars, quite the aspect which it presents to us. The two figures in Plate III. will explain any ambiguity in pages 15 and 16, where reference is made to the *section* and *solid form* of our cluster. Perhaps these should now be reperused.

evidence as to our approximate position in the central mass with reference to that brilliant girdle. "I think," says he, "it is impossible to view this splendid zone" (speaking of the southern Milky Way) "with the astonishingly-rich and evenly-distributed fringe of stars of the third and fourth magnitudes, which form a broad skirt to its southern border, like a vast curtain—without an impression amounting almost to a conviction, that the Milky Way is not a mere stratum but an ANNULUS; or at least that our system is placed within one of the poorer and almost vacant parts of its general mass, and that eccentrically, so as to be much nearer to the parts about the Cross, than to that diametrically opposed to it."—Look again at our picture of that Nebula. Strange, surely, such close affinity of form! What link, what far-reaching sympathy can connect these twin masses—that unfathomed firmament and ours? What virtue in a shape so fantastic that it should thus be repeated? Or what the august law, thus working at the opposite extremities of space, which has caused those corresponding shapes to come into being? Prompted by reverential curiosity, we eagerly put such questions; but to resolve them baffles our loftiest philosophies!

Thus then we enter on new views; we are introduced to perhaps the grandest phenomena in the Stellar Universe. We are raised to an elevation never scaled before, below which Creation and its wonderful arrangements are expanded; and be it never forgotten, we owe this conquest to the genius of one Man. But as the sphere of knowledge has extended, the circle of our recognised ignorance—that dark circle which hems in all we know—has stretched out likewise. How different is Astronomy now, taking cognizance of the number of these firmaments, attempting to determine their magnitude, and account for their form, from the Astronomy of a recent day, which was limited to discussions concerning the habits of the small bodies attending our Sun, and which looked at the farther Heavens only with vague and incurious eye, content to admire their beauty and confess their mystery! There was true prophecy in the exclamation of La Place, who, although then knowing more than any man of the celestial mechanism, said earnestly on his deathbed, "That which we know is little, that which we know not is immense." And the spirit was partaken of by Newton in the very flush of his immortal discovery, when, with the modesty of

all great minds, beside whose infinite aspirations the highest possible attainment is ever insignificant, he is recorded to have spoken thus:—"I am but as a child standing on the shore of the vast undiscovered ocean, and playing with a little pebble which the waters have washed to my feet."

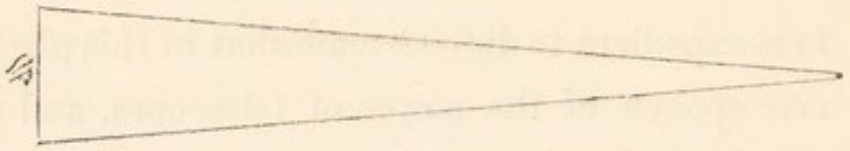
CHAPTER II.

ON THE POWER AND REACH OF TELESCOPES.

It is expedient to digress somewhat in this place. I have spoken of the power of telescopes, and of the profundities through which they pierce; and it will be pleasing that my readers be satisfied as to the possibility of such power, and persuaded that I am not amusing them with romance. A brief and simple explanation of the principle on which telescopic power depends, will accomplish this object; and they will then yield me belief, instead of mere confidence, when I refer again to what, but a short time ago, would have seemed an incredible fable.

Although not according to the strict mode of expression, it suffices here to say, that we see objects, or that they occasion in a spectator the sensation of seeing, when a certain luminous influence radiating from them, enters the eye in such quantity, as can irritate or excite the nerve

of vision. Bright or visible bodies send out this influence in straight lines, and on all sides, so that the luminous matter will always be *thinner* the farther it is from the radiating point, as it cannot be dispersed without suffering diffusion—a truth illustrated in the subjoined diagram, where a luminous point is represented diffusing rays.

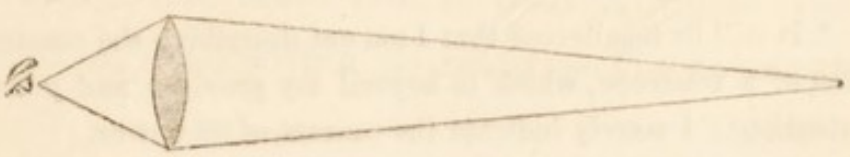


It follows, accordingly, that as the eye is nearer or farther from the source of the rays, the greater or less will be the amount of light received by it; and there will always be a point of distance, intended to be exhibited in the figure, where no more than is barely adequate to cause the sensation of sight falls upon the retina. This would manifestly be the *remotest limit of visibility* in that case and to that eye. Let that spectator retire, although only by the smallest quantity, and the luminous point would disappear and be lost in space.

Such being the process of vision, may we hope ever to extend the boundaries of our sphere, to reach depths, from which the physical constitution

of humanity might appear to have excluded us? There are plainly but two imaginable methods by which so great an aim may be accomplished,—either we must act upon the shining body and compel it to give forth light of higher intensity, or we must, if I may say so, *enlarge the pupil of the eye*, and enable it to receive a greater number of rays. The former method is impracticable—for bodies lying profoundly in space are wholly remote from our control; but if by any marvellous artifice we *can produce a virtual enlargement of the pupil of the eye*, our success will be equally brilliant and sure. Nature, indeed, has expressly pointed out this very plan, for she acts on it herself. Birds and other creatures which wander in the night have all large pupils, and our own organ of vision enjoys a limited power of expanding in the dusk, so that, when the light is faint, we take in a larger than usual ray, and discern objects, which must have been unseen, unless for that preparatory change.

Observe, without further preliminary, my next diagram.



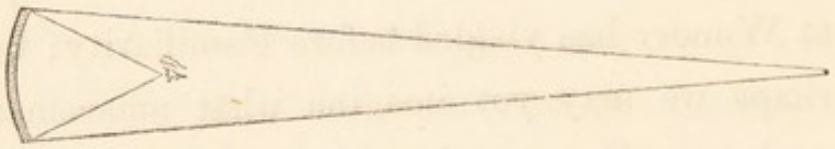
The reader knows a *lens*—a common burning glass? If such a glass is held before the beams of the sun, it is seen to compress much of the light which falls upon its surface into a bright pencil behind it. Suppose, now, a large lens of this description placed, as in this diagram, immediately in front of an eye, looking towards a radiating point which is nearly invisible through faintness, and notice the change of circumstances.* Instead of the eye receiving, as in the first case, only a faint and almost imperceptible quantity of light, it now takes in *the whole mass of rays, which pass through the large lens in front of it;* for the lens has united that mass, and made it converge into a pencil sufficiently minute to enter the eye. A portion of the rays which reach the lens from the luminous body, do not indeed pass through it, and are therefore lost to the eye; but as the diminution is not great, *an eye in the position referred to would receive nearly as much light as if its pupil had been enlarged to the dimensions of the lens, and its power would necessarily be increased in proportion.* Thus armed, through what a remoteness

* It will be recollected that I am not describing the construction of a telescope, which is beyond my province and present intentions: I merely indicate the sources of its power.

might we reach that luminary, formerly just escaping us! Without the slightest hazard of its fading away, it might evidently be withdrawn into space, until the whole light compressed by the lens were not more intense at the bright point of its pencil, than the faint ray at the pupil in the first diagram; and this mighty acquisition has been gained by the simple interposition of a lens! We have been so long accustomed to the telescope, that Wonder has yielded before Familiarity; but perhaps we may yet imagine what amazement spread over Europe when the rumour was first heard, that by a process of such simplicity, the hither boundaries of the unseen had been passed, and remote faintly-twinkling worlds brought near for the inspection of man! No Arabian tale could have seemed wilder, and no fabled charm of more incredible potency. Art in our own day has often seemed to realize the fables of the most wonderful talisman; but our greatest advances—our mightiest triumphs over time and space—are mean and commonplace beside the achievements of the telescope. Let our race labour on! the best magic—one loftier and more potent than Agrippa ever dreamt of, is all within its reach:—The assistant

Genius is Nature herself; and the spell, that Intellect which comprehends her.

Lenses, however, or *refractors*, are not the sole instruments by which light can be collected and compressed. A concave mirror of polished metal answers the same purpose; only, as represented in our next figure, the mirror throws the conver-



gent pencil forward, while refractors throw it behind them. I need not remark that the vital source of power, in either case, is the size or diameter of the reflecting mirror or refracting lens; for, according to its diameter, the pupil of our new eye is great or small. Refractors of a moderate size are common, but large ones are very rare,—Art still failing in the regular construction of great lenses.* It has hitherto been easier to work in metal than in glass, and accordingly powerful

* It were altogether unjust to omit to notice here the admirable glass produced by Merz at Munich. I lately saw in the workshop of this excellent artist an object glass of some fifteen inches diameter. Of the workshops of Merz and Ertel, Bavaria is justly proud.

telescopes, on the reflecting principle, are most frequently employed. Reflectors of nine inches diameter have long been in general use; a considerable number of twice this size have likewise searched the heavens with singular effect; and Sir William Herschel, after incredible labour, constructed one whose mirror reached the size of FOUR FEET diameter. This great instrument, which, from causes never fully explained, did not achieve many services for Astronomy, was yet virtually an eye whose pupil approached the size of its enormous disc! The light it collected, and the consequent lustre with which it clothed the bodies in our immediate vicinity is said to have been nearly inconceivable. Intent on far discovery Herschel seldom looked at the larger stars; and, because their blaze injured his eye, he rather evaded their transit. But at one time "the appearance of Sirius announced itself, at a great distance, like the dawn of the morning, and came on by degrees, increasing in brightness, till this brilliant star at last entered the field of the telescope with all the splendour of the rising sun, and forced me to take my eye from the beautiful sight.'

In regard of Reflectors, we are touching on new times. An Irish nobleman—the Earl of Rosse

(late Lord Oxmantown)—has successfully devoted his great talents and fortune to the invention and execution of means, by which large discs of metal can be cast and safely ground to a true form; and the scientific world rejoices in his entire success. A telescope of three feet diameter has already issued from the workshop of this noble lord; and, if report speaks truly, the temporary use of it has evolved several most startling facts, even where novelty was scarcely looked for. But why speak of *three feet?* At the present moment the polishing tools of that workshop are busy with a disc, whose diameter is SIX FEET; and I have the best ground for believing that, up to this time, every operation has been auspicious. The completion of this telescope will form an epoch in Man's History. It will recall the time when first he trod beyond the enclosure of his small home under the guidance of Gallileo.

The principles above explained show how we may compute the *precise and definite power of telescopes*, or the distance to which they reach, compared with the naked eye; and such knowledge is of highest importance, as, without it, one could not estimate the relative profundities of the objects

which different instruments reveal. The first element or essential is manifestly the size of the speculum or object-glass, compared with the pupil of the eye; and the second is the proportion of light lost in the process of reflection or refraction. If no light were lost, the artificial eye and the natural eye would, as I have said, be efficient, according to the comparative magnitudes of what I may term their respective *pupils;* but as light always is lost,—and the amount may be determined by careful experiment,—a certain deduction must be made from the telescope's power. It were useless to go into the minutiæ of this computation —I merely desire to hint at its ground and rationale. A few precise statements, however, will be interesting. Herschel considered that his ten-feet telescope had a space-penetrating power of $28\frac{1}{2}$, *i. e.* it could descry a star $28\frac{1}{2}$ times farther off than the naked eye can; to one of his twenty-feet telescopes he assigned the power of 61, and to another of much better construction, the power of 96. The space-penetrating power of the forty-feet instrument he settled at 192! But as this mode of expressing such profundities may be vague, I shall convert them into more familiar quantities. The depth to which the naked eye can penetrate into

space, appears to extend to stars of the twelfth order of distances,* *i. e.* it can descry a star twelve times farther away than those luminaries which, from their superior magnitude, we suppose to be the nearest. Multiply, then, each of the foregoing numbers by twelve, and you have, as a first approximation to the *independent* powers of telescopes, a new series of figures, indicating how much farther they can pierce than the first or nearest range of the fixed stars. In the case of the forty-feet reflector, this number is 2304, which signifies, that if 2304 stars, extended in a straight line beyond Sirius, each separated from the one before it by an interval equal to what separates the still immeasurable Sirius from the earth—the forty-feet telescope would see them all.—I subjoin only one farther statement:—the same instrument could descry a cluster of stars consisting of 5000 individuals, were it situated three hundred thousand times deeper in space than Sirius probably is; or, to take a more distinct standard of com-

* This is Herschel's computation, which, as I have said already, has been questioned. I repeat that I shall adhere throughout to his estimates; nor will the error therein involved affect one of the general truths I mean to expose.

parison, were it at the remoteness of 11,765,475,948,678,678,679 miles ! *

It is important to remark, that one telescope may easily be adjusted to different space-penetrating powers. Its highest power is, of course, defined and limited by the diameter of the speculum; but we have only to confine that speculum,

* The limits to the space-penetrating power of telescopes is manifestly this :—No object fainter than the *general light* of the skies—a light constituted by the intermingling of the rays of all the stars—will ever be seen. Herschel calculated, however, that a telescope, at least three times more powerful than his, might still be used. In a letter addressed to me by Sir David Brewster, on occasion of our instituting what I am now rejoiced to term, the Observatory of Glasgow, is the following interesting paragraph :—" To such an Observatory, where the finest achromatic might be accompanied with a better reflecting telescope than has yet been made, it would be a leading object to delineate with precision the hills and valleys of the moon. This planet is much within our reach ; and an accurate knowledge of the phenomena it presents, and of the changes these undergo, would be a great and most interesting contribution to science. When we compare the telescope in Newton's time to that of Sir William Herschel's, we need scarcely despair of discovering the structures erected by the inhabitants of that luminary. An achromatic object-glass of the same size as the speculum of Sir William Herschel's forty-feet telescope, would certainly accomplish this ; and no person can say that it is impracticable to do in glass what we have done in metal. Had I the means, I would not scruple to undertake the task of building the lens in zones and segments." The wishes of this distinguished philosopher have, in the meantime, been answered in another way by the Earl of Rosse.

to contract its pupil, by placing an opaque circular rim of greater or less breadth around the mouth of the tube, to obtain whatever degree of inferior reach we desire. This artifice enables us to take, without trouble, an observant *walk* through space. We know, for instance, that the naked eye can perceive stars of the twelfth order of distances; so that whatever we see without telescopic aid must lie within the sphere at whose outer circumference stars of that order are placed. A telescope with a space-penetrating power of 2, or which reaches to the 24th order of distances, will of course show us much more than the naked eye; but, whatever additional it reveals, must, in the main, lie between stars of the 12th and stars of the 24th order; so that we have not only new discoveries, but a view of the contents of that particular stratum or *layer* of the firmament, which surrounds our visible sphere.* By employing a power of 3, the next

* It will be manifest, that the whole of the reasoning in the text proceeds on the idea, that smallness of size signifies greatness of distance. I have already explained that this does not apply to *individual orbs*—but to *masses of orbs:* and it must be held to afford results approximately true, unless, contrary to all fact and analogy, the observer should choose to consider, that different classes of magnitudes have separate and distinct localities or spheres assigned to them.

layer might be explored; and advancing thus, as far as our powers will sustain us, we may yet complete the speculations referred to near the close of last chapter, and take cognizance of the *whole interior structure of the cluster wherein we are.*—Meantime, however, we shall proceed no farther with speculation; and therefore I close this chapter by quoting, in illustration of the above, Herschel's graphic account of his treatment of one of the richest and deepest portions of the Milky Way. He had previously prepared four telescopes in the manner described—with a series of gaging or sounding powers, ascending in regular progression. He adjusted the finder of his seven-feet telescope to the powers of 2, 3, and 4; to his night-glass he gave space-penetrating powers of 5, 6, 7, and 8; to his seven-feet reflector he gave powers of 9, 10, and upwards, to 17; with his ten-feet reflector he continued the series from 17 to 28; and, thus amply prepared, he undertook to explore a particular spot. "I selected," says he, "the bright spot in the sword handle of Perseus, as probably a protuberant part of the Milky Way in which it is situated. At the time of observation, not a star in it was visible to the naked eye. In the finder, with a power of 2, I saw many stars; and,

admitting the eye to reach to stars at the distance of the 12th order, we may conclude that the small stars which were visible with this low power, are such as to contribute to the brightness of the spot, and that their situation is probably from between the 12th to the 24th order of distances. . . .

I then changed the power from 2 to 3, and saw more stars than before; and changing it again from 3 to 4, a still greater number became visible. The situations of these additional stars were consequently between the 24th, 36th, and 48th order of distances. With the gaging power 5 of the night-glass, I saw an increased number of stars; with 6, more stars and whitishness became visible; with 7, more stars, with resolvable whitishness, were seen; and with 8, still more. The stars that now gradually made their appearance, therefore, were probably scattered over the space between the 48th and 96th order of distances. In the seven-feet reflector, with the gaging powers 9 and 10, I saw a great number of new stars; with 11 and 12, a still greater number, and more resolvable whitishness; with 13 and 14, the number of visible stars was increased; and was so again with 15; and with 16 and 17, in addition to the visible stars there were many too faint to be distinctly per-

ceived." And so did the philosopher go on—invoking space, and summoning up multitudes of worlds—through all the powers of the ten-feet telescope, when I find the following entry: "With the whole space-penetrating power of the instrument, which is 28, the extremely faint stars in the field of view obtained more light, and many still fainter suspected whitish spots could not be verified for want of a still higher gaging power. The stars which filled this field of view were of every various order of telescope magnitudes; and, as appeared by these observations, were probably scattered over a space extending from the 204th to the 344th order of distances."

CHAPTER III.

ASPECTS, FORMS, AND DISTANCES OF REMOTE CLUSTERS.

I RESUME progress. The fact has been already established of the existence of vast clusters distinct from ours, sustaining an independent position, as individual constituents of Creation. Go we now into infinity among these firmaments, and ascertain their character.

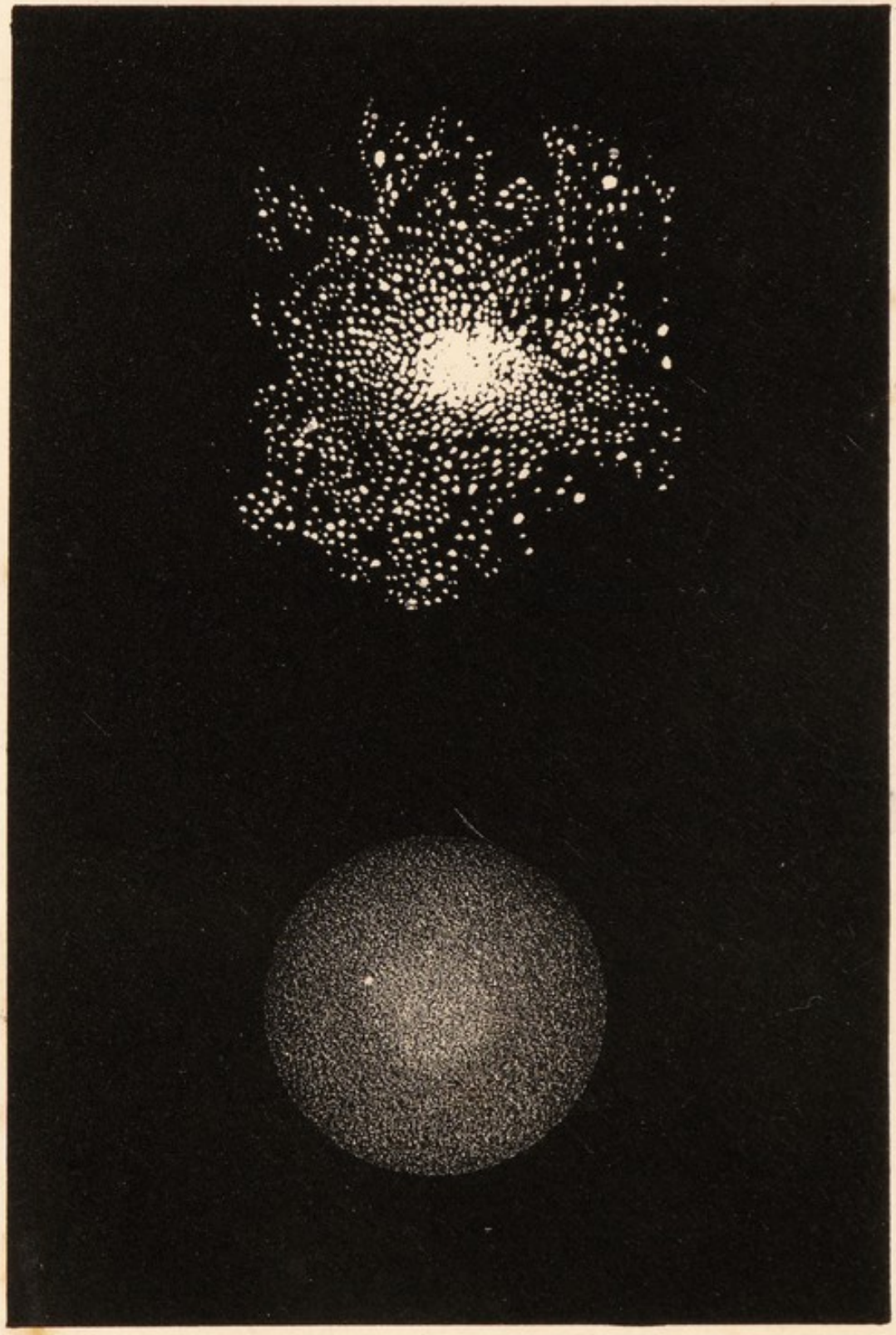
The number of such masses is very great. In the northern hemisphere, after making all allowances, those, whose places are fixed, cannot be fewer than between one and two thousand; and it may express how plentifully they are distributed, if I remark that this is at least equal to the whole number of stars the naked eye can perceive in an ordinary night. These clusters have very various appearances to the telescope. In many of them, individual stars are distinctly defined. As they

become more remote, the distances or intervals between the stars diminish, the light also growing fainter; in their faintest stellar aspect, they may be compared to a handful of golden sand, or, as it is aptly termed, *star-dust;* and beyond this no stars are seen, but only a streak or patch of milky light, like the unresolved portions of our own surrounding zone. This is the state in which they are more properly called Nebulæ, and in which there is risk of confounding them with a singular substance hereafter to be spoken of, but which does not partake of the nature of stars, although very common in our firmament.

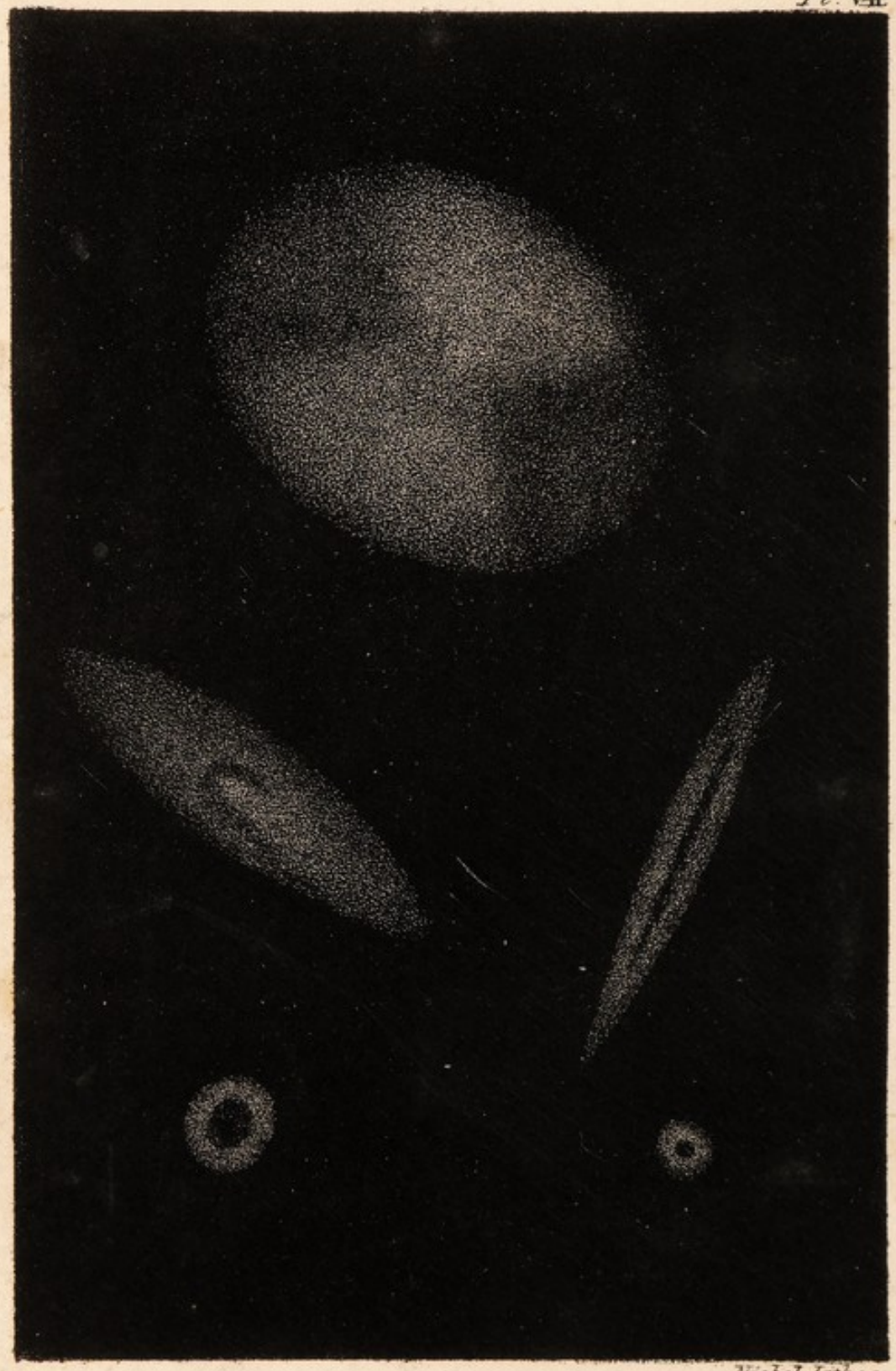
In the first chapter, I drew attention to that splendid object in the constellation Hercules, represented in Plate I. Look at it again, and imagine its magnificence. This cluster, in respect of its leading characteristics, is a good specimen object, as it is a representative or type of a very large class. Notwithstanding the partial irregularity of its outline, it seems almost a spherical mass, in which, with a degree of greater compression probably towards the centre, the stars are pretty equably and regularly diffused, so that, to the inhabitants of worlds near its central regions,

its sky would spangle uniformly all around, and present no phenomenon like our Milky Way. Plates IV. and V. contain representations of other spherical clusters, some of which, however, show decided and great compression about the centre; a circumstance which would manifestly much augment the proportionate number of orbs of the first magnitude, in view of those living within the compressed portion, and thus render their visible heavens inconceivably brilliant. The same plates exhibit the degrees of distinctness with which these clusters appear. One of the figures in Plate V. is a very faint object, placed near the outermost verge of the sphere within which our largest instruments can descry individual stars; it is already in the condition of *star-dust*, almost fading into an irresolvable nebula.

Clusters, however, are by no means confined to the spherical form. Our own, and its curious cognate, are manifest exceptions; and there are other equally remarkable shapes. These are, even when resolvable, of great varieties—sometimes appearing as ovals, more or less oblong, and of greater or less regularity: in a few cases they have a sort of *fan* shape. But it is when we arrive among the almost bewildering multitudes of unresolved sys-



Pl.V.



Nichol Lithog

tems, that we are most forcibly struck by their fantastic forms. The unresolved clusters being at depths much profounder than the sites of the others, the sphere appropriated to them is of course of larger radius, and far more capacious; so that there is *room* for great numbers, and also for a more wonderful display of variety. Plate VI. exhibits a few of these curious shapes. The annular or ring form is sometimes met with;—one fine instance is in the constellation LYRA.* The oblong sharp hoop represented in the plate, is probably likewise a large ring, appearing sharp only in consequence of its oblique position towards us. How different utterly from ours, must be the aspects of the sky to the inhabitant of such a firmament! The space within the ring is nearly a blank, but not perfectly so, a very thin shade of light spreading over it; so that if any intelligent eye looks from within the space upon what it may well consider its universe,—towards its sides there will be nearly an utter blank, and engirdling it round, a zone of dazzling lustre. Perhaps the most peculiar of all, however, is that largest object in the Plate referred to. It has the shape of an hour-

* Dr Robinson thinks that this has been resolved, at least in one part, by the Earl of Rosse's three-feet telescope.

glass, or dumb-bell; the two connected hemispheres, as well as the connecting *isthmus*, being bright and beautiful, manifesting a dense collection of stars in those regions; while the oval is completed by two spaces, which do not transmit a greater quantity of light, or indicate the presence of a larger number of stars, than the comparatively vacant interior of one of the annuli. We are lost in mute astonishment at these endless diversities of character and contour. They indicate among the Forms of these remote regions a variety as great as that which distinguishes the minute things around us. Not improbably it is one aim of the stupendous system of Evolution, of which Creation as it exists is only one Phase, to develop all possible variety; to exhibit how, without infraction of steadfast law, Being may be infinitely diversified, and room found for unfolding the whole riches of the Almighty.

Our knowledge on this engrossing subject, hitherto almost limited to the Northern Hemisphere, has recently received a grand extension, in the fruits of one of the most interesting scientific expeditions which could adorn any age. Prompted by zeal for that science, of which he

has long been a distinguished ornament, and also, perhaps, by the pious desire to complete what his illustrious father began, Sir JOHN HERSCHEL, in the year 1833, quitted England for the Cape of Good Hope—already famous as the seat of the observatory of LA CAILLE—and swept with his large telescope all the southern skies. After devoting five years to this vast and noble work, our astronomer has returned; and he exposed the chief results of his labours before a recent scientific assemblage at Newcastle. As was to be expected, the contents of these heavens are *in kind* wholly similar to our own. Clusters of all descriptions are found there, and of every degree of condensation and brightness,—chiefly round, or approximating to that normal globular form, but often also of other shapes. Among others, we have annuli or rings, exactly similar to the objects figured in a former plate;—a circumstance indicating that the Law of Nature, through which forms so majestic, and yet apparently so capricious, are evolved, is not of anomalous or unfrequent operation: and again, impressively revealing how little that is which we know, compared with what is still claimed for the sacred realm of the UNSEEN —the object, to us, of mute and reverential amaze-

ment.* But if the Southern Hemisphere, in regard of the *nature* of the clusters it contains, presents no contrast to that with which we have been so long familiar; it is in one spot signally distinguished by the *close aggregation of great numbers* of such firmaments—presenting there, probably the most remarkable phenomenon in the whole Heavens. Quite apart from the Milky Way, lie two bright specks noticed long by southern navigators, and named in honour of an adventurous seaman—MAGELLAN'S CLOUDS. These—often celebrated by fame and known otherwise by imperfect sketches—have now been thoroughly analyzed. Instead of simple milky spots, or permanent light flocculi of cloud, as they appear to the spectator, they shone through Herschel's telescopes, objects of inconceivable splendour. That most remarkable one, the Nubecula Major, is a congeries of clusters of stars,—clusters, says Sir John, of irregular form, globular clusters and nebulæ of various magnitudes and degrees of con-

* There are in the south also, as well as in our skies, a number of objects named *planetary* nebulæ,—nebulæ with discs like planets,—*i. e.* having a *uniform* light. The nature of these bodies is wholly unknown. Whether we consider them as clusters of stars, or portions of a substance to be described hereafter, their constitution is equally puzzling.

densation, among which is interspersed a large portion of irresolvable nebular matter, which may be, and probably is, star-dust, but which the power of the twenty-feet telescope shows only as a general illumination of the field of view, forming a bright ground on which the other objects are scattered. Thus also—in a less striking degree indeed—is the Nubecula Minor: so that, in these mysterious spots, there seems an instance of a *system of firmaments*, comparatively isolated or confined within a small space, and hanging before our view as a singular illustration of that grander system to which we and they also belong; just as Jupiter and his encircling moons represent the character of the whole planetary scheme!

But we must close our description of these gorgeous objects. There is one problem, however, of interest so engrossing, and pressing itself so directly on attention, that I cannot quit the theme without giving it a partial consideration. After the mind has mastered the august idea, that the starry system is a scheme of separate firmaments, and reflected on the vast numbers which the telescope has already disclosed, the question springs up as to their probable distances from each other,

or the probable depth in space at which they respectively lie. The task of actually *charting* the extent of those profound regions, was one for the genius of Herschel alone; and accordingly, Sir William undertook it on an early epoch, and thoroughly succeeded in sketching its general features. The principles referred to near the close of last chapter apply at once—although subject to future modification—to the inquiry now opened. The power of a telescope, it will be remembered, can always be compared with the human eye,—as we know the reach of the eye, so we know the reach of the telescope; and if that power be observed which first descries a star, a simple calculation will inform us, in terms of the general distances of the stars, how remot the object is. To ascertain the distance of a cluster, then, note the space-penetrating power of the instrument *which first succeeds in revealing its distinct stars*, and twelve times that power will be an approximation to the required distance. Herschel, by using comparatively small telescopes, thus fixed the remoteness of forty-seven resolvable clusters—ten of which were upwards of nine hundred times more distant than Sirius; and by larger instruments the determinations might be greatly extended: but,

though the fields are white, the labourers have been few.—Inasmuch as the element by which the distance is fixed, is the *resolvability* of the cluster, we cannot come, except by guess, at any conception of the profundities of the milky or nebulous firmaments. A vague guess, however, may be hazarded. How far away, for instance, would the clusters, whose depths we know, require to be removed, in order to look as mere streaks, and to baffle the powers of the best telescope? Suppose that a cluster, ascertained as above to be of the 900th order of distances, were first seen as a whitish speck by a telescope, whose space-penetrating power is 10, it is easy to calculate how far off it must be, to be first descried as a faint spot by an instrument whose power is 200. It would evidently be just 20 times farther removed from us, or at the enormous remoteness of 18,000 times the distance of Sirius. Many unresolved clusters are undoubtedly as profound, and very many still profounder in space. Calculating from the elements of a few known clusters, Herschel reaches the depth of the 35,175th order of distances, in which some of these nebulæ must lie!

And can even *this* with all its vastness be term-

ed—the UNIVERSE? Where are we, with all our knowledge, but in the centre of a sphere, whose circumference is no more than 35,000 times farther from us than Sirius—and beyond whose circuit, Infinity, boundless Infinity, stretches unfathomed as ever? We have made a step, indeed, but perhaps only towards acquaintance with a new order of *infinitesimals*. In our first conceptions, the distance of the earth from the sun is a quantity almost infinite;—compare it with the intervals between the fixed stars, and it becomes no quantity at all, but only an infinitesimal; and now, when the spaces between the stars are contrasted with the gulfs of dark space separating firmaments, they absolutely vanish below us. Can the whole firmamental Creation in its turn be only a corner of some mightier scheme, like one solar system amongst the myriads of fixed stars,—a larger representation of that group which composes the Nubecula Major of the South—*a mere Nubecula itself?* Probably COLERIDGE is not in error:—"It is surely not impossible that to some infinitely superior Being the whole universe may be as one plain—the distance between planet and planet being only as the pores in a grain of sand, and the spaces between system and system no

greater than the intervals between one grain and the grain adjacent!"

But let us not go on to bewilderment. Apart from considerations of Space and Time, we know this fact, that we are in the midst of Being, whose amount, perhaps, we cannot estimate, but which is yet all so exquisitely related, that the perfection of its parts has no dependence upon their magnitude,—of Being, within whose august bosom the little ant has its home, secure as the path of the most splendid star, and whose mightiest intervals —if Infinite Power has built up its framework— Infinite Mercy and Infinite Love glowingly fill, and give all things warmth and lustre and life— the sense of the presence of God!

CHAPTER IV.

INQUIRY INTO THE INTERNAL RELATIONS OF CLUSTERS OR FIRMAMENTS—SURVEY OF THE SIMPLEST FORMS OF THEM—THE DOUBLE STARS.

The remarkable fact of the distribution or arrangement of the stars in distinct clusters, being thus recognised on the grand scale, one cannot withhold a conjecture that each system is itself a Unity, that relations exist which bind together its individual orbs more closely than they can be connected by any tie with the rest of the Universe; and we start on the adventurous search after such relations—not without the inspiring hope even that something of the Great Cause, which has so arranged these myriads of orbs, may possibly thereby be revealed. The telescope has recently instructed us that this clustering principle is not limited in its operation merely to vast masses of stars, but seems to pervade the whole internal constitution of our own firmament. I do not refer to the

connexion of the Sun with his surrounding planets —an arrangement which, if we saw them with sufficient distinctness, might be found to characterize every luminary in existence—but to the striking and significant fact, that our skies abound with schemes or systems of related or grouped Suns, varying in number and complexity from the simplest possible form of a group, in which a connexion is established between *two* individuals, up to related masses of a magnitude sufficient to occupy considerable portions of the Heavens. Now it is through the study of these groups, beginning with the simplest, that light may most easily reach us regarding the vast inquiry we have now adventured to start; and I hasten to unfold the subject in that expectation. The train of discovery we shall advert to, might be the distinction of any epoch, and perhaps it constitutes the proudest title of ours to be ever illustrious in Astronomy.

I.

It had been observed, at least since the time of GALLILEO, that there is a class of stars evincing a very peculiar proximity. The more remarkable of these bodies are so close, that they cannot be

separated by the naked eye, but appear as a single star, until analyzed and divided by good telescopes. For the most part they are exceedingly beautiful; and some idea of their variety in sizes and relative distances may be obtained from Plate VII., where the following eleven are supposed to be seen through the same telescope.

Fig. 1. * Castor.
2. γ Virginis.
3. Mizar.
4. α Herculis.
5. α Arietis.
6. γ Andromedæ.
7. Rigel.
8. γ Arietis.
9. Polaris.
10. Star in Canes Venatici.
11. Vega.

To these singular objects, when, however, comparatively few of them were known—Sir William Herschel happened to give especial attention,

* The figures are supposed to begin at the top of the Plate, and to move from the left hand to the right.

about the close of the last century, in the hope of resolving, by their means, the problem which proposes to determine the distances of the stars, by noting the amount of their apparent displacement, when viewed from opposite ends of the Earth's orbit. At that time the unusual apparent proximity of such bodies was supposed to involve nothing peculiar, and merely to indicate that they lie in almost the *same visual line*, or that their proximity is *optical* only, and not *real;* one star being imagined far behind the other, and divided from it by not less than the wonted interval,—but seen in union with it, because the two are in very nearly the same direction. In his earlier papers Herschel assented to this hypothesis; but when his telescope revealed to him that such stars exceed in number every previous anticipation, he discerned its fallacy, and foreboded a significancy in them far more profound, which he afterwards evolved by a process of ratiocinative observation of the most pregnant kind, and which is still one of our most brilliant examples of philosophic inquiry into the remote unknown. I shall best lay the whole of this great subject before my reader, by arranging it into different articles: and, in the first place, let me survey our reasons for believing

that the *frequency* of the occurrence of such objects does indicate some *physical peculiarity*—some new fact in the Higher Astronomy.

1. The argument I am to use may be familiarly illustrated as follows. Suppose a number of peas were thrown at random on a chess-board, what would you expect? Certainly, that they should be found occupying irregular or random positions: and if, contrary to this, they were, in far more than average numbers, arranged by *twos* on each square, it would be a most natural inference that here there was *no* RANDOM *scattering;* for the excessive prevalence of the binary arrangement would indicate forethought, design, *system*. This inference is so direct and urgent, that we unhesitatingly act on similar considerations in the conduct of life: and its applicability to stellar phenomena will be at once apparent. Supposing our sun placed in the centre of our starry sphere, the other stars may be conceived arranged around him in *zones*, whose distances from that orb are indicated by the relative magnitudes of the stars. Within zone 1, for instance, stars of the first magnitude may be fancied to lie, and those of the third within the sphere 3. Now, on the hypothesis that the

stars in these two spheres are scattered at random, or distributed almost equally in space, it may easily be calculated how often a star of the third magnitude should appear so closely behind a star of the first, so that the two would seem, to the naked eye, almost to coalesce, and thus to form a double star. The question as to the probable frequency of such coalitions is manifestly a mathematical one, and resolvable by a strict process. If, then, we find no more than what that process would incline us to expect, we shall be led to no further conjecture regarding the stellar systems; but if, on the contrary, that number is far exceeded by the reality, we must be startled by the presence of a phenomenon not to be explained by the circumstance of one star lying closely behind the other; for the excess of this number over the calculated optical coalitions, compels us to infer a new law—some ARRANGEMENT among classes of stars, distinguished in all likelihood by characters formerly unknown, and of which this unexpected proximity is the external index.

A tolerably accurate general notion of the nature of my argument may perhaps be obtained from this brief explanation; but, to render it thoroughly

palpable, as well as to show the probable extent of the field to which the discovery thus opening introduces us, I shall produce a few tables from the great work by STRUVE. They represent the actual numbers of stars found in close proximity, and contrast them with the very few which calculation shows to be expected if only *optically* conjoined.

Let me premise two explanatory remarks. 1. It is necessary to attain some notion, more or less distinct, of the size or value of the small *quantities* of which I am to speak. If the whole circuit of the heavens were divided into 360 equal parts, each of these parts would be termed a *degree.* If one of these degrees were subdivided into 60 equal parts, each of these parts would be what is termed a *minute;* and if a minute were again subdivided into 60 equal parts, each of these very small parts would be a *second.* Now, the distances we have to deal with are expressed in seconds, and they are so small that it will cost my reader no little difficulty to apprehend their real or comparative sizes. One fact may assist him. The diameter or breadth of the sun is nearly 2000 seconds, so that if we suppose that breadth, as it appears to the eye, to be divided into 2000 equal parts, one of these parts will be about the size of one second,

two of them that of two seconds, &c.* 2. For the sake of convenience, the approximate or conjoint stars are divided into *orders*, determined by the distance of their constituents. The first eight orders include all bodies within 32 seconds of each other, *i. e.* not separated from each other by so much as the apparent breadth or diameter of the planet Jupiter. These are essentially double stars, *i. e.* they appear single to the naked eye, nor can the nearest of them be separated without the aid of the finest telescope that art has yet produced.—The subsequent tables will now, I hope, be understood without difficulty. The one first presented, contains all the double stars from the Pole to 15° south of the Equator, in which neither constituent is very much less than the least we can discern with the naked eye; they should be easily seen, at all events, with a good common telescope. From the care bestowed in the survey, this list must include nearly the whole of such objects in these regions of the Heavens.

* Degrees, minutes, and seconds, are usually written symbolically.—Thus 10° 11′ 12″, signifies ten *degrees*, eleven *minutes*, twelve *seconds*.

TABLE I.

Orders.	Distances.	Numbers probably only optically within that distance.	Numbers observed.	Difference of the two former Cols. showing the No. of really approximate stars.
I.	0″ to 1″	.05	62	62
II.	1 to 2	.14	116	116
III.	2 to 4	.56	133	132
IV.	4 to 8	2.24	170	128
V.	8 to 12	3.73	54	50
VI.	12 to 16	5.23	52	47
VII.	16 to 24	14.94	54	39
VIII.	24 to 32	20.91	52	31
Sums,		48	653	605

How emphatically this table intimates that these double stars are, as Herschel so soon suspected, peculiar and most interesting phenomena! So far from the principle that these conjunct bodies are only *optically* double—*i. e.* that they appear near, because of the sameness of the directions in which they lie—so far from that principle being able to explain the whole existing arrangements, it accounts, as the table shows, for the proximity of no more than 48 sets out of 653—leaving 605 to be explained by some other law,

and to stand forth—as they impressively did to the mind of our philosophic astronomer—the indices of unknown and profound design! The next table refers to stars whose small companions are of much less magnitude, and of course only includes those of which we have already *complete* lists. The distances corresponding with the orders are the same as above.

TABLE II.

Orders.	Numbers optically double.	Numbers observed.	Numbers really double.
I.	1	16	15
II.	3	82	79
III.	11	176	165
IV.	43	214	171
V.	71	124	36
Sums,	129	612	483

In other words, of 612 conjunctions among the smaller and more numerous stars, there are 483 unaccounted for by the notion that the proximity only indicates that one star is far behind another. STRUVE, in the introduction to the Catalogue referred to, has pursued the inquiry to its apparent limits—*i. e.* until he reaches the distance at which

the probability of the *conjunction being solely optical*, undoubtedly prevails. The following table, containing complete lists of the *brighter* stars only, gives his conclusions.

Orders.	Distances.	Numbers probably optically related.	Numbers observed.	Numbers physically related.
IX.	32″ to 60″	1.536	15	13
X.	60 to 120	6.439	15	9
XI.	120 to 300	7.74	17	9
XII.	300 to 600	27.56	33	10
XIII.	600 to 900	21.50	25	3.5
Sums,		65	110	44

It cannot fail to be noticed, that the number of stars optically related is here much *larger* than in the former table; and in order XIII. nearly the whole are related optically, thus evincing that the limit 15′ or 900″ approaches to the usual or average interval of celestial space between independent stars of those magnitudes. The result of the whole may be briefly stated:—*In reference to stars not smaller than the least we see with the naked eye, there is a possibility of the existence of a certain unexplained connexion or relationship wherever the distance is within* 15″, *or about half the diameter*

or breadth of the sun; when the distance is less than 5′ or one-sixth of the breadth of the sun, the probability of such a connexion is very considerable, and in almost every instance, whether the stars be large or small, where the distance is less than 30″ that connexion may be predicated with an approach to certainty as near as can be attained on subjects so speculative. If the word *speculative* is rightly interpreted by *fanciful* or *hypothetical*, I am in error in thus using it; for the foregoing conclusions are as sound and warranted as if they rested on a long induction of actual and known connexions. The character of the specific connexion we may not, on any grounds I have yet unfolded, venture to assign; but, that a connexion exists, far spreading and memorable, constituting an important feature among the complex arrangements of our firmament —is sustained by that maxim, which is at the root of all philosophy, that Nature is not capricious, and that analogies or correspondences, steadfastly indicate some Law, real though unrevealed. It is from the confidence with which he rests on this belief—one inseparable from his being—that the true Philosopher derives his powers as a Seer. The analogy or group of collocated events, is the bud of mighty truth, whose growth or fulness he

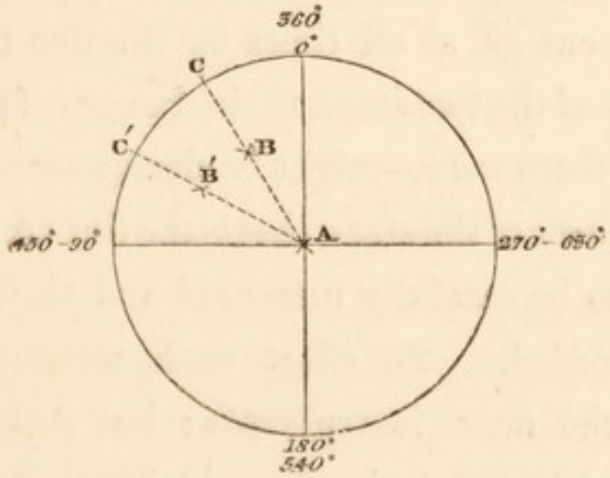
descries from afar, and proclaims in words of prophecy its approaching advent.

2. The force of considerations like the foregoing was not lost upon Herschel. Of all men—with perhaps one exception—who ever adventured into unknown regions of the Heavens, this great Inquirer was most deeply penetrated with an enduring conviction of the all-prevalence of Law, whose characters were first indicated by "collocations;" and he evinced a marvellous quickness and solidity in interpreting the remotest hints; a feature—a single line was enough, and he divined the outline of the portrait. Rising in the present instance to the utmost height of justifiable speculation, he proceeded to the next step in the bold induction, viz. to the question, as to the *nature of the bond or union* between these singular bodies; inquiring whether *gravity*, a law already known, would not account for the connexion which seemed established, and whether, in such a case, the Suns would not—like our planets about their Central Luminary—*revolve around each other* in definite orbits? Herschel, however, was too sound a philosopher to be withdrawn, even by the fascinations of so brilliant a conjecture, from that laborious path

which alone can guide to truth; and at the same moment at which he threw out his ideas, he urged Astronomers to confirm or disprove them by observation, exhibiting labours of his own by which, if extended and repeated after long intervals, all mystery would be withdrawn from these singular bodies. Nor did he summon unwilling labourers. I can compare the sensation occasioned in the astronomical world by these bold views only to the excitement diffused through Europe when Columbus discovered in the Far West, new and mighty Continents resting amid the formerly void and mysterious Ocean. To follow up Herschel's examinations has constituted the chief ambition of observers from that time until now. Observatories, with gorgeous appliances, have been carefully suited to that specific purpose; and many private observers have, with their utmost means, toiled in the same walk. Before the close of his earthly honours, the veteran had himself accomplished the measurements, that is—had fixed the places of above 500 double stars. In 1824, Sir James South and Sir John Herschel produced a catalogue of 380 stars, whose distances and angles of position they had jointly fixed with admirable precision. South followed it up by a distinct catalogue of 480; and Herschel, now also

observing apart, has completed a list of upwards of 3300 of such determinations. Inferior to none, however, is M. STRUVE of Dorpat, who, aided by that noble instrument, the Equatorial of Frauenhoffer, first analyzed and afterwards measured the positions of nearly 3000 double stars, with a precision that cannot be surpassed. His last work, is indeed at once the latest and the classical work on the subject of the motions referred to.—These catalogues, however, do not reach farther than 15° south of the Equator; but this has now also been explored, and another fruit of that memorable expedition, to which I have already alluded, is the discovery there of upwards of two thousand more of these objects. Nothing was known, previous to Sir John Herschel's voyage to the Cape, concerning the double systems of that vast celestial space, except through a small catalogue by Mr DUNLOP of PARAMATTA. Allusion to this remote Observatory forbids me to pass the name of its founder—himself an able and laborious observer, Sir THOMAS MAKDOUGAL BRISBANE; through whose munificence it was established, and British science made coextensive with British dominion. Gracefully does the laurel due to such actions adorn the green autumn of life!

The *mode* by which astronomers examine and record the relative positions of stars presumed to be connected, so that they may be compared with distant records made at other epochs, is extremely simple. Suppose that a circle with cross diameters, such as the following, were placed in the eye-piece of a telescope, that is, so placed, that both it and the stars should be visible at one and the same time. Suppose also that its circumference were divided into 360 equal parts, viz. degrees, beginning at 0°, and passing through 90°, 180°, 270°,



to 360° or 0° again, and let the reckoning proceed without interruption to 450°, 540°, 630°, &c., &c. Now, if one of the associated stars be brought to the centre A of the cross lines, the other will lie somewhere else. Suppose it to be at B, and draw a line through A and B to meet the circle in C; this line will clearly cut off the part of the circle

between 0° and C, which will contain a certain number of the equal parts spoken of: and if that number be known, the exact distance of the point C from 0° may be laid down in a chart or figure. If B should now change its place relatively to A, and, after a certain length of time, occupy the place B′, this change would be immediately detected by the observer, who would find that the line AC′ through A and B′ now cut off a greater number of those equal parts, on a larger part 0°C′ of the circle than formerly. And thus, by noticing carefully the number of degrees, or of equal parts of the circle cut off at all times by the line through the centre of the two stars, their changes of position —if such there were—might be clearly ascertained. The distances of the stars, that is the lines AB, AB′, might also be carefully measured and their variations recorded. To effect such measurements requires the finest instruments; but Art is now fully equal to the task of producing them. The error of the instrument is very rarely so great as the error of the observer in using it.

The instance of ξ Ursæ Majoris will illustrate the method of observing now explained, and exhibit an actual *progress* in an associated star. The table below presents the distances of its two

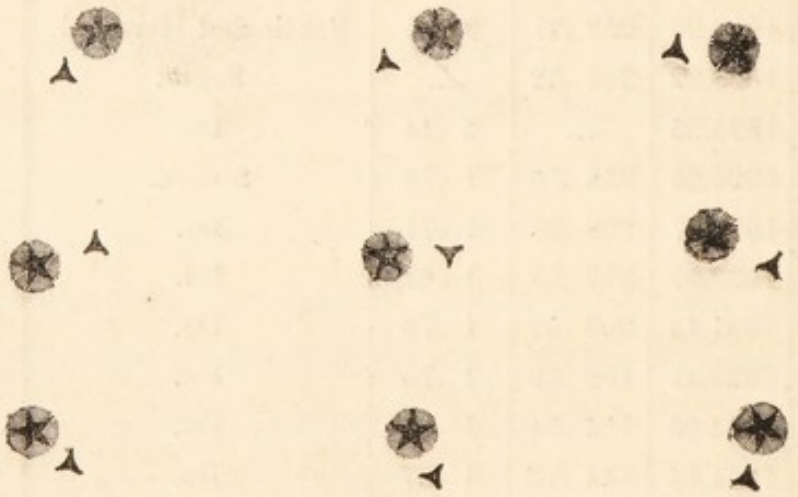
stars, measured at different epochs, their angles of position, *i. e.* the quantity of the circle from 0°, cut off by the line joining their centres at the several epochs,—and the names of the observers. We shall experience little difficulty in drawing from it the proper and suitable inference.

ξ URSÆ.

Epoch.	Portions.	Distance.	Observers.
1781.97*	503°.47′	...	Sir W. Herschel.
1802.09	457 .31	...	Do.
1809.08	452 .38	...	Do.
1819.10	284 .33	2″.56	Struve.
1820.13	276 .21	...	Do.
1821.13	268 .48	...	Do.
1822.08	262 .39	...	Do.
1823.29	258 .27	2 .81	South and Herschel.
1825.22	244 .32	...	South.
1825.25	...	2 .44	Do.
1826.20	238 .75	1 .74	Struve.
1827.27	228 .27	1 .71	Do.
1829.35	213 .59	1 .67	Do.
1831.44	203 .82	1 .70	Do.
1832.41	195 .80	1 .75	Do.
1833.38	188 .24	1 .69	Do.
1834.44	184 .10	1 .87	Do.
1835.41	180 .18	1 .76	Do.
1936.44	171 .20	1 .97	Do.

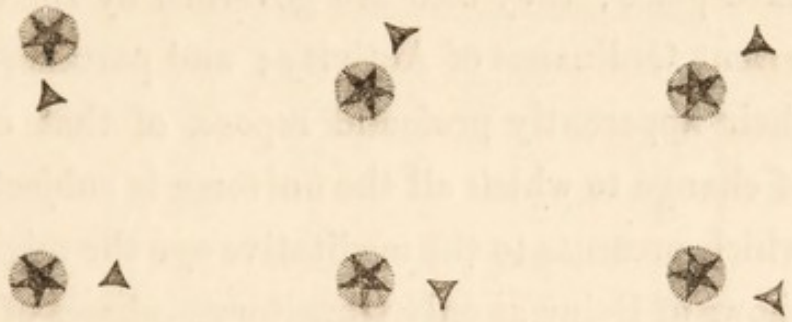
* The decimal places after the year, indicate the *time of the*

The recorded distances of the two stars are ambiguous, and perhaps contradictory; but they vary within limits so extremely narrow, that much may be referred to the error of observation. The change of the angles of position, however, is manifest; and, as the foregoing remarks evince, these enable us to ascertain how the two stars were placed with regard to each other at their respective epochs. Without farther reference to tiresome minutiæ, I shall express these changes to the eye. The following three lines contain a representation of the positions of the two stars, as indicated by the previous table, at certain successive epochs. Observe how the smaller star



year, or the *date* the observation was made. For instance, 1838.5 would signify the exact middle of the year 1838. And so of the other parts.

gradually moves round the other in an orbit! Can any one, on looking at this diagram, doubt concerning the motion of these orbs? Nor is ξ Ursæ singular. The diagram now produced represents the positions of the two stars in Castor,



which, indeed, are found to vary much more slowly, but they equally indicate a grand motion of revolution. Lastly, observe the following pictorial record of the changes of γ Virginis;—it affords

evidence no less emphatic of an alteration of place, intimating orbitual motion; although its period is still vaster than that of Castor. Who can look, even cursorily, at these diagrams without being satisfied of that marvellous truth, which all recent astronomy has confirmed? I know it requires no trifling amount of evidence to induce us to accept

a phenomenon so novel and so wonderful. If aught in the universe were a landmark, it surely might be supposed to be those stars infinitely remote, deep in peaceful infinity, and undisturbed by the commotions of earth;—No! neither have these a fixed place; they also are governed by the omnipotent Ordinance of Activity; and partake, amid their apparently profound repose, of that course of change to which all the universe is subject, and which presents to the meditative eye the mightiest shows of Being as only transitory—phases of some scheme of unresting and stupendous evolution!

But perhaps I press too early to my conclusion. Before accepting the truth indicated, viz. that stars, physically connected, are revolving systems, it may seem reasonable to inquire, whether the cases just instanced are not mere *peculiarities;* or *in how many* of such stars these motions have been recognised? I again reply, from the pages of M. Struve. The following Table presents the whole double stars whose existence this laborious observer has detected, arranged according to their orders; and the subsequent columns contain the number which have evinced the certainty of a mutual relation, by the fact of undoubted change.

TABLE III.

Order.	Number of double stars in each order.	Number of Stars in which			Sum of Changes.
		Change is certain.	Change is probable.	Change is suspected.	
I.	91	13	4	3	15
II.	314	10	6	5	15
III.	535	12	5	12	19
IV.	582	7	9	14	17
V.–VI.	583	7	9	14	17
VII.–VIII.	535	9	6	18	18
Sums, .	2640	58	39	66	101

The last column is made up, not by taking the *sum* of the three preceding it, but by adding to the third column that *proportion* of the fourth and fifth in which change may safely be assumed. Struve so estimates these observations, that six out of ten in the fourth column, and only three out of ten in the fifth, can be assumed as actual changes. One hundred and one stars out of 2640, are thus all that have yet yielded the secret of the mode of their connexion;* although our argu-

* Sir John Herschel has added a few from the South; but the full value of his labours in this respect will not be known

ments, from their proximity, establish it as indubitable, that in the immense majority of that large number, connexion must exist. But, seeing the date of Observation is only as yesterday, let us not repine at the fewness of the motions ascertained, so much as rejoice that a sure promise remains to stimulate the ardour and reward the industry of inquirers. It is no more than fifty years since measurements of this kind were first undertaken —not more than thirty-eight years since the probability of orbitual motion among the suns of space was ascertained by Sir William Herschel; and then, how slow are many of these motions, how rare and recent the instruments capable of following their evanescent variations, how "envious," too, are the "clouds" of Man's too intimate knowledge of the Heavens? But notwithstanding every obstacle, we have a right to the highest hopes. Not a year can pass without adding some new systems to our catalogue; and long before the lapse of a century, perhaps, the motions of few of these 2640 objects shall have escaped the vigilance of the telescope.

until years hence, when his measurements shall be repeated; for it is only after the lapse of years that changes so slight can be appreciated, with minute accuracy.

The fair mode, however, of estimating what we may expect in this matter, and of judging how far we are entitled even now to generalize the foregoing conclusion; is—not by comparing the number of bodies known to move, with the known number of double stars—but by inquiring how many of those systems, *which have been watched and measured during any considerable number of years*, have been ascertained to change their position. Now, the brighter stars observed by Herschel, *i. e.* those stars whose measurements were taken at the earlier periods, exhibit the changes indicated in the subjoined table.

TABLE IV.

Order.	Number of brighter stars observed by Herschel.	Number of stars in which			Sum of Changes.
		Change is certain.	Change is probable.	Change is suspected.	
I.	10	8	0	1	8.3
II.	19	7	4	2	10.0
III.	42	9	4	9	14.1
IV.	44	6	5	7	11.1
V.–VI.	34	2	6	7	7.7
VII.–VIII.	28	3	3	7	6.7
Sums, .	177	35	22	33	58.1

This table should settle all doubts. It shows no less than 58 established systems in a list of 177, which perhaps intimates the proportion of the foregoing 2640, or 880 systems, as the least number we may expect to find established at the end of the next fifty years; for in Herschel's stars there is nothing peculiar, and telescopes are about to be applied to the Heavens, which must bring the smallest bodies, whose positions are now recorded, within the class of bright stars.

—The expected fact then is not now to be disputed; and yet how wonderful is it! and how wide the field of contemplation opened by these brilliant discoveries! How strange the notion of those mighty Orbs—those master Luminaries—rolling around each other as a small planet revolves around our Sun! Are those revolving Suns also accompanied by planets? The fact of *rotation* on their axes appears established among many of them; and if, as we shall see afterwards, rotation involves the idea of engirdling planets, around these double suns planets will unquestionably roll—obeying perhaps both, and drawing from both, Light and the conditions of their wonderful life! It is when one goes into regions so new and remote that the

character of the Universe, in its majesty and infinite variety, appears in its most striking attributes. In search of magnificence, it is true, we need not wander far,—witness the fields which encircle our homes, the blade of the modest grass which adorns them; but those Heavens are *fresh*, and familiarity has not left its footprint on their untrodden floor. In the silence of midnight, that noble curtain stretched out above me, and the idea present and impressive, of its great orbs obediently pursuing their stupendous paths, I confess there is a solemnity which sometimes falls upon the spirit, not unlike the feeling of the Patriarch, when he heard that still small voice, and knew it to be the presence of God!

—Pausing, as we must, to think of all the meaning of a fact so remarkable, a great truth comes strikingly before our view. It is the known tendency of a mass of matter, on receiving an impulse, to move straight on, in obedience to that impulse; and—as a sling when whirled round teaches one—a body can be made to move in a circle or other curve only by constraint, or *by some attachment or attraction between it and the centre around which it revolves*. Without such attachment, the body

would escape, like the released stone, and dart through space; and it is therefore manifest, that as orbitual motion characterizes the states, not of our planets merely, but of systems of double suns, so numerous and located in all parts of the firmament—some power must exist in matter, to draw other matter to itself, or some mysterious but strong affinity between the central orbs, and such as roll around them. Perhaps this affinity is universal—perhaps the grand phenomena we are viewing are mere ensamples of the energy of a Force penetrating through Creation? And so it is. Not only does one globe thus affect another and bind it within an orbit, but every particle of matter—even the evanescent grain on the sea-shore—is by the same sympathy associated with all else that exists! Knowing this great truth, we can henceforth step through the Unseen, conscious that it contains no deserts. Matter which is termed *inert* is there filling space with its exhaustless activities,—that which is said to be dead, binds its neighbour to itself in indissoluble alliance: its sympathies and *speech*, fill all Heaven's silences!

Possessed of so clear an intimation of the exis-

tence of this singular Power, we should now inquire in how far it may enable us to comprehend more complex arrangements: but there are a few points connected with the double stars, regarded as distinct phenomena, which have sufficient interest to detain us a short time longer.

1. My readers will doubtless be curious concerning the periods of the revolutions of these bodies, or the lengths of their great years: of course they vary exceedingly, and are confined within no limits yet known.

The following four have completed their courses since observation began, and therefore, present epochs, regarding which there can be no mistake.

η Coronæ	revolves in	43 years.
ζ Cancri	.....	57 ...
ξ Ursæ Majoris	.....	61 ...
p Ophiuchi	.....	80 ...

Generalizing on the ground of the known character of the orbits of these stars, and after watching with critical assiduity the changes of three others, astronomers venture to assign also their periods:—viz.

σ Coronæ revolves in 200 years.
Castor, ... 215 ...
γ Virginis ..... 513 ...

Of such periods and orbits the course of discovery will doubtless greatly enlarge our knowledge; though perhaps there may be sufficient similarity in most of them to render them in a great manner devoid of individual interest: but from this we must except *two* classes of stars which promise to afford subject of very attractive contemplation. Struve correctly remarks, that of all his Orders, the *first* is that in which rapid discovery may be most confidently expected, because it is only by telescopes now coming into use for the first time, that stars so very close can be decomposed or measured with requisite accuracy; and it is exceedingly probable that many very close pairs will yet manifest revolutions of much shorter period than even that of η Coronæ. Struve's own work has laid the foundation for large advances in this field: it has already afforded ground of conjecture that ζ Herculis, 42 Comæ Berenices, γ Coronæ, and τ Ophiuchi, have very brief periods.*

* Sir John Herschel, even during his short residence at the Cape, has been able to indicate several separate and remarkable

While referring to these indications of rapid and restless activity among the more majestic bodies of our firmament, the Astronomer expresses his pious gratitude that he has had patience and vigour for the pursuit of them, and that his eyesight is unimpaired. It will be the universal wish of Europe that in the labours of the splendid Observatory, on the care of which he has entered, these blessings be preserved to him; and that the fates of Uraniburg never darken the history of this second instance of the noblest institution the world has seen — dedicated to Astronomy by Royal munificence! — The *second* class I allude to as affording results of singular interest, lies at the opposite extremity of the scale of Orders. I have shown that stars so far separated as 15′ or 900″ from each other, are still within the *suspicious* distance, *i. e.* that probably a few pairs so situated are physically connected and form systems. This information is of itself so vague, that perhaps few observers would be disposed to watch and measure all such stars, in the hope of detecting these few: but fortunately another principle enables us to select the *actual pairs*, to point out many specific

systems. He refers especially to α Centauri, ζ Hydræ, γ Coronæ Australis, and π Lupi.

sets, of whose connexion we are certain, although their motions are yet unrevealed. The principle is this:—A great many stars have what are termed *proper motions* in space, *i.e.* they seem slowly shifting their places in the sky, moving regularly onwards by small annual quantities (quantities which vary with the stars) in what as yet appear straight lines, but which doubtless are portions of vast curves. It happens, that amid all this variety of motion, *both* the constituents of a great number of stars optically connected, partake *equally* of such motions; that is, the one star moves annually in the same direction as the other, and by precisely the same quantity: and how infinitely small—how inappreciable is the probability that they would do this were they *only* optically connected? True, stars may exist separated from each other by gulphs of space, which have proper motions that would appear the same when viewed from the earth; but considering the immense variety of these motions—how trifling the chance of pairs of such objects being frequently found nearly in the same line? This chance, rightly estimated, is much smaller than that which depends upon the mere position of the stars; and the conclusion is therefore inevitable, that when an identity of

proper motion is detected, these two stars—suspicious on other grounds—are *certainly connected physically:* their union in a system being the cause of the identity of their proper motion. Now a considerable number, far separated from each other, are in this way demonstrated to be systems; among which I distinguish the following:—

Castor, and a third small star,	constituents distant		72	seconds.
40 Eridani,	...	...	84	...
Regulus,	...	...	180	...
ε and 5 Lyræ,	...	...	210	...
θ^2 and θ^1 Tauri,	...	...	336	...
36 Ophiuchi and 30 Scorpii,	...	...	720	...
Mizar and Alcor,	...	...	720	..

Between these two last stars, Mizar (ζ Ursæ Majoris) and Alcor, a small star of the 8th magnitude is interjacent, which does not partake of their proper motion. It is impossible to reflect on systems constituted by orbs so far apart, without an emotion of wonder at the periods which must be occupied in their revolutions. If τ Ophiuchi, or ζ Herculis, surprise us by their rapidity, and consequent restless activities; systems like the

foregoing astonish by the durations through which they hurry the imagination. Observation, of course, can alone determine their actual periods, but by a simple calculation we may reach an idea of what they are. By the laws of motion we can estimate what would be the period of any star whose present period and distance we know, were its constituents as far asunder as these others are. Taking *p* Ophiuchi as our standard, whose present period is 80 years, and its distance 4″.33, we find that if its two stars were separated as far as those in 40 Eridani, their period would occupy more than 7000 years; and that, were they at the distance of Mizar and Alcor, it would stretch over no less than 190,000 years! Such, then, or some such, is the period in which Mizar revolves around Alcor,—a period which is the *unit*, the *single year*, of that stupendous system! Our small units, one hundred and ninety thousand of which are thus compressed into one single unit of a vast system, may serve to reckon the days and months of human life—the duration of royal houses—the periods of empire;—to measure the surface-changes even of our own globe, they have been found inadequate—how, then, shall we extend them to the skies, and attempt to read, by their

puny aid, those celestial annals, which must be divided according to numbers of their own?

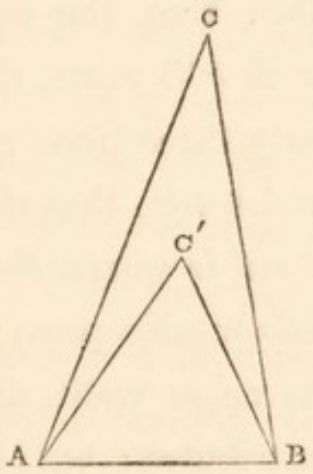
2. The periods of some of these systems being ascertained, it is not unwarrantable to ask whether we know anything of their *actual distances* from each other, or of their *masses*, *i. e.* of the sizes of those majestic bodies compared with our Sun? The *comparative* distances of a number of pairs of stars may be ascertained, with some accuracy, by means of the following considerations:—It is a remarkable fact, that *the greater number of changes are observed in double systems belonging to the first orders:*—the very first order, which includes objects whose constituents are no farther separated than one second, yielding 8.3 systems out of 10. This fact can be accounted for only on the supposition, that the stars *apparently* nearest *move with the greatest velocities*, and that the velocity diminishes and becomes more difficult of detection as the *apparent* distance increases; and, inasmuch as the planets *actually* nearest the sun move with much greater rapidity than those more remote, we infer that the pairs of stars which *seem* to be nearest, *in the main are so;* and that, with a few exceptions,

their comparative proximity is not owing to their remoteness from our Sun. Struve deems the truth now announced of great importance, and he has embodied it in the following proposition:—"*The division of the double stars into orders, according to their mean distances, does not rest on mere appearances. Stars of the first order, distant from each other from* 0 *to* 1″, *are generally those whose actual linear distances from each other are the least; and the same holds good in the case of the other orders. Wherefore, the nearer the stars appear to each other, the more intense is the action of gravity by which they are retained in conjunction, the more swiftly do they move in orbits around the centre of gravity, and the shorter are the periods of their revolutions.*"

But such approximate reasoning is not wholly satisfactory; for it gives us no notion, either of the actual sizes of the orbits of these stars, or of the globes themselves. Happily this very arduous inquiry is already being undertaken. If the distances of these stars from us were ascertained, it is clear, that we could readily convert their apparent distances from each other into miles, and ascertain many other characteristics: and in regard of two stars, one in the Southern and another in the

Northern Hemisphere, this hitherto mysterious remoteness will, in all probability, be soon determined. Professor HENDERSON of Edinburgh, to whose rare sagacity and exactness Astronomy can acknowledge many obligations, has lately given us reason to suspect that the parallax* of α Centauri is about one second,—a result, which nice and continued observation at the Cape of Good Hope

* The word *parallax* may be easily understood. Suppose A B, the diameter of the earth's orbit, and C a star, the appar-



ent size of the orbit at the star, or the quantity by which the two lines C A and C B *open*, is termed the parallax of the star C. It will be easily seen, that the nearer a star is, the greater will this opening or parallax be,—that at C′, for instance, is manifestly greater than that at C ; so that from the parallax the distance of the star may be discovered. It was thought until now, that the stars had no parallax,—*i. e.* that from their remoteness, the earth's orbit would appear a mere point ; but we are at last entering on the course of specific determinations.

appears to confirm: and the illustrations BESSEL has shown, that the same element for 61 Cygni, —a double star in the Swan, is about one-third of a second. The orbitual motions of the two stars constituting α Centauri not being fully ascertained, we cannot yet speculate on *their* masses: but in the case of 61 Cygni, while Bessel's determination proves them to be 657,700 farther from the earth than we from the Sun,—a distance, which Light, with its almost magical velocity, would consume more than ten years in tracing,— it is also probable, that the one star revolves around the other in 540 years, that the diameter of its orbit is nearly three times greater than that of our Uranus, and hence, that *the two stars taken together* are not *equal in mass to the half of our Sun*. Here, then, is indisputable proof that the bodies which spangle the upper vault, differ as much in size as in other attributes: but, however striking the speculations which this variety might induce, we are involuntarily arrested by the discovery itself—that highest triumph of astronomical instruments, and for which all arts may be said to have hitherto toiled. Surely that Essence—that Power, which, at whatever labour, can traverse spaces so enormous, and, by aids of its own creating,

pass through intervals before which imagination is appalled—ascertaining what lies at their extremity, weighing the worlds which roll there in a balance, and gathering from them new views of the character of things,—surely that Essence, though often weak and frail, though subject to the destiny of birth and the sad throes of departure, cannot yet be other than a great and everliving Potentate—one of the most wondrous of those ACTIVITIES which throng the Universe.*

3. I have lingered not unwillingly among these interesting fields; but the space already occupied warns me that it is fitting to close. One other point, however, connected with these pairs of suns, is so singular, that I anticipate my reader's pardon though I detain him a moment longer,—I allude to their *colour*. It has long been observed that the stars shine with different colours; for the diversity is apparent to the naked eye. Among those of the first magnitude for instance, Sirius, Vega, Altair, Spica, are white; Aldebaran, Arcturus, Betelgueux, red; Capella and Procyon, yellow. In lesser stars the difference is not so

* See Note A. at the end of the volume.

perceptible to the eye, but the telescope exhibits it with equal distinctness. It is likewise far more striking in countries where the atmosphere is less humid and hazy than ours: in Syria, for instance, one star shines like an emerald, another as a ruby, and the whole Heavens sparkle as with various gems.* Now, this attribute of variety of colour distinguishes also the double stars, which, indeed, was to be expected; but the *association* of these colours presents a new and remarkable phenomenon. STRUVE records that, in at least 104 binary systems, the two stars exhibit the *complementary* colours, that is, the colour of one constituent belongs to the *red* or least refrangible end of the spectrum, while that of the other belongs to the *violet* or most refrangible extremity,—as if the entire spectrum had been divided into two parts and distributed between the two companions.†

* There is no doubt that, in the course of long periods of time, stars change their colours. Sirius was celebrated by the ancients as a red star, now it is brilliantly white; and other changes have occurred of a like nature. It is not my purpose now to speculate regarding the causes of these variations. They are indicative of a set of laws, to which, in another volume, I shall have occasion more distinctly to allude.

† May this distribution not be used as another argument in behalf of the physical connexion of the stars? Does it not darkly intimate a common origin? See Part Second of this volume.

It has been supposed that this phenomenon is the mere effect of contrast, or of an optical delusion depending upon the well-known law, that when the eye has looked for a time on one bright light, it is inclined to clothe any smaller light near it with the opposite or complementary colour, for the sake of relief. The explanation is plausible, but it will not stand *testing*. In the first place, the law, if true, ought to be universal: whereas we find many systems similar in relative magnitudes to those wherein the contrast appears, in which *both* stars are yellow, or, although of other colours, still both belonging to the *red* end of the spectrum. Secondly, if the *blue* or *violet* colour came from contrast, it ought to disappear when the *yellow* star is concealed. Now, Struve refers to the three stars composing 0^2 Cygni. The larger is of the fourth magnitude and very *yellow*, while the others, which are of the fifth and sixth magnitude, are *blue;* and *though the first be hid, these two preserve their blue colour*. The double star β Cygni affords also an emphatic confirmation of the truth: indeed, I cannot see those stars blazing, one with its yellow, the other with its blue light, and encourage the optical hypothesis for one moment. The constituents of β Cygni are considerably

apart, and may be divided by an ordinary telescope. By means of a thin slip of darkened brass or copper, hide the one star, and note the colour of the other. If the yellow star be hid, its companion loses nothing of its peculiar splendour; and if one observes only the blue star, the other radiates precisely as before. Whatever the origin then, of this mysterious power, on the part of such binary stars, *to divide the light*, or however it may be connected with the process which brought these systems into being,—no shadow of doubt of its *reality* remains. And think of the novelties, the peculiarities, which the existence of double and parti-coloured suns must cause to the planets encircling them! "It may easier be suggested in words," says Sir John Herschel, "than conceived in imagination, what a variety of illumination two stars—a red and a green, or a yellow and blue one, must afford a planet circulating around either; and what cheering contrasts and grateful vicissitudes, a red and a green day, for instance, alternating with a white one and with darkness, must arise from the presence or absence of one or other, or both, from the horizon!" All the products of the material constitution of this earth, the character of its living families, perhaps the action of

its magnetic and other influences, are coördinated and adjusted to the regular succession of night and day, or to the supply and nature of our solar light. No such families, then, none bearing other than remote analogies to ours, can exist in planets engirdling such double suns. They, too, are surely the abodes of beauty and harmony, but their features are hidden from man—perhaps for ever. And who, after all, would grieve although there be some enclosed spots—quietudes, in Creation, which will be unexplored, unpenetrated for ever; who that has felt the soft healing of Evening, can regret that, even in the intellectual world, there are regions into which faintness and weariness may sometimes flee, and take shelter and repose, away from the scorch and glare of oppressive light! Sweet and inviting mysteries—among whose gentle shadows Hope and Fear, and all unnamed yearnings, tremblingly advance, and find or fashion for themselves images of purity, convictions of immortality, vistas of a Life to come, through which the soul may wander freer and greater than now, "having gained the privilege by virtue!"

CHAPTER V.

TRIPLE AND MORE INTRICATE COMBINATIONS—LARGER GROUPS—CONJECTURES RESPECTING THE FIRMAMENTAL CLUSTERS.

II.

ENCOURAGED by the signal success which has attended our investigation of the binary arrangements, we advance cautiously, but without dread, to take cognizance of higher schemes.—The arguments which induced Herschel to pronounce on the connexion and motion of the constituents of the simpler systems, penetrate much farther, and intimate as a general law, *that every apparent cluster or unusual aggregation of orbs must be systematic, and probably united by peculiar relations.* If it is unlikely that the principle of random scattering would produce numbers of close PAIRS, it is still more unlikely that TRIPLE OR QUADRUPLE BODIES should originate in fortuitous optical positions: and, as a

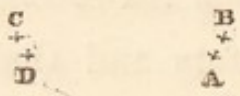
great principle has started into view, belonging probably to matter as a primal quality, its energy ought to be traceable through all these arrangements,—viz., in the existence of *systems of revolution*, of varying complexity, and often of surpassing grandeur.—Let me continue to detail what is known by rising through the simpler orders.

1. The occurrence of triple stars or of approximate conjunctions of *three*, is much rarer than that of *pairs*; but there are sufficient numbers of these to justify a profound interest. Struve has specified 11 sets of bright triple stars, that is of conjunctions of three bodies, within the space of 32″, and none of which is too small to be seen with an ordinary telescope (none being smaller than *his* 8th magnitude); and, of these *eleven*, the calculation of probabilities will not permit us to suppose that more than *one* system owes its character to mere optical proximity. Systems of three suns, probably connected by the physical law of attraction, and therefore revolving, perhaps, round their common centre, are thus at once brought upon the scene. In another list our astronomer records 57 more within the same distance of each other, but in which one attendant belongs to the class of smaller

magnitudes,—a list containing likewise, without doubt, many physical systems: and in a third series of 59 similar combinations, not confined, however, within the limits of 32″ of distance, he exhausts our present knowledge of the subject. —The nature of the connexion of the constituents of these ternary clusters has been already discerned; and they too are obedient to the law which regulates our small system, and all the motions of the double stars. The double star ζ Cancri, which performs its binary revolution in a retrograde direction in 57 years, is accompanied by a small companion in which motion has been seen; and which, if, as is unlikely, it continue to perform its whole path with its present velocity, would accomplish a grand orbitual motion in about 600 years. Nor is ζ Cancri the only combination whose phenomena have realized our most sanguine expectations. In the three stars of ξ Libræ, the two nearer have performed half a revolution in 54 years, intimating 104 as their probable period; and the third has in that time moved in *the opposite direction*, only about the twenty-fifth part of an entire circle. Motion has been suspected also in the triple star ψ Cassiopeiæ, but due confirmation is here wanted. We can, however, as

before, deduce from the *common proper motion* of several double stars and their companions, the necessary systematic connexion of various groups not yet observed to change. For instance Castor, and the small star near it, must be a triple system; whilst 36 Ophiuchi, (a double star of short period,) and 30 Scorpii on the one hand, and Mizar (also double) along with Alcor, on the other, constitute related schemes upon the grandest scale. Is it wonderful, with these prospects in the distance, that multitudes of enthusiasts are crowding into the service of Astronomy, and peers and princes vieing for honourable notice in the science, by acts of costly patronage?

2. Passing from triple to yet higher combinations, we find everything to hope. Near the brilliant star α Lyræ, a good eye discerns a star of a somewhat irregular or elongated form. When viewed through a telescope, this irregularity is explained, for the star separates into two ε and 5 Lyræ, distant 219″ from each other, which also, by the test of their common proper motion, we know are physically connected. Now each of these two stars is itself double, constituting a scheme like this.



—a quadruple scheme, in which A will revolve around B, C around D, and perhaps both double systems, nicely balanced and harmonized around some intervening point. It has been surmised, from some changes in this curious system, that in one of these double sets, the period of revolution is about 2000 years, and that of the other somewhat less than 1000: if these numbers are even approximately accurate, and if, as is almost certain, there is a movement of the two sets around a common centre, the period of that stupendous motion cannot occupy a shorter period of time than one million of our years!—Among Struve's first list of eleven physical triple stars, we find θ' Orionis—a star which, fully examined, turns out sextuple, or composed of six constituents so closely placed, that this distinguished astronomer declares them, without scruple, to be all conjoined by the force of attraction. This star is the celebrated trapezium in the nebula of Orion, and it seems that motion has been observed in it. Until Struve obtained the Dorpat telescope, only four stars had been seen in this beautiful cluster; but he had

hardly examined it until he discovered the fifth. He lost no time in communicating the discovery to Sir John Herschel, who confirmed it with his twenty-feet reflector; stating besides, that, if the star had been previously visible, he could not have missed it on occasion of his sketching with great care that outline of the Nebula, to which I will soon have occasion to refer. Similar motions have been suspected elsewhere. Does the lost Pleiad for instance—the sorrowing Merope—refer, after the fashion of that beautiful mythology, to a like phenomenon, the retirement of a star formerly visible? Allusion to the Pleiades, enables us to rise to the conception of still grander collocations. The stars of this fine cluster, represented from Harding's Atlas in Fig. 1. Plate VIII., must be connected and bound together by mutual relations. It contains 1 star of the fourth magnitude, 6 stars of the fifth, 5 of the sixth, and 32 of the seventh —in all 44 stars within a circular space of the radius of one degree; and the probability of their merely optical connexion is measured by the almost evanescent fraction $\frac{1}{4409 \times 10^{50}}$!—Nor are the Pleiades singular; for the celestial sphere contains many such groups, to which the same reasoning applies. Figs. 2 and 3 represent a group in

Lyra, and in Taurus, amidst whose individuals there is doubtless unison and deep sympathy—each holding by all the others for its fates. Striking as these are, however, they give only a faint notion of that gorgeous mass in the sword-handle of Perseus, which I have described Herschel as exploring; a group whose glory dazzles the eye, and whose internal mechanism, although reason can ascertain its existence, imagination altogether fails to conceive. Thinking of such marvels, and of their profound and wondrous harmonies, one's satisfaction is almost damped by reflection on the time and labour still necessary to unfold their intimate nature. When referring to the field they open—to the little hitherto accomplished, compared with what remains to be done—to the deep mystery still hanging over almost all the skies—there is apt to supervene a despondency, a hopelessness that the handwriting which is on them, will ever be interpreted. But we take encouragement from the aspects of the times. Astronomy is not now in that stage of its history in which only a few men in a century would consent to wear out a long and healthful age in examining the Heavens. Observers of the first capacity and becoming ardour, are yearly multiplying; while

adequate instruments, through the advance of Art, grow more accessible. Doubtless, with all advantages, we, of this time, may do little more than roughly chart the boundary lines, and, it may be, fix down the prominent points of the landscape; —the filling up and mapping of the details constitute the harvest of the future. But how soon may that future come! The wheels of time are revolving rapidly—truth mingling with truth, as light gathered into a focus. Alike within and around us, events succeed without the usual interval, nor is astronomy unaffected by the general acceleration. The knowledge of what the Heavens are boding may not be long deferring. If we, in present times, industriously act our part, much still unintelligible will become plain to the generation whose buds at this moment are the spring tidings of the world—the generation now pressing on us, and to which we must yield the stage.

III.

Advancing still farther, and viewing our cluster or firmament as a whole, systems and motions, in one case certain and in others more than probable, and of an extent altogether stupendous, immediately meet our eye. Referring back to the

Figure 1. Plate III., we discern that this firmament consists of two main portions, viz. the *central mass* and the *Ring*, or Milky Way, in a state of sufficient isolation to force the idea on our minds—that they may enjoy peculiar internal connexions or constitutions. Let us recount what facts are already known, regarding a contemplation so extensive; and when clear knowledge leaves us, let us trust somewhat to the guidance of analogies.

1. Directing attention, in the first place, to the central mass of our firmament, within which our sun undoubtedly lies, we find it placed beyond question, by the comparison of many catalogues, that great numbers of its stars enjoy proper motions, real or apparent,—indeed it is now rather daring to speak of any of these bodies absolutely as a *fixed* star. Their motions I have said are *real* or *apparent*. They will be apparent only, if the seeming change of place is caused by motions of our sun—if, for instance, he and his planets are sweeping through space towards some point or centre; and the attempt to discover whether this is the cause of such motions, is not arduous. If they are due to the sun's change of place, it is clear that they ought to be *harmonious*, or to agree with the supposed

direction of his grand path. But as these motions are exceedingly small—almost evanescent,—not only was the lapse of years required to establish their true character, but a lapse of years since the creation of our best astronomical instruments. The investigation is one, therefore, essentially for modern times; and it is no wonder that only now it has assumed a definite form. So soon as the problem seemed possible, Sir William Herschel, indeed, ventured some general speculations concerning it, which, like almost all his wide and daring views, have, to the very letter, been confirmed. At the close of much critical examination, and the sifting of some discordant opinions, M. ARGELANDER—one of those many astronomers on the Continent who unite fine powers of generalizing with patience and exactness in observing—seems to have settled the question that the *sun is moving in some grand path towards a point in the constellation Hercules.* The discovery of the laws of this motion—of the nature of his path and the amount of his velocity—is necessarily reserved for after times: but the main fact cannot now be doubted, and surely—looking on it even by itself, it is fraught with materials for singular reflection. How varied, for instance, and momentous may be the effects of

this motion even upon us—within our small world: for in this exquisitely related Universe, where the great and the small are interlaced and form one whole, even such boundless and immeasurable phenomena may not pass, without affecting and assisting through their allotted destinies the small planets encircling our sun. The recent conjecture of a Continental analyst is not to be summarily rejected or overlooked in a philosophical induction —that a degree of those changes of temperature which the earth has undergone since life appeared in it—and because of which our northern climes were one day capable of harbouring the palms and gigantic ferns of the tropics—may have supervened in consequence of our gradual translation into chiller regions of space.—But tho' this motion of translation is clearly brought out by many phenomena, it is yet not sufficient to explain all ascertained changes. Many of the stars have also well-established motions of their own—proving that they too partake of that scheme of external revolutions by which the Sun is affected—and indicating, with the highest probability, the prevalence of an arrangement and coördination of this description, and of inconceivable vastness, through the whole central mass of our firmament. This fact brings us

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into immediate and definite contact, with magnitudes and durations beside whose magnificence the grandest schemes of the double stars dwindle into nothingness, seeming liker to the evanescent quantities of earth. Some, with the ingenious Lambert, have deemed it possible that these motions indicate revolution around a mighty central body, which probably is opaque, but which guides all the mechanism—as our planets' orbits are guided by the Sun: but it is more likely that the *orbs balance each other*, and that their various paths encircle the common centre of gravity of the whole, which, observation shows, lies in the plane of the Milky Way.

2. Turning now to the Milky Way itself, let us seek in its aspects for some clue to its probable constitution. It is proved, even by a rapid survey of this brilliant belt, that *it is by no means a uniform zone*, but rather a succession of bright spots, generally separated from each other by a comparatively dark line or space, manifesting *a succession of clusters* easily detected by the naked eye. These groups are for the most part of a spherical form, and are in many cases almost isolated. Nor is the peculiarity confined to the Northern Hemisphere. Plate IX.

is an eye-sketch of part of this zone by Mr Dunlop, showing its aspects in the Southern Hemisphere; which are precisely corresponding with the appearance of its northern regions. It is not improbable that the Magellanic clouds in the south, chiefly differ from these groups in that they stand alone; while the others form a successive bed or stratum through the Heavens. And surely it requires no great stretch of fancy to extend the truths we have detected among the smaller masses, also to these vast and immeasurable collocations, to view each of those mighty groups as a great and compact system, upheld by the great power of gravity, and wherein harmony is preserved by their appointed, though inconceivable motions! "How much," says Sir John Herschel, in the enthusiastic confidence that even the immensity of such changes is not beyond reach of our faculties, "how much is escaping us! How unworthy is it in them who call themselves philosophers, to let these great phenomena of nature—these slow but majestic manifestations of the power and the glory of God—glide by unnoticed, and drop out of memory beyond reach of recovery, because we will not take the pains to note them in their unobtrusive and furtive passage, because we see them in their every-

day dress, and mark no sudden change, and conclude that all is dead, because we will not look for signs of life; and that all is uninteresting because we are not impressed and dazzled." "To say indeed," he adds, "that every individual star in the Milky Way, to the amount of eight or ten millions, is to have its place determined, and its motion watched, would be extravagant; but at least let samples be taken—at least let monographs of parts be made with powerful telescopes and refined instruments—that we may know what is going on in that abyss of stars, where at present imagination wanders without a guide!"

IV.

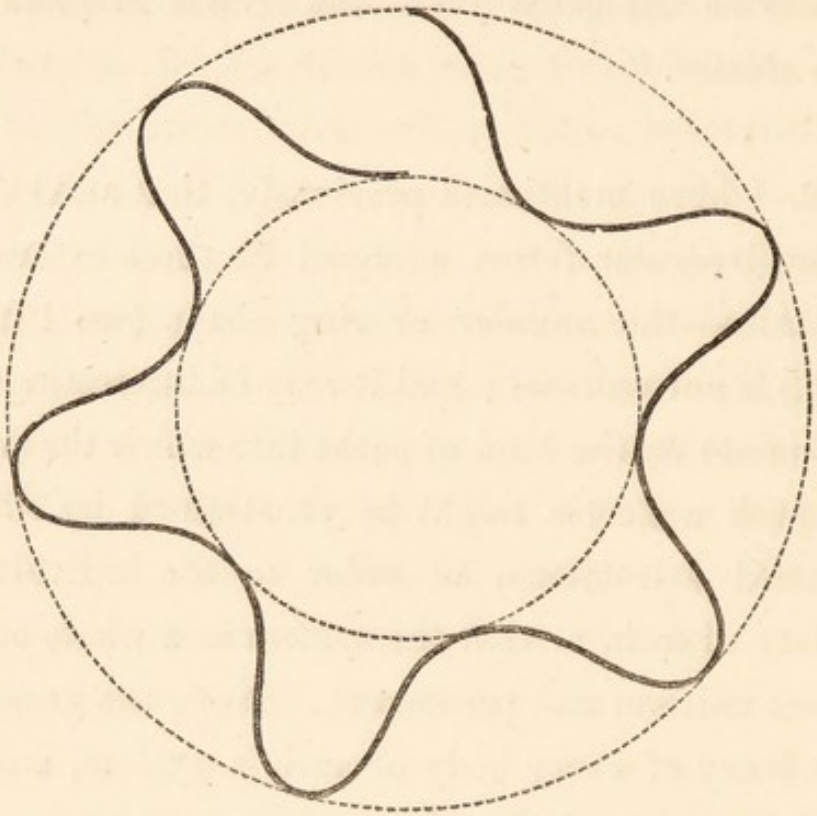
If these previous conceptions, bold tho' they are, be held as not wholly unfounded, the imagination far from stopping with them, will pass immediately the bonds of this Firmament which so long was our Universe, and examine, under the influence of the same ideas, those distant clusters which it finds strewn through space. And now no longer do these seem mere dazzling spots, reposing—as a spectacle—amid Infinity, but schemes through which the life that animates our own homes, flows in warm and full tide; where the orbs may

be related to each other by the very sympathy that rules the phenomena of our double stars—a sympathy also expressed by vast revolutions. What can be the nature of such motions—what their course? Doubtless, as well as among the arrangements of our small world, there are there too all the elements of strength, security amid complexity, and fine adjustments and compensations; and the thought of these does stir us with the hope of wonderful revelations to come—of brilliant records for the future pages of science. Even now, two conjectures may be allowed us.

1. Taking at first the simplest case—that of a regular globular or oval cluster, it were not difficult to imagine one mode by which it might be endowed with an absolute stability. We have indeed only to suppose, that every sun within it describes an oval or ellipsis around the general centre of attraction and *all in the same time*. In whatever direction the bodies might move, whether direct or retrograde, in the same plane or across each others' orbits, such a cluster would be permanent; and during all time its orbs would thus revolve, arriving together, after some vast interval, at the exact position from which they departed—which interval

would be the great year—the *Annus Magnus* of the cluster.

2. I have mentioned previously, that amid the more irregular forms assumed by these external galaxies—the annular or ring shape (see Plate VI.) is not unusual; and it may be interesting to speculate on the kind of paths into which the orbs of such a cluster might be constrained by their mutual attractions, in order to the individual safety of each, or that the system as a whole continue uniform and permanent. Now, the general tendency of every body of such a system, must, as in the case of the planets in our own scheme, be to pass towards the seat of prevailing attraction; and this, in the case of the annulus, is not a point, but a *line*—the line, viz., passing round through the interior of the ring, midway between its inner and outer boundaries. Wherever a body is placed then, in such a system, and in whatever direction it is moving, it will always be incited by a tendency to approach that line; and of the singular motions thence resulting, an idea will probably be obtained from the following diagram:—



Suppose a star at the inner part of the ring, (which is meant to be represented by the interval between the dotted circles,) to be endowed with a motion of its own, tending to carry it through space in some direction towards the left. Let us suppose, also, that it starts from some point in the circumference of the interior boundary, and observe its singular course! First, its tendency towards the seat of prevailing attraction, must carry it towards that seat, or through the mass of stars towards the middle line; but it will not stop there, as, by the time it has reached it,

it must have acquired a velocity that will carry it beyond it, and in obedience to which it will move until the force of the attraction, now dragging it backwards, shall extinguish that velocity and bring it to rest. This will not take place until it has reached the outer boundary ; and, still obeying the central force, it must thence start anew, and wend its course backwards to its first position. The motion of the body, then, must be an oscillating one, carrying it, like the pendulum, now to one side and now to the other of the point towards which it is drawn ; and if this oscillation be combined with the onward motion we have supposed proper to the star itself, no other fate can belong to it, than that it move in the path marked by the waving line in the diagram, and unwind its destiny through such strange and unending evolutions !

—But let us cease from minuter conjectures. Rising to the highest elevation—conceiving the entire stellar creation spread out, as on a mighty plain, may there not be seen—even as they are internally harmonious—the firmaments themselves, rejoicing in common external sympathies, and in majestic concert sweeping through profound abysses ?

CHAPTER VI.

THE NEBULÆ.

The reader who has accompanied me thus far, will not deem it unnatural or over-rash that I now suggest inquiries of another sort. Pondering on the strange outline which those stellar arrangements present in space, one is almost compelled to ask whether all this is *permanent*—whether phenomena so curious are the representation not only of all that is, but also of all that has been and will be, or if they have not likewise profound relations to *Time*,—being rather, as they now appear, results of a former condition and germinant of something future? These questions warn me, that again we break new ground, and enter on speculations, perhaps the most adventurous which have yet engaged the reason of Man.

Astronomy has recently been obliged to recognise a Matter—or rather a modification of Matter,

wholly distinct from stars—a thin and filmy substance diffused through the stellar intervals, and spreading over regions so immense, that its magnitude, or the space it fills, is absolutely inconceivable. It unquestionably becomes us not to admit an element so remarkable, and which, if real, must perform important functions, and materially affect our general views of things—until its claims have undergone the severest scrutiny; and I shall therefore minutely follow the process of thought, by which Sir William Herschel—only, however, at a comparatively late period in the course of his researches—was, slowly and almost reluctantly, led to the conviction of its reality.

In his earlier inquiries, Herschel was inclined to consider all the faintly-illuminated spots in the heavens, as clusters so remote, that only their general illumination, and no individual object, could be seen; and the inference, so far from being constrained, seemed to result from his whole previous experience. On viewing the heavens, for instance, with a seven-feet reflector, while many distinct clusters wholly invisible by the naked eye were revealed to him, a great number of new illuminated spots were also visible. Now, on

applying the ten-feet telescope, a proportion of these last were at once resolved into stars—others formerly of a milky hue put on the resolvable aspect; that is, they seemed like a distant handful of glittering dust: and although many retained their former irresolvable appearance, what more natural than to refer their continued intractability to their still greater distance? "When I pursued these researches," says our Astronomer, "I was in the situation of a natural philosopher, who follows the various species of animals and insects, from the height of their perfection down to the lowest ebb of life; when, arriving at the vegetable kingdom, he can scarcely point out the precise boundary where the animal ceases and the plant begins, and may even go so far as to suspect them not to be essentially different. But recollecting himself, he compares for instance one of the human species with a tree, and all doubt upon the subject vanishes before him. In the same manner, we pass, by gentle steps, from a close cluster down through others more remote, and therefore of a finer texture, without any hesitation, till we find ourselves brought to an object such as the NEBULA in ORION, when we are still inclined to remain in our once adopted idea of stars exceedingly remote,

and inconceivably crowded, as being the occasion of that remarkable occurrence. It seems, therefore, to require a more dissimilar object to bring us right again. A glance like that of the Naturalist who casts his eye from the perfect vegetable to the perfect animal, is wanting to remove the veil from the mind of Astronomers."

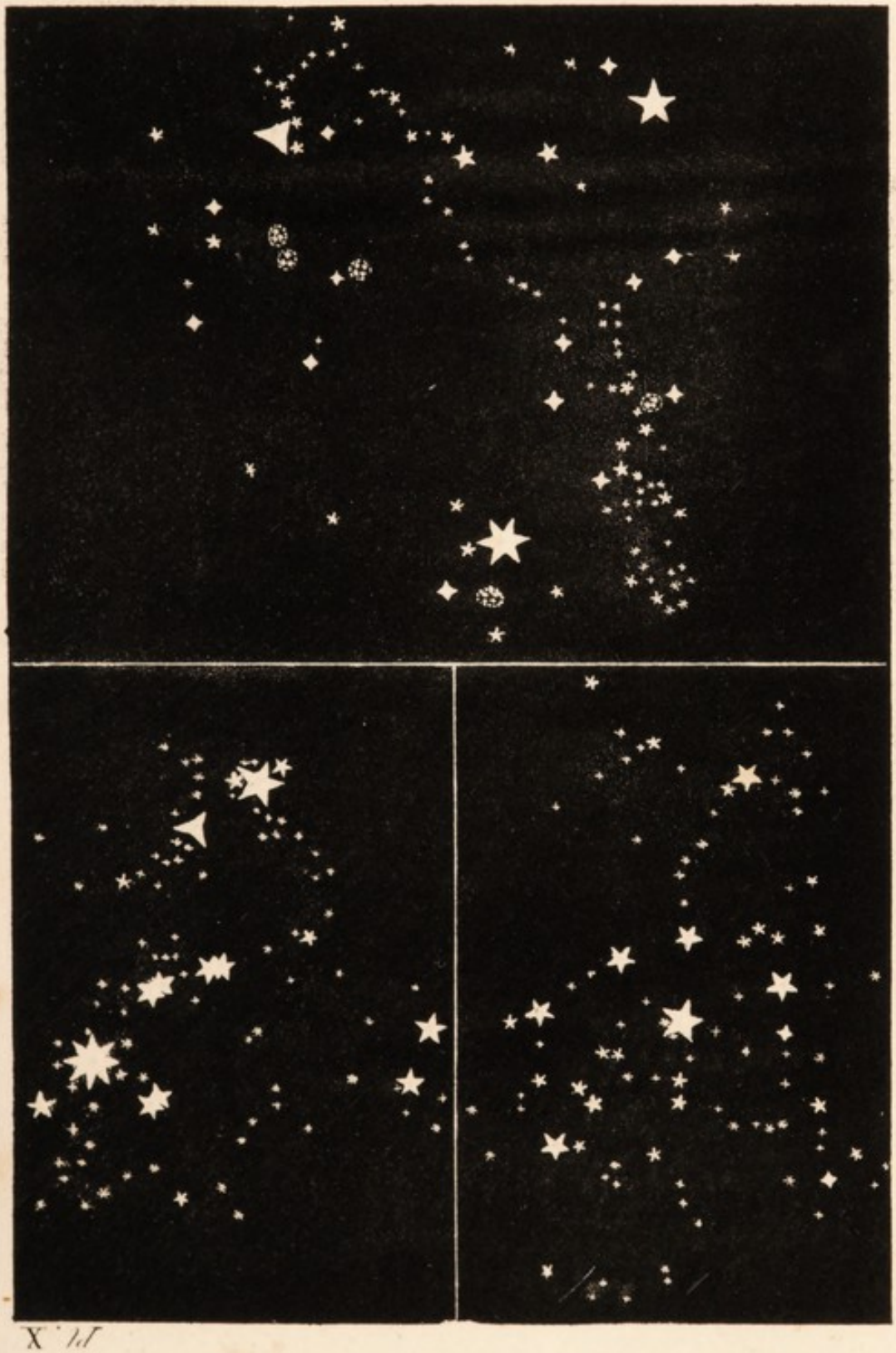
The object which broke in upon Herschel's previous continuity of inference was a *nebulous star* —a perfect star with a halo or dim atmosphere around it,—such an object as is represented in the lower line of Plate XVII. I transcribe the record of the observation, and his subsequent remarks. After noting the elements which fix the star's place, he says, "A most singular phenomenon! A star of about the eighth magnitude with a faint luminous atmosphere of a circular form, and about 3′ in diameter. The star is perfectly in the centre, and the atmosphere so diluted, faint and equal throughout, that there can be no surmise of its consisting of stars." Herschel arrived at the latter positive conclusion as follows. "In the first place," says he, "if the nebulosity consists of stars appearing nebulous because of their distance, which causes them to run into each other, what

must be the size of the central body which, at so enormous a distance, yet so far outshines all the rest? In the next place, if the central star be no bigger than common, how very small and compressed must be the other luminous points which send us only so faint a light? In the former case, the central body would far exceed what we call a star; and in the latter, the shining matter about the centre would be too small to come under that designation. Either, then, we have a central body which is not a star, or a star involved in a shining fluid of a nature wholly unknown to us." The latter alternative may, at first sight, appear the strangest and the most remote; yet it is the one to which the balance of probability manifestly inclines. And our judgment rests upon this,—the nebulous fluid, supposing it to exist, could not become known *under any other aspect or modification;* while, if stars of enormous comparative dimensions, were scattered through space, the likelihood is, that some one such body would be sufficiently near *to permit us to recognise it under less ambiguous characters.*

Many other appearances — admitting of no plausible solution on the supposition that all those

dim lights are sent from remote and accumulated stars—sustain the inferences just deduced, and thus greatly augment their probability. The wonderful Nebula in Orion, is in this respect a most instructive phenomenon. On directing the unaided eye to the middle part of the sword in that beautiful constellation, the spectator fancies, on the first impulse, that he sees a small star; but closer observation shows him that it is something indefinite—hazy—having none of the distinctness of the minute stars. When he looks at the spot through a small telescope, these suspicions are confirmed; and as the power of the telescope is increased, the more diffuse and strange the object appears. Its form, as revealed by a twenty-feet reflector, is shown in Plate X.; but its low situation in our latitudes, conceals many remarkable radiating branches which are seen in the southern hemisphere.* Now, observe two facts;—the Nebula is *visible to the naked eye*, and distinctly visible

* These winding branches were exhibited in the chart shown by Sir John Herschel to the British Association at Newcastle. My friend Professor Lamont, Astronomer Royal at Munich, has also seen a considerable number more than the foregoing plate represents. I prefer retaining it, however, in the meantime, because it exhibits the Nebula as it appears through our best reflectors in this climate. Undoubtedly, any attainable representation can contain only a part of the features of this strange object.



Pl. X

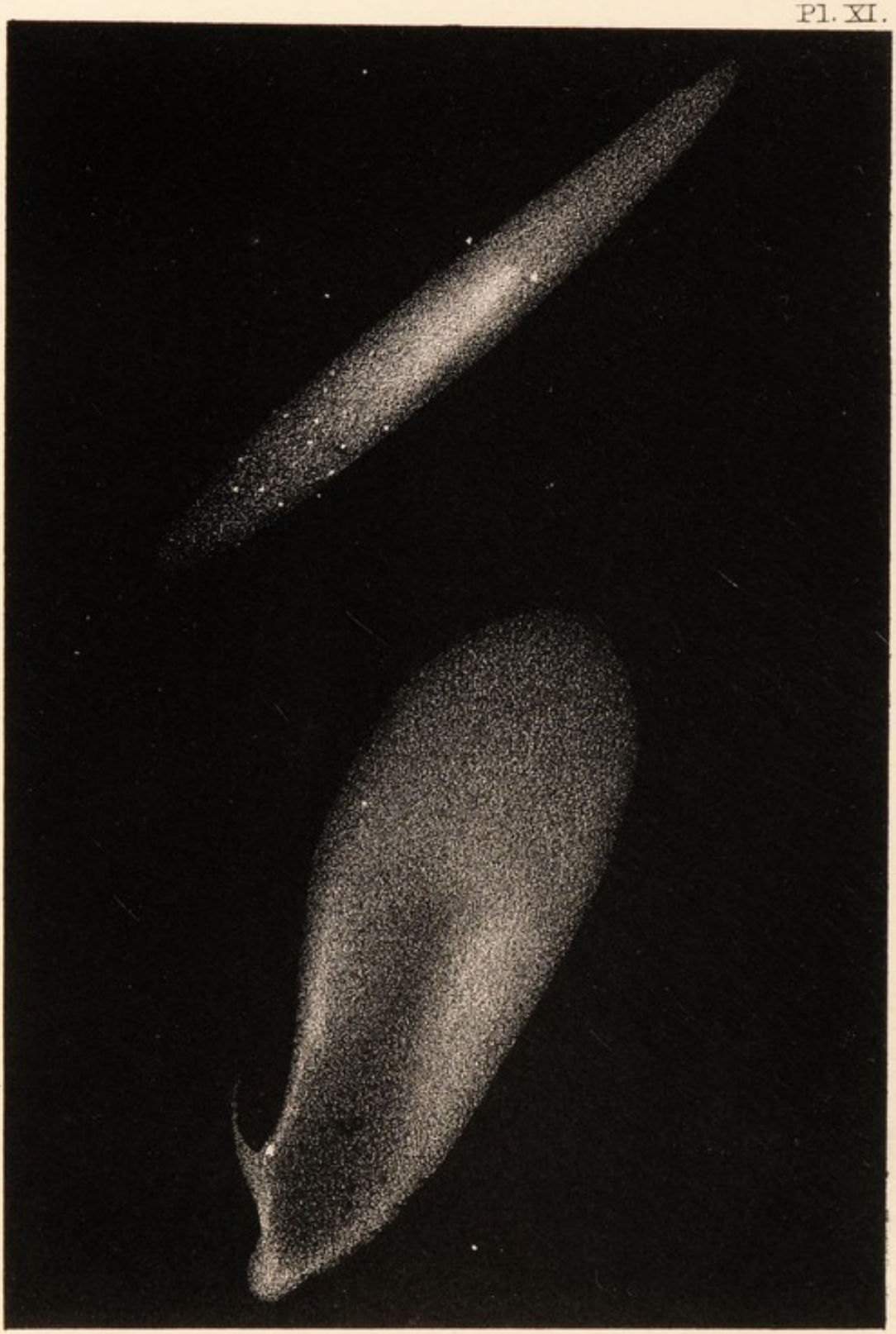
through glasses of small powers; and *the whole light and efficacy of the forty-feet telescope could not resolve it into distinct stars.* But, to be irresolvable by the largest telescope, the stars in the Nebula—supposing it a cluster—must be placed at a distance from us, which we cannot express in language; and to enable them to send us even a milky light through so vast an interval, they would require *a most improbable compression*,—improbable because unknown in degree even, in any explored portion of the universe. The hypothesis of a filmy or Nebulous fluid shining of itself, is thus again forced upon us, precisely as in the case of the Nebulous stars; and our general argument is here farther and very strikingly supported by the ascertained peculiarities of the mass. When telescopes are not sufficiently powerful to resolve a cluster, it still commonly takes on a succession of appearances, which distinctly indicate to the experienced observer—its resolvability, or stellar constitution. In the Nebula in Orion, however, no such change appears. It grows brighter in one sense, the larger the telescope, but only to become more mysterious. As we then see it, the illumination is extremely unequal and irregular. "I know not," says Sir John Herschel, "how to

describe it better, than by comparing it to a curdling liquid, or a surface strewed over with flocks of wool, or to the breaking up of a mackerel sky, when the clouds of which it consists begin to assume a cirrous appearance. It is not very unlike the mottling of the sun's disc, only—if I may so express myself—the grain is much coarser, and the intervals darker; and the flocculi instead of being generally round are drawn into little wisps. They present, however, no appearance of being composed of stars, and their aspect is altogether different from that of resolvable Nebulæ. In the latter we fancy by glimpses that we see stars, or that could we strain our sight a little more, we would see them. But the former suggests no idea of stars, but rather of something quite distinct from them."—This great Nebula seems to occupy in depth the vast interval between stars of the second or third, and others of the seventh or eighth magnitudes, and its superficial extent is probably corresponding. Its absolute size is thus utterly inconceivable; for the space filled by a Nebula of only 10′ in diameter, at the distance of a star of the eighth magnitude, would exceed the vast dimensions of our sun, at least 2,208,600,000,000,000,000 times!

Although to the interruption of our course of logical proof, I cannot refrain from adverting to some of the engrossing contemplations, which never fail to occupy me, when I gaze upon this remarkable substance. What is the intention of such a mass? Is it to abide for ever in that chaotic condition—void, formless, and diffuse in the midst of order and organization—or is it the germ of more exalted Being—the rudiments of something only yet being arranged? Then too—although these questions were answered—what is its present state? It is not enough to tell us that for such and such ultimate purposes a certain object is destined,—we would know farther the peculiarities and adaptations of its present or actual constitution? No part of creation exists merely as a *means*;—everything is besides an *end* to itself: and within that looming mass, whatever be its final destiny, there are doubtless wide and systematic relationships,—each particle of its matter will be arranged and adjusted to its neighbour; nay, who can tell, who that has looked on those monuments of bygone worlds—the fossil relics which mark the early progress of our own planet—but, this amorphous substance may bear within it, laid up in its dark bosom—the germs, the

producing powers of that LIFE, which in coming ages will bud and blossom, and effloresce, into manifold and growing forms, until it becomes fit harbourage and nourishment to every varying degree of intelligence, and every shade of moral sensibility and greatness!

Probable evidence of the foregoing nature might now be almost indefinitely accumulated. For instance, the magnificent appearance in the girdle of Andromeda affords similar conclusions. This Nebula, represented by Fig. 1, Plate XI., is distinctly visible to the naked eye, seeming like a greasy spot upon the dark blue of the firmament, or a light shining through a horn: but as with the Nebula in Orion, *no telescopic power has yet sufficed to give it the resolvable aspect.* Farther pursuit of such considerations, however, is unnecessary, inasmuch as we are in a condition to produce, what—taken in supplement—amounts to positive and direct proof at once of the reality and extensive diffusion of the Nebulous substance. I request attention to the phenomenon of COMETS.—There is much connected with the comets of which we yet know nothing; but two general and essentially characteristic facts are established, and these suf-



fice for my immediate purpose. In the first place, the phenomenon demonstrates not the *possibility* merely, but the actual *presence in Nature* of a nebulous modification of matter. The comets are nothing but *nebulosities*, small portions of a substance precisely similar in physical constitution to that which our hypothesis assumes. Even their nuclei dissolve into a fog under the inspection of the telescope. Fig. 2, Plate XI., is a sketch by Sir John Herschel, of the second comet of 1825, and through the heart of another, the same observer once descried a cluster of stars of the sixteenth magnitude. Secondly: These small nebulosities are not connected with the structure of our solar system: from which we infer that *they are connected with some system in the spaces external to our limited sphere.* There is no essential tie between us and these comets; the variety of directions from which they come, altogether distinguishes them from the bodies which roll around the sun with singular and systematic regularity; they are chance visitants, most of them perhaps never approaching us but once—for, unless in a few instances, there is little reason to believe that their eccentric paths are continuous, or that they reënter into themselves, and form a definite and bounded

curve. But shall we therefore go into the usual inference, that the comets are mere anomalies—freaks of nature? Because they have no connexion with the order of our planetary worlds, is it necessary that they should have no meaning—no place in the universe? Look around you! What is there, what existing creature—which has not such a place? Of the fine web of Being, fitness and relation are the warp and woof. Apparent anomalies are mere finger-posts, pointing where things lie of which we continue ignorant; and when such intimation is received with philosophic meekness, it invariably guides to unexpected discovery. These hazy bodies, now and then reaching our system, and leaving it without ever operating an appreciable effect, are not spectral and isolated monstra! As all things have a home in nature, they too doubtless hold relations with some grand external scheme of matter in a similar state of modification: and since, when influenced by the sun's attraction, they approach us from all quarters of the heavens, *the nebulosities in which they have their* ROOT *must lie around on* EVERY SIDE, *and be profusely scattered among the intervals of the stars.* What an error to fancy these Comets anomalies! They demonstrate *that*, which, as we

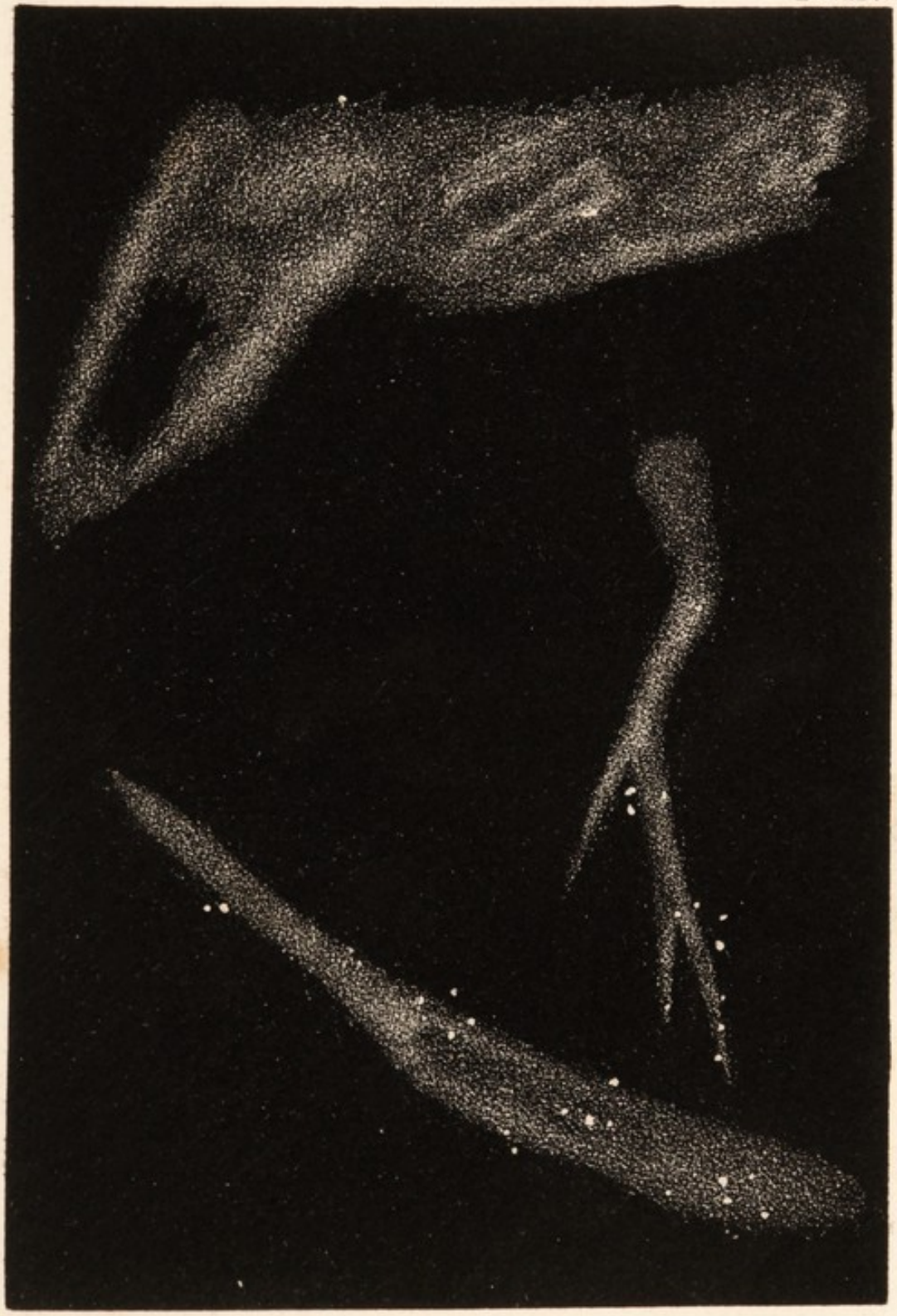
have seen, is required to make a large and varied series of phenomena explicable. They are, in fact, absolutely indispensable; for without them the conjectural disclosures of the telescope would scarcely be established. And in accomplishing this service, they have also exhibited their own position: so that we have at once two of our best intimations that knowledge is advancing—remote phenomena appearing in closest relationship, and objects and occurrences, formerly deemed insignificant, assuming a place as constituents of the compact fabric of the Universe.

We touch on the most obscure problem of Astronomy. As every atom in existence has its object, this nebulous matter, found in such abundance, must have a prominence in purport answering to its prominence in magnitude. But when we ask, *What are the Nebulæ?* we feel that we are adventuring into that dim twilight which always surrounds the sphere of positive knowledge. If we would understand them, however, or know whether they are intelligible, we must examine if they can be arranged under characteristic peculiarities of *structure*, indicative of the operation of LAW; and it was the endeavour so to arrange them which led the Astronomer, whose torch has

hitherto guided us, to conjectures, promising now more confidently than ever, to throw unwonted light upon the course of material transitions. I have, by a series of plates, illustrated this part of our subject so fully, that I am encouraged to hope my reader will easily follow the arguments we are about to entertain.

In its first or rudest state, the Nebulous matter is characterized by a *great diffusion*. The Nebula in Orion is an example of this, and Plate XII. represents a few other instances in which the milky light is spread over a large space so equably, that scarcely any *peculiarity* of constitution or arrangement can be perceived.* The perfectly chaotic modification here illustrated, is perhaps the nearest to the original state of this matter, of anything now remaining in the firmament; but the reason of its being found in separate patches, varying so much in form, manifestly appertains to remoter inquiries,—perhaps to an inaccessible period in the History of Things.

* Still more curious than any of the forms referred to in the text, is a singular mass in the Magellanic clouds, described by Sir John Herschel. It seems to consist "of a number of loops united in a kind of nuclear centre or knot, like a bunch of ribbons disposed in what is called a true lover's knot." Mr Dunlop supposed it *stellar*, which it decidedly is not.



Pl. XVI

Nichol Lithog

As we pass beyond these diffused and amorphous Nebulosities, *Structure* indicative of *Law* becomes apparent. Even the first visible symptoms are emphatic. The winding Nebulosity in Plate XIII., for instance, exhibits a congregating or condensing of the filmy matter in two distinct places, which look like bright nuclei, surrounded by a comparatively dark ring, precisely as if they had been formed by a *condensation* of the diffused matter, under control of the law whose energy has been traced through the forms of the clusters of stars. This is no anomalous appearance; for in *every case*, the seeming commencements of structure are of the same kind. Nothing is anywhere met with, like a dispersion, or indication of a dispersive power; which probably would have been seen, had any power but an aggregating or condensing one been influential over the condition of nebulosities. This aggregating power, indeed, without the interference of any other, appears to lead to the entire breaking up of amorphous masses. The number of nuclei which are found in distinct nebulæ is variable; but there is never a departure from the character due to their supposed origination in a condensing principle.* We have always

* The nebula in Orion, in its densest part, seems undergoing

a regular gradation in their intensities. The point of light grows brighter, while the vacancies or dark circles around the points are marked with more and more distinctness, until we reach a cluster of small round nebulæ perfectly detached from each other. The first figure in Plate XIV. represents an early stage of the phenomenon described; and the others in the same plate carry on the process of apparent separation in regard of two nuclei, until the masses are altogether distinct. The progress may be traced still farther. In their ultimate condition—that condition I mean in which they seem to merge into stars—we find them distinguished from a double star or cluster, only in this, that they rest on a bed of very faint light. Of course when I speak of *progress*, I shall be understood to signify progress as seen through a series of related contemporaneous objects in different and connected states—not that progress which has never been observed—the passing, viz., of one nebula from an inferior into a higher condition. But is the conclusion rash, that this latter pro-

some such change as this. One cannot discern in it anything deserving the name of *nucleus*; but one part of it does seem as if preparing for nuclear formations,—it is divided, as it were, into *lumps* or masses of denser light.

Pl. XVII.

Nichol. Lithog.

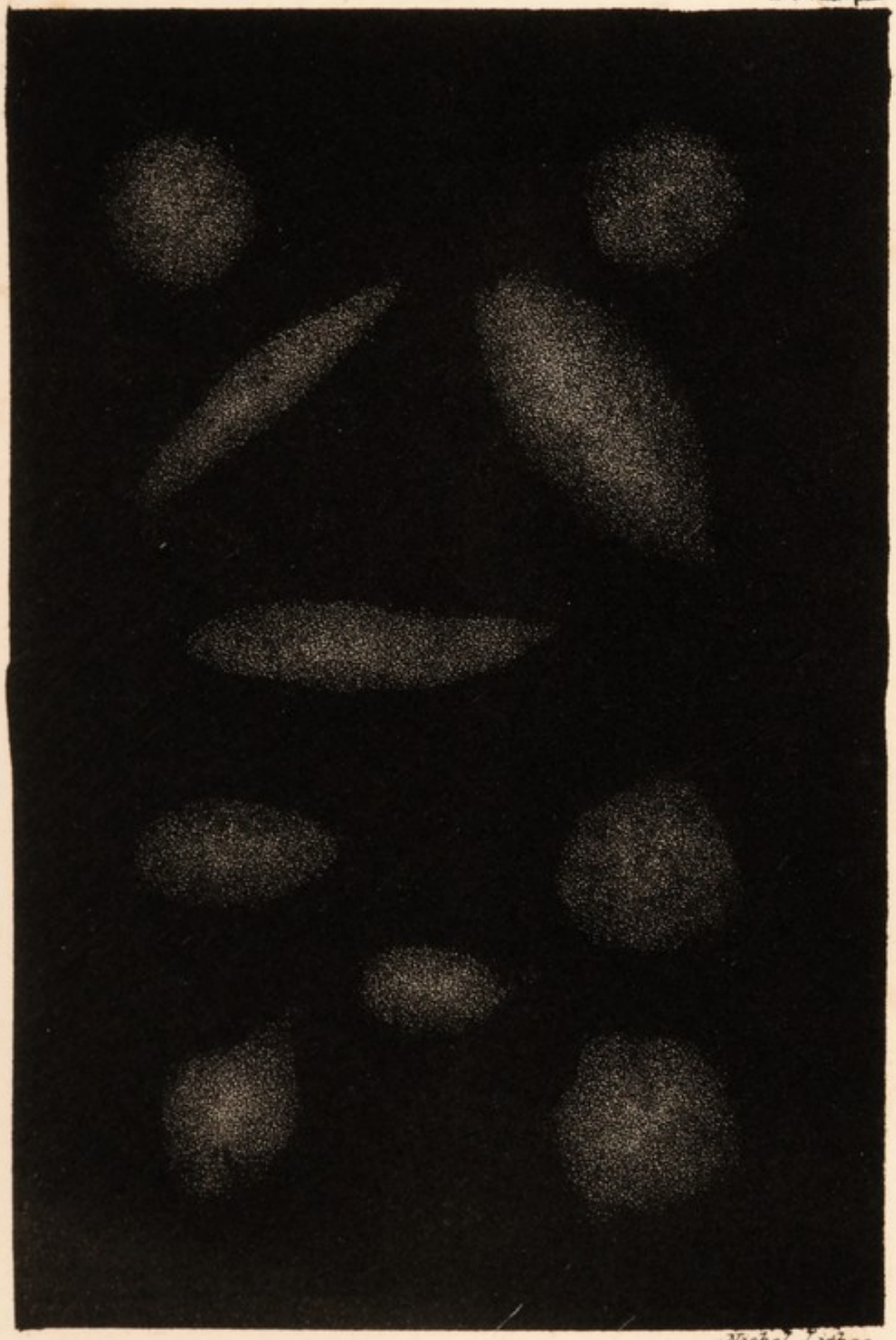
gress is possible? Is it not darkly but impressively intimated by the unbroken integrity of the series? What principle of philosophy hinders the supposition, that each of these varying bodies holds with those on both sides of it also the relations of progenitor and descendant, that the unbroken contemporaneous series is also a picture of youth, ripening, and manhood—in short, that the principle of attraction has actually brought such distinct round nebulæ as are seen clustering together, and also collections of stars imbedded near each other on a whitish light, from the bosom of masses like those looming elsewhere—still all indefinitely—among the recesses of our firmament?

The hypothesis I have started is so strange, and brings up notions so unlike our common thoughts of the stellar universe, that it cannot and ought not to be received without an almost superfluity of evidence. We turn, accordingly, to single and definite Nebulæ, which are possessed of marked structure, in search of the light which they may throw upon it. And we get nothing here but confirmation. Their shapes, and the distribution of light in the separate bodies, so entirely accord with the hypothesis of condensa-

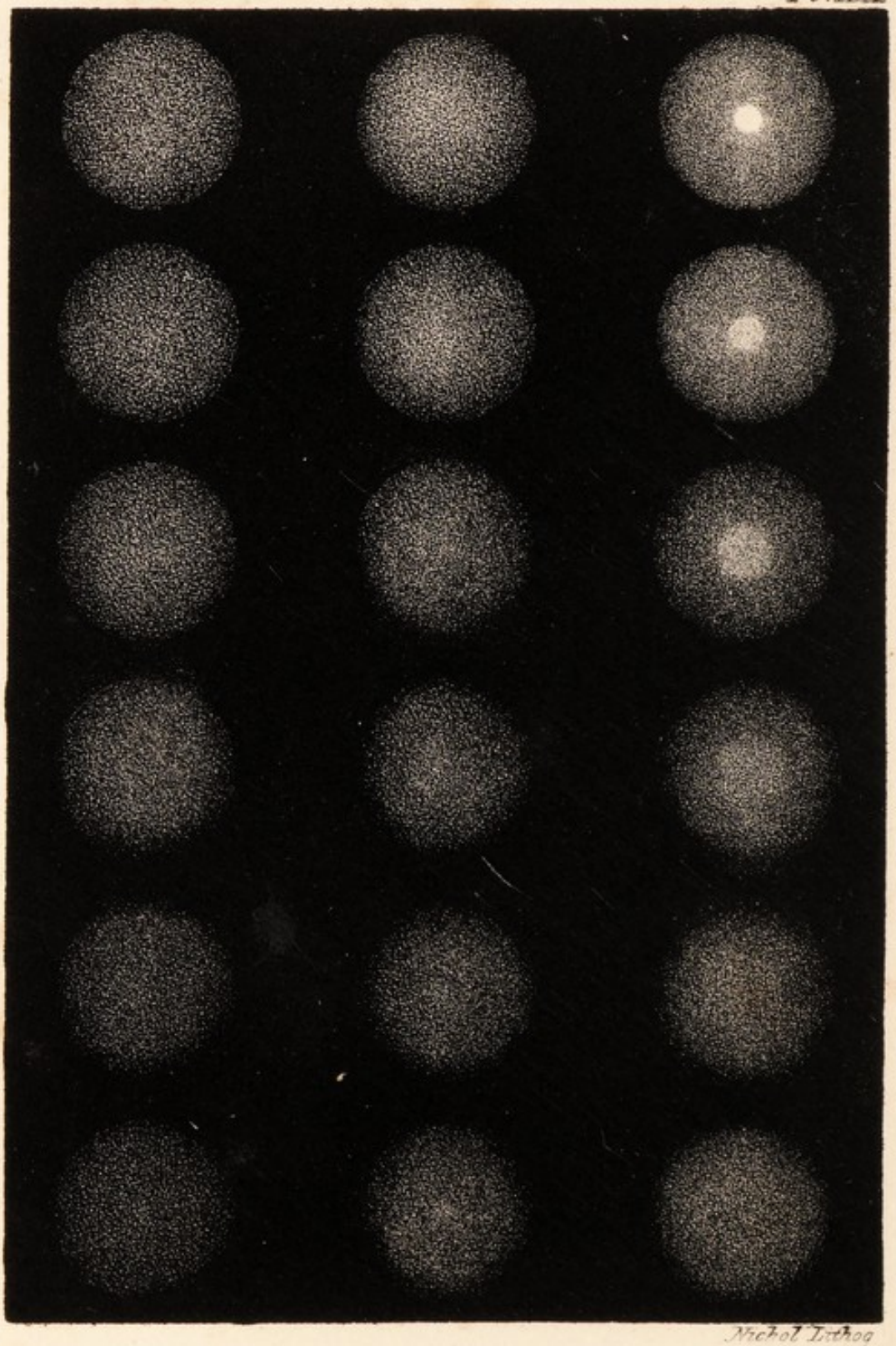
tion, that we have hardly room for evasion or escape.

Single Nebulæ characterized by structure vary considerably in form,—the usual varieties are shown in Plate XV. Some are of an oblong shape, like that in Andromeda, with marked condensation towards the centre. We know not how these flat zones originated, but even in them structure, when manifested, always indicates condensation around the apparent centre of the mass. The great proportion of distinct nebulæ, however, are *round*, or nearly so.* In Sir John Herschel's recent catalogue, the immense proportion are marked as round. Now we are bound to infer, that these round masses are *spheres;* for there is no likelihood that, if they were cones or cylinders, they would all so lie in regard of our line of sight as invariably to present their circular sections. But the sphere is the shape *naturally assumed by masses whose particles mutually attract each other:* and, on the principle that the globular shape of the raindrop is accepted as a common illustration

* It is not meant that any nebula is a perfect circle in appearance, or a perfect sphere. The edges of all are ragged, showing tails and indentations,—and this the more the better the telescope. But those spoken of are all referable to the round form as their type.



Nichol Lithog



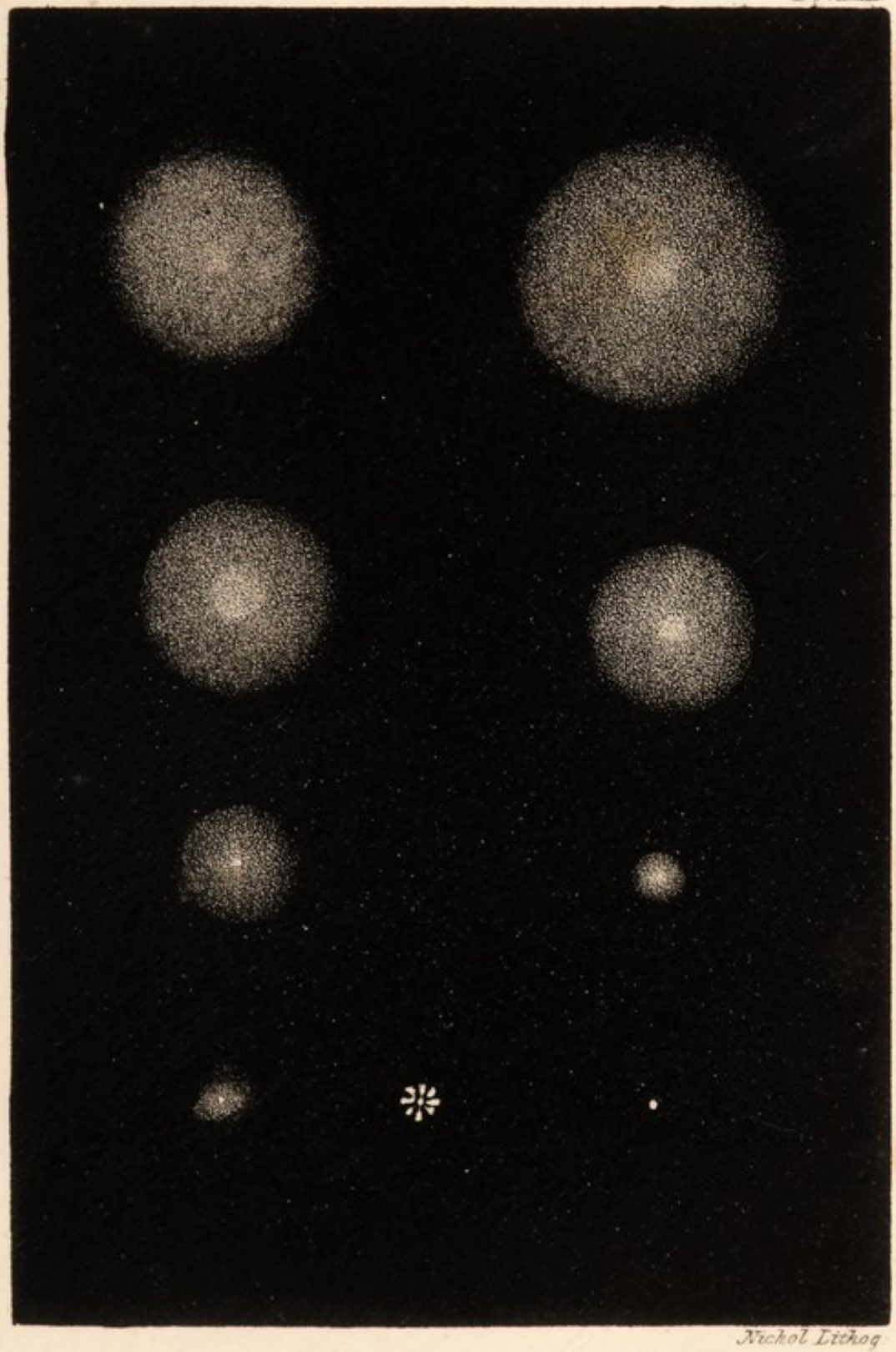
Nichol Lithog

of the all-prevalence of gravity, and the sphericity of the planets held to confirm the same important law, this tendency in the nebulæ to the round form must be received as a weighty and important argument. But it is the mode of the distribution of their LIGHT, which most confirms and settles these views. On the very first glance, this seems a phenomenon *connected with central influence ;* for not only is the illumination uniformly greatest at the centre, but if in any nebula a circle of any radius be described around the centre, the illumination will be found *of the same intensity at every point of its circumference.* By far the most remarkable and important fact, however, is that wonderful *gradation* in the intensity of the central light. Plate XVI. speaks to the eye, and is more valuable than pages of description. Each figure in that plate is the representative, not of an individual, but of an extensive class ; and surely a series so well marked—so striking in its aspects—must indicate the presence and influence of a great law ? From absolute vagueness, to distinct structure, and then on to the formation of a defined central nucleus, the nebula seems growing under our eye ! The illustration of Laplace, reproduced by Mr Airy, here forcibly occurs to me : " We look among

these objects as among the trees of a forest; their change in the duration of a glance is undiscoverable; yet we perceive that there are plants in all different stages; we see that these stages are probably related to each other in the order of time, and we are irresistibly led to the conclusion, that the vegetable world in the one case, and the sidereal world in the other, exhibit, at one instant, a succession of changes requiring time, which the life of man, or the duration of a solar system may not be sufficient to trace out in individual instances." And the progression advances until it is complete. We have objects each more perfect than the last, like those Figures in Plate XVII.; and in the end a STAR is found thoroughly organized with a mere *bur* around it!

Let us collect together and review for a moment the whole facts of this curious speculation. First, We discover a most striking series of objects partaking of the same nebulous constitution, and connected in an unbroken external chain or gradation, each object or link of which exhibits the nebulous chaos in a condition of greater regularity and higher consolidation than the preceding one; and the gradation only closes on reaching an or-

Pl. XX



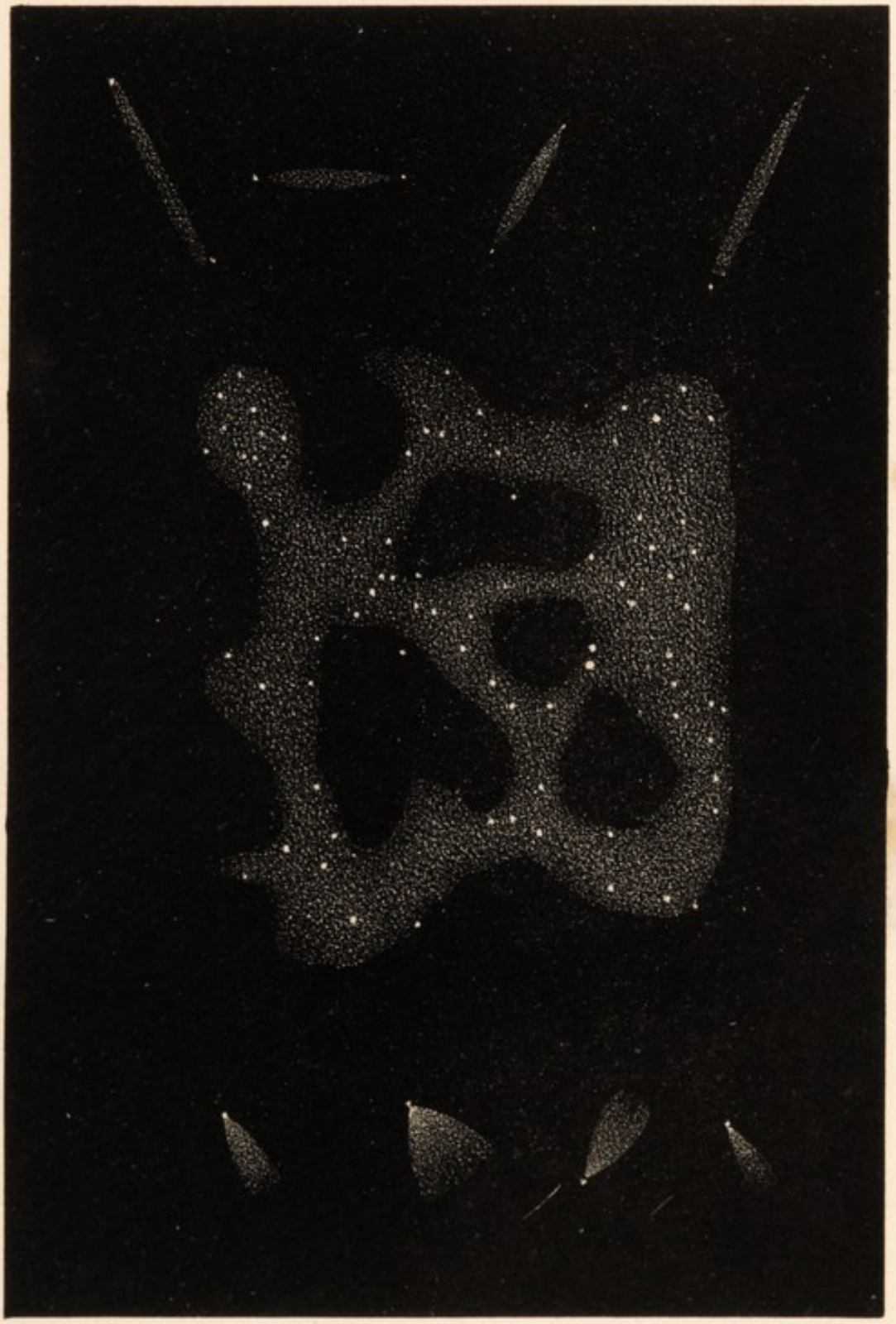
Nichol Lithog

ganized star. Secondly, We are acquainted with an influence or process operating on every side of us,—an influence the most general in Nature, capable of effecting the conversion of a Nebula of one series into a more advanced one of the next; or, to use more accurate language, the actual occurrence of such conversions would be far from unusual or strange, but rather in exact agreement with the course of that most extensive class of material events, whose laws we have hitherto recognised. It is a distinguishing mark of this hypothesis, that we institute no new power, or speculate on mere *possibilities:* that Nature is uniform—that GRAVITY which controls the planetary, and, as we have seen, also apparently all celestial spheres, acts likewise within these masses, is our boldest supposition.* And, besides, there are

* The consideration urged in the text will, if duly estimated, amply suffice to protect the Nebular Hypothesis in this the most general statement of it, from the force of an objection which I have heard very plausibly insisted on. Observe, it has been said—the Living families. Naturalists and anatomists also can lay down a *series* there, as unbroken (especially if extinct species are taken in to fill up gaps) as the Nebular aspects can possibly present; but who dares venture the inference that one species must pass into another? Now the vital difference between the two cases is this:—with regard to the living kingdom, we have not a shred of acquaintance with any law that could make one

positive indications that it does act there. The comets are under its influence, for they are attracted by our sun: their matter, therefore, is the same as planetary matter—obedient to gravity. Instances, too, are not wanting in which the original distribution of external nebulosities appears affected, or altered by the attraction of neighbouring stars. The upper and lower figures in Plate XVIII. show portions of it being drawn towards a star—as if feeding it—or stretched between two. The middle object in the same Plate is very instructive. It is a diffused nebulosity near a reticulated cluster of small stars, and its brightness

form of being—one step of that series—pass into another. Every speculation regarding *transition* therefore, must be utterly vague; and for this reason, among others, that—even allowing the fact of transition—no one can tell, in absence of any knowledge of a causative power, from which end of the scale the transition might be proceeding, whether man is receding or the plant progressing. With respect to the series of Nebulæ, on the other hand, the principle of connexion is known, and therefore the direction of transition. Assuming the operation of Gravity, which, undoubtedly, acts over schemes of matter far more extensive than any Nebula, and which we can almost prove, through the comets, to act within Nebular substances,—the possibility and course of condensation are not subject to doubt. —In a case like this, I do not know any other evidence, *in so far as the general point is concerned*, which can be obtained by Man, and which, therefore, *ought to be demanded*.



follows their line; while in the spaces where no stars are, there is almost no nebulous matter, as if it had been nearly drawn away by attraction, and accumulated in those bright ridges, or absorbed.

Strong though this presumption is, I know that the startling nature of the subject will render many incredulous. "Show us," it will be said,—"*show* us a change; show us the actual progression of one nebula from an inferior to a more organized condition. We grant the unbroken completeness of your series; we grant the law which could advance its individual constituents; but *actual change* alone is proof." Let no man, however, be deceived, or mistake the nature of the problem which is engaging us. The demand is infinitely more unreasonable, than if the inquirer into the motions of the double stars were to insist on an actual inspection of the beginning and close of the vast year of Mizar and Alcor. If that nebular hypothesis be true, all the forces developed upon the thin surface of our planet, and which have given rise to geological transitions, stretching through periods in which the existence of the human race is an invisible speck, will have resulted during a stage of condensation in a secon-

dary nebula, which no instrument from any fixed star could possibly detect. How, then, delude or disappoint ourselves by straining the eye after periods so enormous! There is a creature named the Ephemeron, whose life is confined to the veriest point of time,—in one short hour it dances out its existence in the sunbeam. That creature is in presence of all the phenomena of vegetable growth; it may see trees—it may see flowers, but how could it or its generations actually observe their progressive development? In relation to the nebulæ, Man is only an Ephemeron. Fifty lives succeeding each other, and of a length to which individuals often attain, would reach backwards beyond the recorded commencements of his race; and in the mutability of things, fifty more may constitute a line longer than his allotted epoch. And, no more than one hundred of those creatures, which are born, breathe, and die, could learn of the progress upwards of the majestic pine—will Man ever learn of the changes of the Nebulæ!

The ideas I have now presented—august and strange though they are—should not appear in contradistinction to what every moment is passing around us. Supposing these phenomena did un-

fold the long growth of worlds, where is the intrinsic difference between that growth and the progress of the humblest leaf, from its seed to its intricate and most beautiful organisation? The thought that one grand and single law of attraction operating upon diffused matter may have produced all those stars which gild the heavens, and, in fact, that the spangling material universe is, as we see it, nothing other than one phase of a mighty progress, is indeed truly surprising; but I appeal again in what essential it were different from the growth of the evanescent plant? There, too, rude matter puts on new forms, in outward shape most beauteous, and in mechanism most admirable: and there CANNOT be a more astonishing process or a mightier power even in the growth of a world! The thing which bewilders us is not any intrinsic difficulty or disparity, but a consideration springing from our own fleeting condition. We are not rendered incredulous by the *nature*, but overwhelmed by the *magnitude* of the works; our minds will not stretch out to embrace the periods of this stupendous change. But Time, as we conceive it, has nothing to do with the question—we are speaking of the operations and tracing the footsteps of ONE who is above

all time—we are speaking of the energies of that ALMIGHTY MIND, with regard to whose infinite capacity a day is as a thousand years, and the lifetime of the entire Human Race but as the moment which dies with the tick of the clock that marks it—which is heard and passes!

CHAPTER VII.

THE NEBULAR HYPOTHESIS.

Let us note the exact value of the previous speculation, on behalf of the daring Hypothesis, that all existing stellar bodies sprung by virtue of the law of attraction, from the bosom of a chaos, of which stray specimens are still found in the Heavens. In so far as this Hypothesis undertakes to EXPLAIN THE NEBULÆ, I have said that I do not conceive that much of *accessible* knowledge is now wanting to confirm it; for, the agreement of the forms of the nebular substance with the natural results of the persevering action of gravity, seems almost demonstrated. But it must not be forgotten that there is another correlative and very extensive inquiry which this truth has not touched: *The Hypothesis must also* EXPLAIN THE STARS. If it is the true Cosmogony, and we have at length approached a right theory of the forma-

tion of Things, we should indeed obtain from it a satisfactory idea of the meaning of that curious progression of structure, which so strikingly characterizes the Nebulous masses: but it is no less imperative that it exhibit with proper distinctness, how the mass of stars around us, along with their *peculiar features and arrangements*, might have been evolved in obedience to *known mechanical laws*, by the condensation of Nebulæ. To the inquiry thus suggested, I invite you rejoicingly: at every step in our pursuit of it, we shall gain new views of the unity of Things, indications of remote and unexpected relationships, and proofs the most illustrious afforded by Science, of the compactness of that Domain whose forms occupy SPACE, and the annals of whose changes constitute TIME.

I shall begin the inquiry by testing the hypothesis in reference to the SUN, whose characters we know best; and even under the risk of being felt prolix, I shall pass all these characteristics under close examination.

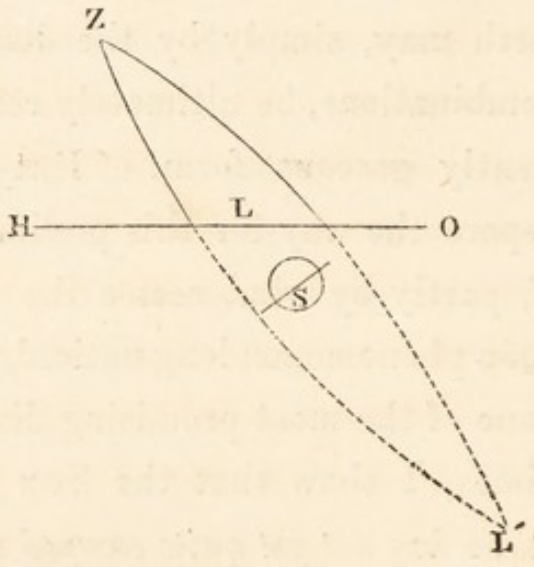
I.

It is difficult to reconcile the imagination to the idea, that an ORB like ours could have origi-

nated in a vague nebulous mass. Observation shows, however, that the *magnitude* of our luminary is no obstacle to the Hypothesis; for the statement in page 122 proves that a Nebula like that in Orion, contains matter or substance sufficient for the generation of a solid globe perhaps some millions of times as large. Neither can the difference between the *solidity* of the Sun and the *gaseous* condition of the Nebula, constitute ground for rational hesitation, inasmuch as, in the laboratory of the chemist, matter easily passes through all conditions, the solid, liquid, and gaseous, as if in a sort of phantasmagoria; and his highest discoveries even now, are pointing to the conclusion that the bodies which make up the solid portion of our Earth may, simply by the dissolution of existing combinations, be ultimately resolved into a permanently gaseous form. But it should wholly prepare the way for this preliminary conception, if, partly by what seems the true interpretation of a phenomenon long noticed, and partly by aid of one of the most promising discoveries of modern times, I show that the SUN is not yet pure, that he *has not yet quite escaped the original nebulous character* I am attributing to him, and that, notwithstanding of his effulgence, he is still

rather in the condition of a nebulous body—something like the objects in Plate XVII., where consolidation, although very far advanced, is not complete.

The first appearance referred to is the ZODIACAL LIGHT. This remarkable phenomenon consists in a long train of faint light of a conical form, left by the sun after setting, and projected on the sky. It is easily seen in tropical countries, but in ours it is visible only when in the most favourable position, and may be looked for on clear evenings in March or April. It has an appearance like that in the subjoined wood-cut, where S is the



sun, HO the horizon, and ZL the faint light. Now, the axis on which the sun rotates is, as the

Figure indicates, at *right angles to the greatest length or axis of the light;* from which simple fact, we venture to trace a connexion between that light and the axis and equator of the sun. Although we see only the upper part of it, that atmosphere is, in all probability, extended also on the sun's other side, as in the dotted part of the line; forming a regular and still uncondensed relic of some *oblong nebula*, in which our luminary probably originated. Of this at least we are certain—the Zodiacal Light is a phenomenon PRECISELY SIMILAR IN KIND TO THE NEBULOUS ATMOSPHERES OF THE DISTANT STARS; and, *these atmospheres have already been connected by a long and unbroken progression with their parent amorphous masses.* In relation to its extent, indeed, it is utterly trifling when compared with the smallest of the stellar nebulæ; for its diameter is less by millions of times than the average of these curious bodies, and if we looked from the nearest of the fixed stars we could not recognise it or guess its existence with the aid of Herschel's largest telescope: but this fact, so far from being barren or forbidding, is itself a ground of important and cheering inference. Previous even to the discovery of such a circumstance, no one could have asserted confi-

dently that the nebulous atmospheres of the stars actually terminate at the point of magnitude below which we cannot see them, or at the varying limits of their visibility to us: but we are now furnished with substantive reason to believe that the phenomenon of the illuminated bur *does* extend much farther; that vast numbers, if not the whole, of the bright and apparently pure constituents of our firmament, may still have Zodiacal Lights; and that the nebulous phenomenon, although to our imperfect vision now characterizing but comparatively few objects, may, notwithstanding of the long lapse of hither time, continue to possess a generality of which all that we see is only the faintest indication.

The other and new phenomenon—one no less remarkable in the mode of its discovery, than because of its intrinsic value—equally confirms the reality of these nebulous attributes of the Sun. The nebulous stars, as seen by our telescopes, have commonly a well marked increase of light towards the centre; or, what is the same thing, a gradual diminution, or shading off, towards their edges. Now, this Zodiacal Light is probably only the *brighter part* of the solar nebulosity, which

may extend much farther. In this further extension it may not give out sufficient light to be perceptible; and the fact is, if it includes the Earth, we could not see it, although it emitted a very considerable quantity of light. Being in the midst of it, its light evidently could not be observed as an *external* thing: it would be confounded with that faint illumination arising from the intermingling of the rays of all the stars, which somewhat brightens the dark ground of our skies; and must have remained unknown, but for another source of information.—Taking the principle of gravity into account, it is easy to see how the permanence of the orbit of each planet depends upon the perfect balance of two forces or tendencies, viz. the attractive power of the sun, and that tendency to fly from the centre, which follows from the motion of bodies being naturally in straight lines, and whose energy depends, in each case, upon the rapidity of the body's motion. If the power of either of those balanced forces be diminished, it is clear that the authority of the other will prevail. Relax Gravity, and the planet will recede from the Sun, and its orbit widen until a balance is restored. In the same manner, diminish the rapidity of the body's motion, and, as the centrifugal force will

be diminished by that act, Gravity will prevail; —so that the body's orbit will be *contracted* or *drawn in*. Now, if a nebulous fluid is diffused through the planetary spaces, every body which moves through it must experience resistance and be *retarded* as we are by the atmosphere, when riding at a rapid pace; and we would thus expect a notice of the ether's existence in the fact of the planetary orbits gradually drawing in, and the revolving bodies approaching the sun. Unhappily, however, for this only mode of observation left, the planets are too dense, too large to be of service in so delicate an inquiry. However light and thin the ether, there is no doubt that it must and will influence even *their* motions; but perhaps, by a quantity so small, that the accumulation of the perturbations arising from it during the whole period of accurate astronomy, would not render it perceptible. No trace of such influence, indeed, is yet found in our planetary tables; and astronomers would have been left in regard of the whole subject to conjectures, which, however plausible, had yet no actual or experimental *ground*, unless for a remarkable and certainly an unlooked-for occurrence. Until recently, astronomical science has not been able to present a complete and minutely accurate

view of the orbit of any comet. The general character of the orbits of these bodies, and the important elements at least of *one* of them, have been known since the time of the celebrated HALLEY; but this philosopher knew nothing further than the general elements; and no orbit was laid down with exactness sufficient for the above purpose, until ENCKE of Berlin examined with so much accuracy the conditions of a *body*—if a thing so small and vaporous merits the appellation,—which completes its eccentric course around the sun in $3\frac{1}{2}$ years.* Now, it appears by observation, that this comet *is approaching the sun*;—on every successive appearance, we find its orbit somewhat contracted; and there is reason to believe that the contraction will go on until it is either absorbed in that luminary, or altogether dissipated by his beams. And after vainly searching for some other cause, inquirers are nearly unanimous in referring this extraordinary and hitherto unparalleled change, to a RESISTING MEDIUM OR ETHER occupying the planetary spaces. "I cannot but express

* The appearance of this comet forms the frontispiece to this volume. Of all the bodies in the Heavens, it is, perhaps, the most remarkable, considering the conclusions to which it has led us.

my belief," says Professor AIRY, "that the principal part of the theory, viz. an effect exactly similar to that which a resisting medium would produce, is perfectly established by the reasoning in Encke's memoir;" and similar opinions have been offered by other great authorities. That the sun, then, has a widely diffused nebulous atmosphere—extending far beyond the limits of the Zodiacal Light, and if not beyond, at least deep into the planetary spaces—an atmosphere of which that light may merely be the densest portion, is at length rested on a high degree of probability; and how singular is it that we should have been guided to a truth so remote and difficult—one concerning which the grander phenomena of our system are silent, by the motions of a wandering object, in comparison with whose ethereal nature, even one of these light flocculi or flakes of cloud, which scarce stain the sky of a summer evening, is heavy and substantial! Even thus harmonious is the universe! And seeing the perfect continuity of that golden line of order, which unites its mightiest phenomena with its least, so that the motions of a speck of dust may illustrate causes adequate to generate worlds,—what achievement is too high to be hoped for future discovery, and

why may not a time arrive, when, in return for man's close observation, and unwearied questioning of nature, the darkest of those speculations in which we have just been indulging, shall be doubtful and venturous no more?

II.

The mere physical agreement of the body of the Sun, however, with the idea of his Nebulous origin is not enough, for he has other very definite and distinct characteristics that demand to be explained. And the first of them, viz., his *rotation around his axis*, is clearly a phenomenon of a cosmical kind,—one not belonging to him peculiarly, but probably partaken of by all the fixed stars. It is singular, that the first class of stellar changes, by which the attention of astronomers was arrested, seems to refer to this interesting relationship. A number of stars have long been known to vary in lustre—increasing to a certain degree of brightness, and then waning to a certain degree of faintness—a variation found to be *periodical*, *i. e.* it takes place *regularly*, and within a definite time. The star ALGOL, for instance, varies regularly, from the second to the fourth magnitude, and again back to the highest brightness in about two

days, twenty-one hours; the second star in the Lyre, goes through a periodic variation in six days, nine hours; a star in the Swan varies from the sixth magnitude to absolute invisibility, and from that resumes its original brightness in eighteen years; and the following table exhibits the course of similar changes in others of the celestial bodies—

Names of Stars.	Periods of Variation.			Degrees of Variation of Magnitude.	
	Days.	Hrs.	Min.		
δ Cephei, . .	5	8	37	3.4	5
η Antinoüs, . .	7	4	15	3.4	4.5
α Herculis, . .	60	6	0	3	4
ο Ceti, . . .	334	21	0	2	0
χ Cygni, . . .	396	0	0	6	11
367 Hydræ, . .	494	0	0	4	10
420 Leonis, .	Several years.*			7	0
ϰ Sagittarii,				3	6
ψ Leonis, . .	...			6	0

Now there are only two accessible explanations of these still mysterious and little-explored changes.

* I am not sure if all these latter stars exhibit a *regular periodicity* in their changes. Probably some of them merely indicate another class of phenomena, to which I shall have occasion to request attention in the second volume of this series.

—Inasmuch as the *position* of these stars in the Heavens is wholly unaltered during their recurring changes, we cannot rationally attribute to them an orbitual motion, or explain their varying brightness by varying distance ; so that we are reduced to an obvious alternative. Either dark bodies of considerable magnitude revolve around them, and by their periodical intervention intercept part of their light; or the orbs themselves rotate on axes, and at equal intervals turn towards our solar sphere parts of their surfaces which may be covered with spots, or are otherwise dimmer than the rest. The former hypothesis is captivating, for it would establish at once the reality of other planetary systems upon a scale surpassingly grand; but the very grandeur of this scale, the relative magnitude with which it would require the subservient bodies to be endowed, militates against all analogy; neither does the rigorous *periodicity* of the variations agree with this notion,—for the intervention of the planets or dark bodies would not in such a case be regular or periodical.—The second hypothesis, on the contrary, is in some resemblance with well-known attributes of our own Sun. His disc, owing to the varying number of its *spots*, gives out varying lights, and if, as has been sup-

posed, there be a slight permanent inequality in the illuminating power of the two hemispheres of that disc, he would necessarily appear to remote bodies as *a variable star*—his variation being a strict consequence of his *rotation* on his axis. Now the variation of other stars may be owing to similar possible peculiarities of constitution, joined to the fact, that they ROTATE likewise. This reasoning is quite identical with what is esteemed adequate to establish the rotations of some of the satellites belonging to the more distant planets of our own system. Too remote to exhibit small individual spots on their surfaces, these yet show a general variation in the light of the discs they alternately present to the earth,—they are, in fact, *variable satellites;* and this varying light, whatever its physical cause, is supposed to demonstrate alternation of their surfaces.

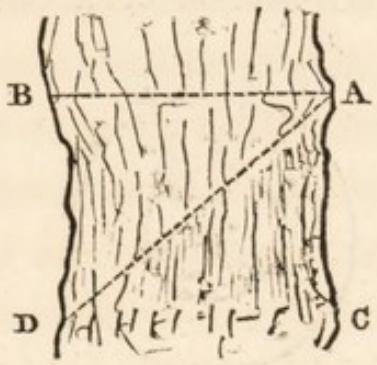
Regarding *rotation* then, to be an established attribute of organized stars, let us, with a view to its origin, reflect on the Solar or any other Nebula in the act of condensing. It appears that this phenomenon consists in a *flow or rush of the nebulous matter from all sides towards a central region;* which is virtually equivalent, in a mechanical

point of view, to what we witness so frequently, both on a small and large scale—the meeting and intermingling of opposite gentle currents of water. Now what happens on occasion of such meetings? Herschel's keen glance lighted at once on this simple phenomenon, and drew from it the secret of one of the most fertile processes of nature! In almost no case do streams meet and intermingle, without occasioning, where they intermingle, a *dimple* or WHIRLPOOL: and, in fact, it is barely possible that such a flow of matter from opposite sides could be so nicely balanced in any case, that the opposite momenta or floods would neutralize each other, and produce a condition of *central rest.* In this circumstance, then—in the whirlpool to be expected where the Nebulous floods meet—is the obscure and simple germ of rotatory movement. The very act of the condensation of the gaseous matter as it flows towards a central district, almost necessitates the commencement of a process, which, though slow and vague at first, has, it will be found, the inherent power of reaching a perfect and definite condition, and from which consequences ultimately issue, not less various and astonishing than the foliage and stature of the

noble tree, considered as the development of an insignificant seed.

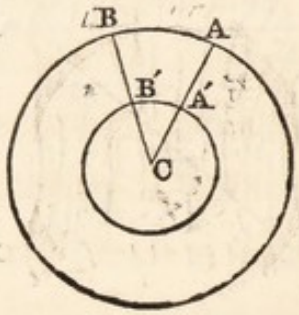
It is not difficult to perceive, that—the whirlpool motion once originated—there is an inherent power in matter, under such circumstances, to evolve finally a definite rotation *of considerable velocity*. Several well-known facts amply illustrate this. My readers are all aware of the effect of shortening a pendulum, or of bringing the moving mass nearer the centre of motion. The motion is instantly *accelerated*, and it is the same with the little instrument the metronome. The moment at which the pirouette dancer desires to increase the velocity of his whirling, he brings his arms, previously perhaps stretched out, close to his sides—and this enables him to perform the more rapid gyration without increased effort. But the truth, that the approach of the matter towards the centre, or the *process of the condensation of the nebula*, must gradually and surely increase the velocity of its rotation, may be illustrated very plainly by a reference to simple mechanical principles. It is a general law or fact, that if a body is subjected to two moving influences acting in different directions, *it obeys both*, or moves in obe-

dience to each, as if the other did not exist. For instance, let a person in a boat start from A, with



the intention of pushing his boat right across a stream; and suppose, that in the time he would occupy in rowing from A to B, *if the water were still*, the power of the stream could carry him from A to C *if he did not row at all;*—the question is, how his boat will actually move? Now, all experience tells us, that if he merely rows *right across*—pushing his boat from the bank A towards B, with its side invariably to the stream, he will, previous to reaching the opposite bank, have been carried down by the current, precisely as far as if his boat had merely floated; so that he will reach the bank at D, immediately opposite C, and his boat will have *partaken at once of the two motions or influences impressed upon it.* This law, as I have said, is general; it holds in every case where a body is under the influence of two moving powers; and

the consequences of its action in a condensing nebula, cannot be mistaken. Let the subjoined sketch represent a section of a circular nebula,



revolving about the central region C, and in which condensation is permanently going on. It is evident that the particle at A, in consequence of the whirlpool, moves from A to B, while the particle at A′, only moves from A′ to B′; but, as the attractive power, by drawing the first particle from A to A′, cannot, by the foregoing principle, *diminish its circular velocity*, the result of such condensation will be *the attaching to* A′ of another particle A, whose circular velocity is greater than its own. Now, the permanent consequence is manifest. If two balls, A and B for instance, are moving forward

with different velocities, A much faster than B,

what will follow when A overtakes B? Certainly an acceleration of B's motion, and a retardation of A's; and the two together will, after contact, move on *much more rapidly than at B's former rate:* so that, by the very act of A (see previous diagram) being brought into union with A′, the rotatory velocity of A′ would be augmented; and if the whole *outer* circle A B, &c., were attracted towards the inner circle of matter A′ B′, &c., that inner circle would accordingly rotate more rapidly than before, and the velocity of the rotation of the entire nebula must therefore be increased. Plausible objections, I am aware, may be taken to this explanation;—I propose it merely as a *popular* one: but it indicates, nevertheless, the principle which assures us that the condensation of a diffused and comparatively slow whirlpool cannot take place without a great and growing increase in the velocity of its rotation, inasmuch as the momentum, or amount of the *rotatory force*, must, in all its stages and conditions, continue the same. And thus, may it clearly be seen how, out of phenomena the rudest and most unpromising, and by the simplest laws of nature—those which guide the facts of every-day experience,—even that stupendous rotation might be generated

—a rotation whose discovery was one of the first achievements of the telescope, and which, all who know Nature ought to be assured, does not stand by itself or as an independent fact, but is a cosmical phenomenon of wide significancy, and closely, however mysteriously, related with the whole scheme and progress of Things.*

A conclusion here forces itself on our notice, of the most unexpected kind. As might be anticipated from the previous speculation, the individuals of the double stars also rotate on their axes; but it is fortunate that the fact is distinctly indicated by observation. The periodical variation of brightness has recently been much noticed among these interesting groups. In a very striking object γ Virginis, the phenomenon is most distinct, each constituent in turn presenting a clear and dim face to us. The fact is likewise undoubted in ε

* The velocity of the resulting rotation will manifestly depend on the magnitude and condition of the original Nebula; so that we would expect to find no uniformity of period in the rotations of the stars—an expectation perhaps verified in the phenomena of the *variable* orbs.—This probable diversity of size in the original Nebula, also leads to the belief that there is necessarily a very great variety in the magnitude of the resulting stars.

Arietis, ζ Bootis, 38 Geminorum, 48 ι Cancri, and at least 20 other systems; and changes are suspected in 40 more. Now, observe how the revolutionary or orbitual motions of such systems flow at once out of the fact of the rotation of their constituents! The solution of this great and interesting fact afforded by our Hypothesis, I cannot term less than picturesque,—it excites instantaneously our surprise and admiration. Has my reader walked in a mood of tranquil thought along the side of a quiet river, whose waving banks reflect a thousand currents, by the intermingling of which, numerous dimples or whirlpools are produced—their easy glide only marking the river's stillness? Has he followed these dimples as they pursue each other in gambol, and watched the phenomenon of the near approach of two or three? Then he has witnessed the secret of the mystery of the double and triple stars! When one of these dimples approaches the vortex of another, the two begin *to revolve around each other;* and, in fact, they must, on approximation, act upon each other as TWO WHEELS; so that a revolution of each around the other *must* immediately supervene, and increase in rapidity, until, by external pressure, they are forced into one. Plate XIV., in

which Double Nebulæ are presented in various stages, enables us to apply this illustration. If the single nuclei are rotating, as we are now almost entitled to say they must be, it is precisely a case of two contiguous whirlpools; and *how could revolutionary motion be prevented?* Two such masses in approximate contact *must* originate such a motion: as the principle of gravity draws the nuclei nearer each other, the velocity of revolution will manifestly increase; and the two bodies will constitute themselves into a stable system when the rapidity of revolution suffices to counterbalance their mutual attraction. The case is manifestly the same in instances of three, four, or more nuclei, formed in the immediate neighbourhood of each other, or out of one such mass as Fig. 1. in the same plate: so that now we have not only a CAUSAL solution of Herschel's remarkable prophecy; but also an intimation that the *modes* of revolution of small clusters, may be as varied and fantastic as the multifarious revolutions of associated dimples in a stream. To deduce from the dynamical laws which govern the interlaced motions of those tiny whirlpools, the *classes* of related orbits whose discovery may be expected in the sky, were in the mean time premature;—the

more so that our conjectures concerning this peculiarity in the play of the Nebular hypothesis, present a point of experimental but unexplored verification. *All known double Nebulæ should be sedulously watched;* although they may move slowly, still their motions might in some instances be detected :—a positive discovery, which I do not hesitate to allege, would not be second in interest to that which has immortalized our age—the discovery of the actual motions of the double stars. . . . I am not sure that the portion of the nebular speculation, over which I have just gone, is not in my eyes the most engrossing of the whole of it, for it points emphatically to a moral I am extremely anxious to impress. We are all too easily inclined to look on creation as made up of isolated parts—of independent or individual classes of beings, and to regard Nature as we do a case of botanical or mineralogical boxes; so that it requires a fact as striking as the identification of the Stellar motions of REVOLUTION with those of ROTATION, to startle us from the habitual error, and to bring us to right views of that stupendous ORDER within which we live, and of which our own beings constitute a part. The unity of things—their inter-dependence—their adjusted relation-

ships, are proclaimed by every department of the Universe. I deny not that different laws may exist; nay, they *must*,—for it is only by the commingling of Opposites that Variety and Progress can be produced; but all is not opposition which seems so, and most of what we divide and parcel out into isolated bundles, is nothing other than the parts of the same grand scheme. Philosophy has taught this for ages—it is, in fact, the secret of her life; for she aims to gather up all fragments, and to present the Universe united, compact, tending to one end—a type of its August CREATOR.

III.

We now enter on the most difficult part of our speculation,—viz., the question as to the origin of planets connected with these central Luminaries, and characterized in their arrangements by the existing peculiarities. If the discussions about to be presented are somewhat more intricate and tedious than what precedes, I believe they will yet reward attention; for we are also about to demonstrate the necessary existence of planets around every star in which the elementary principles of matter, as we know it, are freely opera-

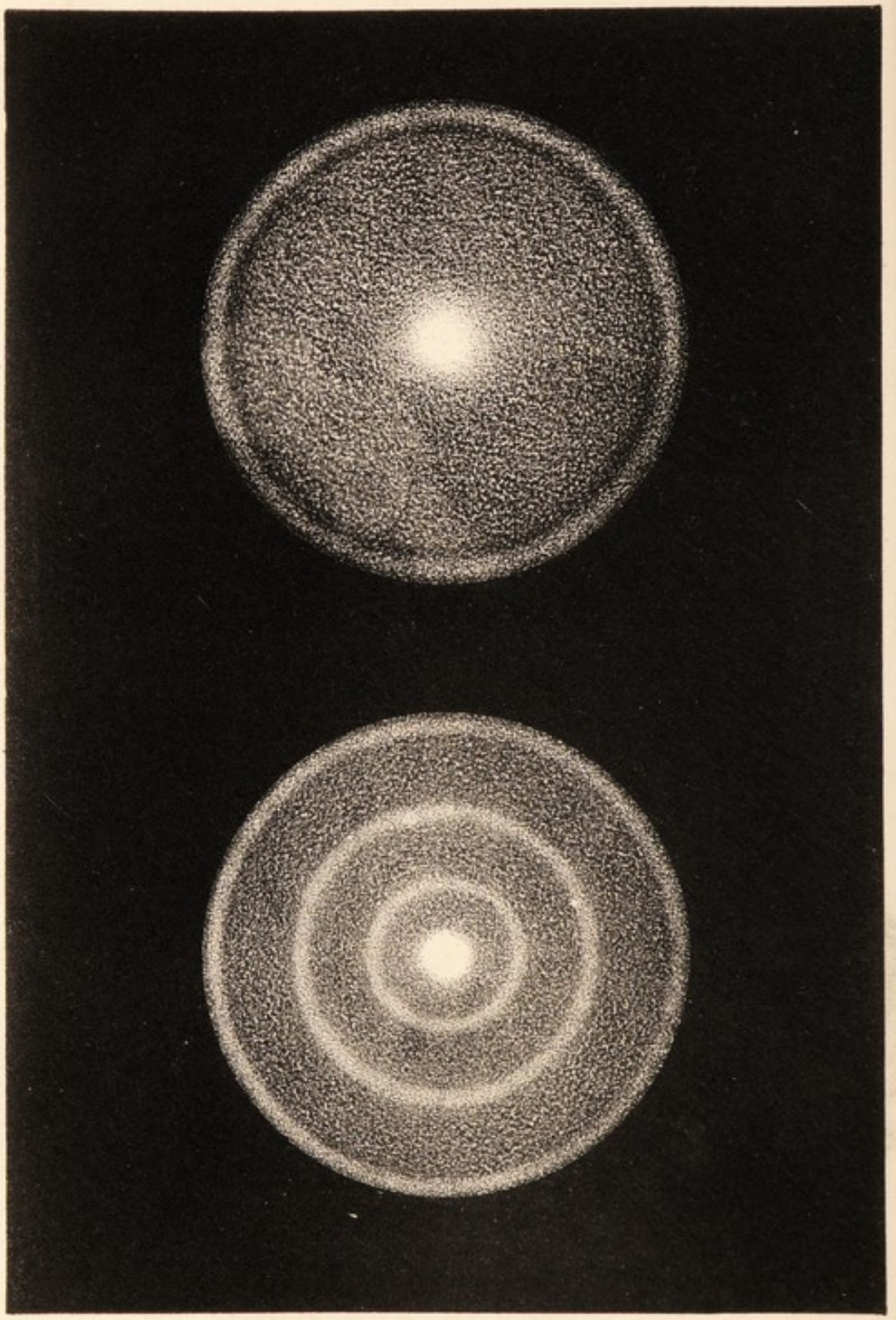
tive.* I shall separate the investigation into several distinct steps.

1. The preservation and permanence of the place of a point on the surface of a rotating body

* This problem may soon be withdrawn from the region of surmise, and resolved in separate instances by the telescope. Sir John Herschel—a mere hint from whom is of authority—has requested attention, in the most express way, to the minute and point-like companions of such stars as ι Ursæ, α^2 Capricorni, α^2 Cancri, γ Hydræ, ζ Geminorum, &c., as in some of the cases probably shining by *reflected* light; and still more recently, his impression has been confirmed by what he saw in the southern hemisphere. If these small silvery points—lurking within the rays of their respective suns, should indeed prove to be planets, the telescope will have performed the greatest of its achievements; and if, upheld by observation as far as it can stretch, we shall ever be enabled to state it as a general law, that all the orbs of space—not merely those which shine above us, but also the myriads whose wonderful clustering is seen in distant firmaments—that each one of this mighty throng is, through the inseparable exigencies of its being, engirt by a scheme of worlds proud as ours, perhaps far prouder;—how immeasurable the range, how illimitable the variety of planetary existence! No wonder that our small world—a mere nook in space—an infinitesimal item of that mighty whole—should be incomplete and fragmentary, silent concerning the interior of many phenomena which are developed in it, and containing few illustrations of much which we desire to know of the fundamental conditions of Being. The Great Book of the Universe—that which explains the labyrinth and leaves no enigma, deduces its easy expositions from the premise of the *perfect* Universe: the few stray leaves of this book which have reached terrestrial

depend on the circumstance that the centrifugal force is not greater than the power of the central attraction. The inevitable consequences of an excess of the former are seen in simple operation in a common phenomenon. It is known to mechanics, that a grindstone may be made to revolve with a rapidity sufficient to cause splinters fly from its rim, and even the whole rim to break in pieces—indicating that the centrifugal force of the rim with that velocity, more than counterbalances the mutual attraction or cohesion of the particles of the stone. Now, if the rim, instead of being formed of brittle stone, had consisted of an elastic belt, say of caoutchouc, what would result in such a case? Clearly a separation of the rim from the mass of the rotating body—it would expand somewhat, just as the orbit of a planet in a similar position; and, if other circumstances permitted, it would revolve around the stone as a separate ring at a distance where the balance or equilibrium of the forces would be restored. Plate XIX. will

shores, must seem sibylline, often incoherent—speaking of laws which enter among visible arrangements only by their lateral actions, and whose roots are down, far from present sight—deep in the bosom of that all-encompassing Wisdom which comprehends the entire system of things.



enable us to apply these considerations to the case of a condensing and therefore *rotating* Nebula with striking effect. Fix your attention on Fig. 1. We have already seen that causes continually operate to increase the velocity of the Nebula's rotation; but when this velocity in any case became so great that the centrifugal power of the exterior portion or ring just balanced the attraction exercised over it by the mass of the Nebula, that ring would necessarily assume an independent character, and acquire, so to speak, a self-sustaining power; it would therefore be *abandoned* by the main or parent mass at the next stage of condensation, and left as a *distinct portion of matter revolving in* SOME FORM *around the central body*. There is no doubt whatever of the mechanical principles on which these inferences rest; and it is equally certain that there are almost infinite chances against the condensation of any large or original Nebula, without the occurrence of circumstances which would throw off numbers of such rings; so that, in a more advanced condition, every such mass might (*if the forms of the thrown-off rings had not altered*) present the appearance of the second figure in Plate XIX.,—a large central nucleus, with subservient rotating annuli,

composed of quantities of matter necessarily very small when compared with the main body.

Here, then, have we our first idea of the origination of planetary—or of quantities of parasitic revolving matter; and the question next arises, what *forms* would these rings probably ultimately assume? There are three possible forms. 1. The mass, if tolerably equable in its original constitution, and undisturbed from without, might condense as it is, or into a *rotating* SOLID RING; but the chances against such a result are so numerous, that we would expect the phenomenon to be very rare in the Universe. 2. If the mass broke up or separated while condensing—as its own internal irregularities would, in all probability, constrain it to do—it might divide into a number of portions so equal in attractive energy that none of them would have any tendency to coalesce with, or fall into the others; so that the ring would ultimately be transformed into a number of distinct small solid bodies, revolving around the central mass at nearly the same distance from it. These bodies, it is clear, would in their final state be *spherical* or *round planets;* and although not so evident, it is yet mechanically certain, that they would *necessarily rotate on their axes in the direction of their*

*revolutions.** 3. Even this second supposition, however, is not a very probable one, inasmuch as its essential condition—the attraction of the mass of the ring towards equally balanced centres—could, in the nature of things, occur but rarely. By far the likeliest result is the division of the ring into nuclei of unequal power—the larger of which would, by its superior attraction, assume the others into its mass,—the whole solidifying into one considerable globe. Such globes would likewise invariably follow the law of rotation above specified; and every one of these secondary masses might, during the phenomena of its subsequent condensation and augmenting velocity of rotation, throw off rings corresponding in all respects to those around the primary nucleus,—which, condensing in their turn, and according to the foregoing laws, would form solid annuli and *Satellites*.

How exact the correspondence of these general results with the character of the bodies in

* Suppose the rim of a carriage wheel in rapid rotation suddenly broken up: its splinters, as they flew off, would all *rotate* in the direction of their previous motion, and this because of the excess of the motion of the outer part of the rim over that of the inner part. The phenomenon is well-known to glass-blowers, in whose hands a disc of crown glass often breaks while it is being turned.

our solar system! 1. We have a central massive globe, with subservient globes engirdling him at various distances, and of magnitudes very inferior to his. 2. The great proportion of the planets which compose our luminary's cortège, belongs, in strict accordance with theory, to the last of the three defined classes of forms into which a ring might break up. MERCURY, VENUS, the EARTH, MARS, JUPITER, SATURN, URANUS, are single globes, revolving in orbits of their own, and around some of them are dependent satellites. 3. In one instance only, does the ring seem to have divided into equally balanced parts—I allude to the four small planets, those ASTEROIDS between Mars and Jupiter, which have nearly a common orbit, or which revolve at almost the same distance from the sun: and 4. We have, also, in one solitary instance, a specimen of that most singular of cosmical appearances—AN ORIGINAL RING, solidified in its pristine condition, and revolving around the planet SATURN.*

* It is not unlikely that there are many other very small bodies which have come into being in the same manner as the others, revolving in various and *disturbed* orbits, within our planetary spaces. Meteors, or falling stars, are now generally believed to be most easily accounted for, by supposing them

There now bursts upon us, for the first time, the reason of a very signal peculiarity and co-ordination in the arrangements of the motions of our planetary bodies, whose origin cannot otherwise be unfolded. The planets, without exception, move around the sun in ovals differing little from circles, and never far removed from the plane passing through the sun's equator; they all revolve in these orbits in the direction of the sun's rotation on his axis; they rotate on their axes in the same direction, and—excepting what we have been told concerning the still enigmatical and but partially known body Uranus—the whole Satellites, including the rings of the Saturn, revolve around the primary planets also in that direction; nor are the rotations of these secondary bodies, in so far as they are known, subject to a different law. Now, these phenomena are serious puzzles in a mere solar astronomy; they receive no explanation whatever from what we usually term the

bodies of this sort drawn within the earth's atmosphere by attraction, and there ignited. The annual occurrence of a shower of meteors in the month of November, distinctly intimates the existence of an unexplained *astronomical* phenomenon; because, by being connected with the ecliptic and a particular season of the year, it is connected with the position of the earth in its orbit.

law of gravitation, inasmuch as gravitation could sustain systems distinguished by no such conditions,—nay, it actually does so, for the comets are free from all these laws, moving in very eccentric orbits, often very far removed from the plane of the sun's equator, and their motions are as often retrograde as direct. Most fortunate it was that an inquiry baffling even the resolving power of Gravity, and thus profounder than any undertaken heretofore, fell into the hands of a philosopher whose knowledge of celestial mechanism was then complete, and whose capacity to trace elementary laws to their remotest consequence, has never been surpassed! It occurred at once to the illustrious LAPLACE, that the ordinary operation of Gravity is to sustain or regulate systems which have been brought into being; and that the higher conditions of which I have spoken, pertain directly to the manner of our system's origin; nor did he meditate long ere the splendid speculation I have detailed arose in full maturity in his mind, and connected itself with the revelations men were at that time first receiving from the telescopes of Herschel. Observe how intimately the system of the generation from *rings*, coördinates with these constituent phenomena.

The rings in the first instance must be circular, and thrown off at the sun's equator where the velocity of rotation and therefore the centrifugal force is the greatest; the bodies resulting from them must revolve all in one direction, and with velocities corresponding to the velocity of the Nebula at the period of their separation; the separate and consolidated masses resulting from their destruction must, as stated, rotate on axes in the direction of their revolution; and finally, all Satellites subsequently formed must both revolve and rotate according to the same order! The Cosmogony has thus every mark of truth: its roots are *seen* in the Heavens, and it appears to go through every nook and alley of solar and planetary arrangements; not only explaining them, but comprehending their variety, and deducing the whole from one grand principle. How different the Cosmogony of BUFFON—a man to whom genius was never wanting, who brightened every subject on which he touched, and kindled every mind which approached him, because, although with faculties imperfectly balanced, he lived and had his being amid the richest and rarest qualities of the philosophic spirit,—how different and wholly fantastic his idea that planets were chips struck

off the sun by the collision of comets! Not one of the fundamental conditions of our system's mechanism could be explained by this wild and reckless imagination; whereas Laplace's bold and brilliant *induction* (may I not now so name it?) includes and resolves all! The theory is so beautiful and perfect, that perhaps we might have assumed it to be universal, and asserted that every planet springing out of rotation, and engirdling each of those infinite orbs, must be subjected to the chief laws which control the earth—had not presumption been checked by one emphatic indication. If, as we are informed, the two least problematical Satellites of Uranus have retrograde motions, *i. e.* if they move in directions opposite to the general one, there must be some influence or law capable of checking in so far, and modifying the operations indicated by the Nebular Cosmogony; and this intimation reaches us from the farthest verge of our system—that confine where novel external actions would be the most sensibly felt. Whatever this influence is, it cannot invalidate the theory of Laplace. The laws of nature never destroy but only modify each other, —just as the systems of circular waves, diffused from two centres in a pool, intermingle and affect

each other's undulations—each spreading meanwhile out to the extreme limits of the sphere.

—A question may be suggested here, that reminds me of a class of objections to our hypothesis. The planets do not move in perfect circles, but in ellipses that are almost circles, and they also deviate slightly from the plane of the Sun's equator. Laplace refers these incongruities to irregular molecular actions arising during condensation—*to the operation of inferior laws*—laws which work within the sphere and power of Attraction, but with whose exact character we are not acquainted. It is not in the least unreasonable to attribute the few apparently inconsistent facts to the agencies of this large region of the unknown; but it is surely wholly unreasonable to claim for them the rank of a solid objection to the grand process we have discussed. It is never legitimate to draw objections from within the sphere of unknown influences against an all-environing law. The objector, indeed, is in this case the theorist, for he assumes something as true, which after-discovery may wholly disprove. The large shadows of twilight show that great lights are onward—just beyond the horizon—even though their boundaries are

undefined, modified by the many terrestrial lustres that the approach of night brings.

Let us pause now and look back on the grand perspective below us. We set out by asking, can the Nebular Hypothesis *explain the stars?* Somewhat, indeed, remains to be fathomed, and phenomena apparently disparate may still be found in the sky; yet, short way as we have gone, every one of the grand features of the stars—facts which, but to mark, have often worthily conferred deathless fame—are seen in union and harmony the most unexpected, proceeding hand in hand from the bosom of previous night, and going through untold ages in singular companionship,—as if we had even attained the privilege of witnessing the arranging influence of that Dove Spirit which erst brooded over chaos. It is, indeed, an impressive spectacle! Who can ascend so far up that vast chain which unites the eternal past with the fleeting present; who—to go no higher—can dwell on the idea of our Sun being born from one of those dim nebulæ, order growing within him by effect of law, and the worlds he illumines and sustains, springing gradually into being,—without engrossing emotions! Sometimes on contempla-

ting this mighty progression, and thinking of the changes, visible and concealed, which must have marked the advance of an organisation so majestic; asking, too, what is Man, save a transient organisation, with whose progress the education of a Spiritual Being has been for a moment connected —I confess I have been so fanciful as to doubt whether those great and good men who endowed the stars with spiritual principles, ought to be esteemed mistaken,—whether that orb, during its fathomless evolutions, may not have been the seat of a SPIRITUAL POTENTATE, gifted with the divine capacity to rise in knowledge, power, and beneficence, by experience of all the vast events of which he is the centre—whether we should not look upon these HOSTS OF HEAVEN, as something still more awful than inanimate worlds fitted to sustain a Life like ours?—Far as our ken has reached, between us and the HIGHEST there is still vastness and mystery:—sometimes to take wing beyond terrestrial precincts, perhaps, is not wholly forbidden; provided we go with unsandalled feet, as if on Holy ground.

Apart, however, from all speculation,—surely the view of an actual order whose beginnings are

hid in what seems in our eye nothing less than Eternity, cannot but elevate our thoughts of that BEING, who, amid change, alone is unchangeable—whose glance reaches from the beginning to the end—and whose presence occupies all things! If uneasy feelings are suggested, and I have heard of such—by the idea of a process which may appear to substitute *progress* for *creation*, and place *law* in the room of *providence*, their origin lies in the misconception of a name. LAW of itself is no substantive or independent power; no causal influence sprung of blind necessity, which carries on events of its own will and energizes without command. Separated from connexion with an ARRANGER in reference to whose mind alone, and as expressive of the Creative Idea it can be connected with the notion of control—Law is a mere name for a long order—an order unoriginated, unupheld, unsubstantial, whose floor sounds hollow beneath the tread, and whose spaces are all void; an order hanging tremblingly over nothingness, and of which every constituent—every thing and creature fails not to beseech incessantly for a substance and substratum in the idea of ONE—WHO LIVETH FOR EVER!

IV.

There are certain supplementary presumptions on behalf of the Nebular Hypothesis in its application to the organisation of the sun, which, although out of the line of direct demonstration, are too interesting and important to be omitted here. Comprehending these remote or *constituent* phenomena of our planetary system, and therein dividing itself from all other cosmogonies,—it will appear, besides, in exquisite accordance with all known "originating principles," when we understand the especial play and influence of these phenomena on our system's destiny. It is a memorable circumstance, that those characteristics which the Nebular Hypothesis alone explains, *constitute the secret strength or comparative permanence of our system.* Thinking of the disturbing action of each planet on the others, it appeared to NEWTON, that the path of no such body could be perfectly stable, but, on the contrary, that every orbit must be constantly moved somewhat from its place by these unsteady influences: and he thought that the accumulating disturbances would soon abate the symmetry of existing arrangements, and probably cause their destruction by one irregular shock. The dissipation of New-

ton's fear was reserved for that age whose terminations we are still touching; when the subtile analysis of the illustrious LAGRANGE instructed us that every one of the disturbances referred to must be PERIODICAL or oscillatory, *i. e.* if the moon is now approaching the earth, or her orbit drawing in, a time must come when that approach will cease, and when an opposite action, or a retrograding, will take place, which also will be stopped in subsequent ages by a superior limit: and so of all other perturbations. Now this truth results from the existence of *those very constituent elements of our system, which the Nebular Hypothesis alone comprehends;* for if the planets and satellites had not moved in the same direction, alike in their revolutions and rotations, and if the spheres within which they move had not approached to circles, and been comprised almost in the plane of the sun's equator—*the periodicity would not have supervened, and no antidote had been found to Newton's sorrowful forebodings.* It were pleasing here to arrest our progress and admire so signal an illustration of that beauty of design and beneficence of purpose visible in every portion of the great chain of causes and effects; but passing the attractive theme we rather hasten

to conclusions directly in view. Those constituent elements are the *elements of the strength* of planetary arrangements; and it is in closest connexion with *them* that we have found the originating cause of the whole planetary system. But in every department of organized life—whether vegetable or animal—it is a law that in the progress of reproduction and growth, we have an especial adaptation to produce or ensure the existence of such *essential* circumstances, while the causes of the accidental ones are evanescent and of irregular action; and perhaps it is its fine accordance with this wide and striking analogy, its adaptations to that portion of planetary phenomena which, more than all others, must have sprung directly from the causes of our system's birth, which have gained for the theory of Laplace the respect of all, and the silent acquiescence of many Astronomers.

Still farther;—the system, though strong, is not framed to be EVERLASTING; and our Hypothesis also develops the mode of the certain decay and final dissolution of its arrangements. Remember the effects of the Solar Ether! Although no mark of age has yet been recognised in the

planetary paths, as sure as that filmy comet is drawing in its orbit, must they too approach the sun, and, at the destined term of their separate existence, be resumed into his mass.* The first indefinite germs of this great organisation, provision for its long existence, and finally its shroud, are thus all involved in that master conception from which we can now survey the mechanisms amid which we are! And mark the nature of this decay. It comes, not as Newton thought, by accident, derangement, or disease, but through the midst of harmony; it is an easy consequence of the venerable power which first evolved us, infused our scheme with the spirit of life, and gave it structure and strength. Our supposed origin of the planets gave them and their satellites that kind of orbits, and that kind of rotation, which produced their permanence; and the inherence of this same Nebulous parentage, viz., the existence of an ether, leads gently to their decline.

* It may be asked does not this Ether rotate along with the planets, and therefore not retard them? It must rotate somehow—the comets will one day discover that for us; but it cannot rotate with velocities corresponding to all the planets. Nay, the very ellipticity of the planetary orbits, small as this is, necessitates a retardation in every one of them, however the Ether may rotate.

So dies nature's unblemished child—the simple flower! It bursts its seed, buds and blooms; and then in unimpaired obedience draws in its leaves and sinks into the lap of its Mother Earth.

The idea of the ultimate dissolution of the solar system, has usually been felt as painful, and forcibly resisted by philosophers. When Newton saw no end to the deranging effect of the common planetary perturbations, he called for the special interference of the Almighty to avert the catastrophe; and great was the rejoicing when that recent Analyst descried a memorable power of conservation in our system's constituent phenomena; but, after all, why should it be painful? Absolute permanence is visible nowhere around us; and the fact of change merely intimates that, in the exhaustless womb of the future, unevolved wonders are in store. The phenomenon referred to would simply point to the close of one mighty cycle in the history of the solar orb—the passing away of arrangements which have fulfilled their objects that they might be transformed into new. Thus is the periodic death of a plant perhaps the essential to its prolonged life: and when the individual dies and disappears, fresh and vigorous

forms spring from the elements which composed it. Mark the Chrysalis! It is the grave of the worm, but the cradle of the sunborn insect. The broken bowl will yet be healed and beautified by the potter, and a Voice of joyful note will awaken, one day, even the silence of the Urn!

—Nay, what though *all* should pass? What though the close of this epoch in the history of the solar orb, should be accompanied, as some with a strange fondness have imagined, by the dissolution and disappearing of all these shining spheres? Then would our Universe not have failed in its functions, but only been gathered up and rolled away, these functions being complete. That gorgeous material framework, wherewith the Eternal hath adorned and varied the abysses of space, is only an instrument by which the myriads of spirits borne upon its orbs, may be told of their origin, and educated for more exalted being; and a time may come when the veil can be drawn aside—when spirit shall converse *directly* with spirit, and the creature gaze without hinderance on the effulgent face of its Creator: but even then —no, not in that manhood or full maturity of being, will our fretted vault be forgotten, or its

pure inhabitants permitted to drop away. Their reality may have passed, but their remembrance will live for ever. The warm relationships of dependent childhood, are only the tenderer and the more hallowed, that the grave has enclosed and embalmed their objects; and no height of excellence, no extent of future greatness, will ever obscure the vividness of that frail but loved infancy, in which, as now, we walked upon the beauteous earth, and fondly gazed upon these far-off orbs—deeming that they whisper from their bright abodes the welcome tidings of Man's immortal destiny!

CHAPTER VIII.

SPECULATION.

If our desire of knowledge did not quicken as its sphere expands, or if Man, so long as one eminence is unsurmounted, could lay himself down in peace, satisfied with the view of the vastness and variety which already stretch out beneath him, doubtless our task had now ended, and the volume of Astronomy might have been closed. But Desire, happily insatiable, has no confine on this side the Infinite; and no sooner have we reached the elevation of one thought or idea which resolves some large portion of the unknown, than ambition is fired afresh, and speculation, never at rest, takes flight towards remoter regions.

In the present instance, indeed, there is every encouragement to further adventurous inquiry. The Nebular Hypothesis, in its relations to the

planetary system, may be termed complete;—it comprehends its beginnings, establishes those elements on which its duration depends, and exhibits the causes and mode of its ultimate transition into a novel form; and thus—surveying it from its commencement to its close—we are as if in possession of that primeval Creative Thought which originated our system, and planned and circumscribed its destiny. Now, in reference to one of these epochs, our Hypothesis seems to hold equal connexion with the whole contents of the Heavens,—the epoch, viz., of their origin; and is it—as a conclusion of our task—too daring to fancy that likewise in *their* progression under the control of law from primitive chaos, principles are evolved which regulate the existing distribution of stars into firmaments, which have determined the form of the present condition of Universe, and from which new forms will issue unceasingly, until, as with the planets, the hour of final transmutation comes, and the cycle of their existence is complete? In endeavouring to pursue such an inquiry—supported, as we are, only by a few very remote hints from observation—there is need of all our cautiousness; nor can we hope to obtain farther than the most general idea of what DEITY

keeps in store for those majestic stellar arrangements.

I.

The great oak-tree has a breathing and circulating machinery, fitted for action during a thousand years, while those of the blades at its feet decay and die after a brief summer: and, doubtless, if we knew them well, those conjectures adventured in the first part of this treatise, regarding the prolonged stability of complex clusters through the nice arrangement of their constituents, would be confirmed. But now we would view them in reference to that new notion which has been started —that, viz., of *progress* or *decay*.

It is demonstrable that if any of that thin or incondensible ether, of which we have spoken, remains, for instance, among the systems of double suns,—these must also underly the destiny of the planetary scheme; and, however gradually, however harmoniously, aggregate into one. Now, among many of these systems we find, by observation, distinct proofs of the existence of this retarding influence. *They are often found imbedded on a faint oblong light—quite what the Zodiacal Light would appear in reference to any individual star.*

But, starting at once to the utmost that can be asked of such speculations, we inquire whether progress is seen in the different aspects of the *clusters*, or whether their characters exhibit evidence or even suspicion of a changing state? If any action similar to what we are supposing exists, there ought to be a SERIES of appearances in regard of their *condensation* around their centres;—we ought to see the different masses in different or progressive states, manifesting the growing approximation or aggregation of their orbs. Now this *series* exists; and if we regard it as a phenomenon to be accounted for, it must be received as a confirmation of our conjecture. The following are Herschel's words. "There are besides additional circumstances in the appearance of *extended* clusters and nebulæ, which very much favour the idea of a power lodged in the brightest part. Although the form of these be not globular, it is plainly to be seen that there is a tendency towards sphericity, by the *swell* of the dimensions the nearer we draw towards the most luminous place, denoting as it were a *course* or *tide* of *stars*, setting towards a centre. And, if allegorical expressions may be allowed, it should seem as if the stars, thus flocking towards the seat

of power, were stemmed by the crowd of those already assembled, and that, while some of them are successful in forcing their predecessors sideways out of their places, others are themselves obliged to take up lateral situations; while all of them seem eagerly to strive for a place in the central swelling and generating spherical figure." The series required, indeed, is so distinct, that if I would characterize the globular clusters we have resolved, and without reference to theory, it would be in language referring to their various compressions. They present a line quite unbroken; and are in the exact condition illustrated by Herschel, when he compared them with plants in different stages of progress, from adolescence to proximate ripening, (which in this case is decay,) precisely as Laplace afterwards most aptly characterized the varying aspects of the Nebulæ. It is not possible that these phenomena are mere illusions: nor are they to be explained by the mere presence of "*a power lodged in their brightest part.*" That might be counteracted by motions of revolution, and, as we have seen, stability still preserved. The whole appears a solemn indication, that here too, as with our own system, and arising probably in the same

circumstance, is there the action of an evolving and transmuting cause.

—How immense the field of contemplation opened by these new but most simple considerations! Even the larger forms of the Heavens are not stable! Those globular masses at least, appear in process of growth, or *ripening*,—they are congregating towards that nucleus, around which the new order of things is slowly up-growing, and where the mighty orb, foretold by their progressing aggregation, is preparing to be born. I cannot avoid reverting to the notion of Coleridge: what is this after all, save a prolongation of the condensing of a Nebula? Already some few of its particles have come together and formed its secondary stage; and now, that secondary stage, which we term a firmament, is passing into a third, where all the dispersed atoms will be gathered together, and lodged at the centre of the mass!

We may venture a step higher. If the suns of each firmament, which are but the congress of multitudes of atoms originally distinct, are related in this wise—may not some similar system and similar destiny characterize Systems

of Firmaments? Perhaps, as has been already conjectured, in the meanwhile these are also related, somehow as the stars in each cluster—slowly performing mighty revolutions, whose recurrence constitutes the august *Annus Magnus* of Creation—the highest unit of existing Time. And meanwhile the elements of decay, or rather of change, are also amid this mechanism;—probably all is passing, in a silence next to motionless—quietly as the leaf grows—towards some unknown consummation! The eye stretches in vain in the direction of the epochs thus foreshadowed,—they are epochs with which the duration of all we can imagine is utterly incommensurable: but yet their coming seems sure; and by the existing forms and arrangements of matter their features appear preparing.

II.

It is fortunate for speculations like the foregoing, that within our own Firmament, aspects are distinguishable not only sustaining them through a strong analogy, but even pioneering the way to yet bolder thoughts. Our milky zone has been already described as a ring for the most part isolated, in which the stars are very dense, and

where an aggregating power, within themselves, has drawn them from the general mass, and compressed them into a crowded girdle. But, as will be recollected, neither is this girdle uniform. In Chapter V. I called especial attention to its division apparently into groups for the most part inclining to the spherical form, and separated from each other by dark spaces like wrinkles of age. Sir William Herschel counted no less than 225 such groups or subordinate clusters, within the extent of it he examined; and as all these were of a kind to mark the action of gravity, he concluded the existence of a clustering power, *drawing the stars of it into separate groups*, a power which had *broken up the uniformity of the Zone*, and to whose irresistible power it was still exposed. "Hence," says Herschel, in one of those bold moments in which he fearlessly traversed the infinities alike of past and future, "Hence may we be certain that the stars will there be gradually compressed through successive stages of accumulation, till they come up to what may be called the ripening period of the globular cluster and total insulation; from which it is evident that the Milky Way must forcibly be broken up, and cease to be a stratum of scattered stars." "We may also," he continues,

in the same lofty mood, "draw an important additional conclusion from the gradual dissolution of the Milky Way; for the state into which the incessant action of the clustering power has brought it, is a kind of *chronometer*, that may be used to measure the time of its past and present existence; and although we do not know the rate and going of this mysterious chronometer, it is nevertheless certain, that since a breaking up of the parts of the Milky Way affords a proof that it cannot last for ever, it equally bears witness that its past duration cannot be admitted to be infinite!" Surely the vision of these unfathomable changes—of the solemn march of the majestic Heavens from phase to phase, obediently fulfilling their awful destiny, will be lost on the heart of the adorer, unless when beneath the canopy on which their annals are inscribed, it swells with that humility which is the best homage to the Supreme!

Grounding on these sublime speculations, and taking into view some other facts, we are led to remoter conclusions. If the aggregation of the stars in the Milky Way goes on, as it prognosticates, for Ages,—the clusters, now with some

intermission forming its ring, will become isolated, and appear in the character of separate systems. But, if this may happen in time future, *may something similar not have happened in time past?* And what other is the meaning of those Magellanic clouds in the south? May they not exhibit a multitude of stars and clusters originally belonging to our system, in *the very act of becoming isolated?* Referring once more to that approximate chart in Plate II., how irregular it is, how narrow in one direction and how ragged its edges! Can it be possible that masses of stars have been torn away from it in those directions, so that its thinness may simply indicate, that through the action of some irresistible cause, parts of it had there *ripened* sooner? Singular to relate, it is precisely towards these thin sides, and almost immediately beyond them, that the vast mass of *neighbouring* isolated clusters is found—clusters all spherical, and grouping together in extraordinary proximity. In Plate XX., you have part of the wing of VIRGO—a constellation situated near the shallowest part of our firmament. Observe how crowded it is with groups—some of them Nebulæ indeed, but most of them small round clusters, exhibiting a marked degree of compression. In the regions on the op-

posite side, the same phenomenon occurs; from which, aided by speculation, we infer that the process of separation *has gone on*, and that the apparent breaking up of the Milky Way in our time, is simply a prolongation of part of the changes of the long past, to which our capricious firmament owes its irregular form.

Collecting now these scattered gleams of truth, we reverently approach our last generalization. The separate firmaments which the telescope has descried and mapped down, show, as has been stated, even more emphatically than the groups in the Milky Way, the efficacy and progress of a clustering power;—may not *all* have come originally from one homogeneous stratum or mass of stars, so that their present isolation—their separation and various groupings, are only the ongoings of the clock—the gigantic steps of the hand, by which Time records the days of the years of the existing mechanism of the Universe! Stupendous the conception, that these great Heavens—the Heavens we have deemed a synonym of the Infinite and Eternal, are nothing, after all, but one aspect in which matter is destined to present itself —their history like the birth, life, the death and

dissolution of the fragile plant! If this, indeed, is true, and on behalf of the conception we can marshal many probabilities, how immense the sphere of real existence—how little can we ever know of it; at least how much must be referred to that higher state of existence—an expected eternity of sublime contemplation.

We have entered on solemn ground. Take into consideration the influence of this vast mechanism over the minute arrangements of its subservient parts: observe the amount of most diverse organisation, the almost infinite varieties of intelligence —wonderfully various even within our limited ken—which must be attached to the progress of the Heavens, growing with them as they grow, changing during every new phase, and sympathizing with their decline:—who then shall say that even the highest created spirit will ever exhaust the fulness of that volume which God has spread before us all, in illustration of his own Infinite Nature!

—Suppose we are yet mistaken: suppose the Nebular Hypothesis, with all its grasp, not to be the true key to the mystery of the origin and

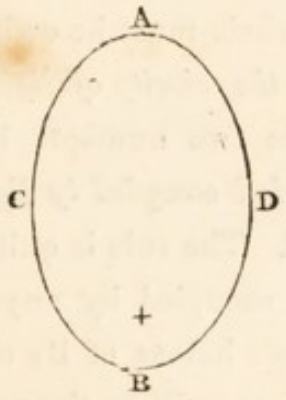
destinies of things, what is gained—what new possession—by that course of bold conjecture on which we have ventured to embark? This, at least, is established on grounds not to be removed. In the vast Heavens, as well as among phenomena around us, all things are in a state of change and PROGRESS: there too—on the sky—in splendid hieroglyphics the truth is inscribed, that the grandest forms of present Being are only GERMS swelling and bursting with a life to come! And if the Universal fabric is thus fixed and constituted, can we imagine that aught which it contains is unupheld by the same preserving law, that annihilation is a possibility real or virtual—the stoppage of the career of any advancing Being, while hospitable Infinitude remains? No! let the night fall; it prepares a dawn, when Man's weariness will have ceased, and his soul be refreshed and restored.—To COME!—To every Creature these are words of Hope spoken in organ tone: our hearts suggest them, and the stars repeat them, and, through the Infinite, Aspiration wings its way, rejoicingly as an eagle following the Sun.

NOTES.

NOTE A.

THE ORBITS OF THE DOUBLE STARS.

In the *Annuaire de Bureau des Longitudes* for 1834, M. Arago has, with his usual precision, detailed a very ingenious method, first pointed out by Savary, which promises to afford accurate results on the subject discussed in the text. It depends on the fact, that Light does not move instantaneously, but with a certain definite velocity, so that a specific time elapses between the moment when the ray leaves a luminous body and that when it enters our eye. The following considerations will illustrate the method I speak of. Suppose ACBD the orbit of a double star, whose period is 200 years, and let the star be so distant from the earth when at the points A



and B of its orbit, that its light occupies two years in the

first instance, and one year in the second, in passing toward us,—what will be the effect of this upon the body's apparent motion? The result will be brought out most distinctly by calculation.

Let the star be at A in the year 1800,
It will be at B in . . 1900,
And at A on its return in 2000.

But since light occupies two years in arriving from A to the Earth, and one year in reaching us from B,

The star will be seen by us at A in 1802,
And at B in . . . 1901.

So that it will seem to have performed one-half of its revolution, or to have gone through the half A C B of its orbit in *ninety-nine* years.

Again,

It is seen at B in . 1901,
And once more at A in 2002.

So that it will seem to have revolved from B to A, or to have gone through the other half of its orbit BDA in *one hundred and one* years. But as it really does pass through these two arcs in precisely the same time, this apparent difference of its periods must be owing to the *size of its orbit as measured by the velocity of light;* and in fact half the difference of the two numbers 101 and 99, or one year, *is just the period occupied by light in traversing the distance from A to B.* The rule is quite general: Observe the apparent times occupied by any revolving star, in going through the two halves of its orbit; and half the difference of these times will be the period in which light passes through the diameter of its orbit; and as the velo-

city of light is known, that diameter may therefore be computed in miles. The only obstacle to the general application of the method consists in the difficulty of noting exactly when the star is at the two opposite points of its orbit; but it will yield, nevertheless, results accurate within certain limits. It is impossible to give too much credit to the ingenuity of M. SAVARY.

NOTE B.

LAPLACE'S ORIGINAL PAPER CONCERNING THE NEBULÆ.

I HAVE considered that a reprint of the following memoir by the most remarkable Analyst of the age, must be interesting to all my readers. It contains the ground of the chief part of our seventh Chapter.

"We have the five following phenomena to assist us in investigating the cause of the primitive motions of the planetary system. The motions of the planets in the same direction, and very nearly in the same plane; the motions of the satellites in the same direction as those of the planets; the motions of rotation of these different bodies and also of the Sun, in the same direction as their motions of projection, and in planes very little inclined to each other; the small eccentricity of the orbits of the planets and satellites; finally, the great eccentricity of the orbits of the comets, their inclinations being at the same time entirely indeterminate.

"Buffon is the only individual that I know of, who, since the discovery of the true system of the world, endeavoured to investigate the origin of the planets and satellites. He supposed that a comet, by impinging on the sun, carried

away a torrent of matter, which was reunited far off, into globes of different magnitudes and at different distances from this star. These globes, when they cool and become hardened, are the planets and their satellites. This hypothesis satisfies the first of the five preceding phenomena; for it is evident that all bodies thus formed should move very nearly in the plane which passes through the centre of the Sun, and through the direction of the torrent of matter which has produced them: but the four remaining phenomena appear to me inexplicable on this supposition. Indeed the absolute motion of the molecules of a planet ought to be in the same direction as the motion of its centre of gravity; but it by no means follows from this, that the motion of rotation of a planet should be also in the same direction. Thus the Earth may revolve from east to west, and yet the absolute motion of each of its molecules may be directed from west to east. This observation applies also to the revolution of the satellites, of which the direction in the same hypothesis, is not necessarily the same as that of the motion of projection of the planets.

"The small eccentricity of the planetary orbits is a phenomenon, not only difficult to explain on this hypothesis, but altogether inconsistent with it. We know from the theory of central forces, that if a body which moves in a reëntrant orbit about the Sun, passes very near the body of the Sun, it will return constantly to it, at the end of each revolution. Hence it follows, that if the planets were originally detached from the Sun, they would touch it, at each return to this star; and their

orbits, instead of being nearly circular, would be very eccentric. Indeed it must be admitted that a torrent of matter detached from the Sun, cannot be compared to a globe which just skims by its surface : from the impulsions which the parts of this torrent receive from each other, combined with their mutual attraction, they may, by changing the direction of their motions, increase the distances of their perihelions from the Sun. But their orbits should be extremely eccentric, or at least all the orbits would not be *q. p.* circular, except by the most extraordinary chance. Finally, no reason can be assigned on the hypothesis of Buffon, why the orbits of more than one hundred comets, which have been already observed, should be all very eccentric. This hypothesis, therefore, is far from satisfying the preceding phenomena. Let us consider whether we can assign the true cause.

" Whatever may be its nature, since it has produced or influenced the direction of the planetary motions, it must have embraced them all within the sphere of its action ; and considering the immense distance which intervenes between them, nothing could have effected this but a fluid of almost indefinite extent. In order to have impressed on them all a motion *q. p.* circular and in the same direction about the Sun, this fluid must environ this star, like an atmosphere. From a consideration of the planetary motions, we are therefore brought to the conclusion, that in consequence of an excessive heat, the solar atmosphere originally extended beyond the orbits of all the planets, and that it has successively contracted itself within its present limits.

"In the primitive state in which we have supposed the Sun to be, it resembles those substances which are termed nebulæ, which, when seen through telescopes, appear to be composed of a nucleus, more or less brilliant, surrounded by a nebulosity, which, by condensing on its surface, transforms it into a star. If all the stars are conceived to be similarly formed, we can suppose their anterior state of nebulosity to be preceded by other states, in which the nebulous matter was more or less diffuse, the nucleus being at the same time more or less brilliant. By going back in this manner, we shall arrive at a state of nebulosity so diffuse, that its existence can with difficulty be conceived.

"For a considerable time back, the particular arrangement of some stars visible to the naked eye, has engaged the attention of philosophers. Mitchel remarked long since how extremely improbable it was that the stars composing the constellation called the Pleiades, for example, should be confined within the narrow space which contains them, by the sole chance of hazard; from which he inferred that this group of stars, and the similar groups which the heavens present to us, are the effects of a primitive cause, or of a primitive law of nature. These groups are a general result of the condensation of nebulæ of several nuclei; for it is evident that the nebulous matter being perpetually attracted by these different nuclei, ought at length to form a group of stars, like to that of the Pleiades. The condensation of nebulæ consisting of two nuclei, will in like manner form stars very near to each other, revolving the one about the other like

to the double stars, whose respective motions have been already recognised.

"But in what manner has the solar atmosphere determined the motions of rotation and revolution of the planets and satellites? If these bodies had penetrated deeply into this atmosphere, its resistance would cause them to fall on the Sun. We may therefore suppose that the planets were formed at its successive limits, by the condensation of zones of vapours, which it must, while it was cooling, have abandoned in the plane of its equator.

"Let us resume the results which we have given in the tenth chapter of the preceding book. The Sun's atmosphere cannot extend indefinitely; its limit is the point where the centrifugal force arising from the motion of rotation balances the gravity; but according as the cooling contracts the atmosphere, and condenses the molecules which are near to it, on the surface of the star, the motion of rotation increases; for in virtue of the principle of areas, the sum of the areas described by the radius vector of each particle of the Sun and of its atmosphere, and projected on the plane of its equator, is always the same. Consequently the rotation ought to be quicker, when these particles approach to the centre of the Sun. The centrifugal force arising from this motion becoming thus greater; the point where the gravity is equal to it, is nearer to the centre of the Sun. Supposing therefore, what is natural to admit, that the atmosphere extended at any epoch as far as this limit, it ought, according as it cooled, to abandon the molecules, which are situated at

this limit, and at the successive limits produced by the increased rotation of the Sun. These particles, after being abandoned, have continued to circulate about this star, because their centrifugal force was balanced by their gravity. But as this equality does not obtain for those molecules of the atmosphere which are situated on the parallels of the Sun's equator, these have come nearer by their gravity to the atmosphere according as it condensed, and they have not ceased to belong to it, inasmuch as by this motion, they have approached to the plane of this equator.

"Let us now consider the zones of vapours which have been successively abandoned. These zones ought, according to all probability, to form by their condensation, and by the mutual attraction of their particles, several concentrical rings of vapours circulating about the Sun. The mutual friction of the molecules of each ring ought to accelerate some and retard others, until they all had acquired the same angular motion. Consequently the real velocities of the molecules which are farther from the Sun, ought to be greatest. The following cause ought likewise to contribute to this difference of velocities: The most distant particles of the Sun, and which, by the effects of cooling and condensation, have collected so as to constitute the superior part of the ring, have always described areas proportional to the times, because the central force by which they are actuated has been constantly directed to this star; but this constancy of areas requires an increase of velocity, according as they approach more to each other. It appears that the same cause ought to

diminish the velocity of the particles, which, situated near the ring, constitute its inferior part.

"If all the particles of a ring of vapours continued to condense without separating, they would at length constitute a solid or a liquid ring. But the regularity which this formation requires in all the parts of the ring, and in their cooling, ought to make this phenomenon very rare. Thus the solar system presents but one example of it; that of the rings of Saturn. Almost always each ring of vapours ought to be divided into several masses, which, being moved with velocities which differ little from each other, should continue to revolve at the same distance about the Sun. These masses should assume a spheroidical form, with a rotatory motion in the direction of that of their revolution, because their inferior particles have a less real velocity than the superior; they have therefore constituted so many planets in a state of vapour. But if one of them was sufficiently powerful, to unite successively by its attraction all the others about its centre, the ring of vapours would be changed into one sole spheroidical mass, circulating about the Sun, with a motion of rotation in the same direction with that of revolution. This last case has been the most common; however, the solar system presents to us the first case, in the four small planets which revolve between Mars and Jupiter, at least unless we suppose with Olbers, that they originally formed one planet only, which was divided by an explosion into several parts, and actuated by different velocities. Now if we trace the changes which a farther cooling ought to produce in the planets formed of vapours, and of

which we have suggested the formation, we shall see to arise in the centre of each of them, a nucleus increasing continually, by the condensation of the atmosphere which environs it. In this state, the planet resembles the Sun in the nebulous state, in which we have first supposed it to be; the cooling should therefore produce at the different limits of its atmosphere, phenomena similar to those which have been described, namely, rings and satellites circulating about its centre in the direction of its motion of rotation, and revolving in the same direction on their axes. The regular distribution of the mass of rings of Saturn about its centre and in the plane of its equator, results naturally from this hypothesis, and, without it, is inexplicable. Those rings appear to me to be existing proofs of the primitive extension of the atmosphere of Saturn, and of its successive condensations. Thus the singular phenomena of the small eccentricities of the orbits of the planets and satellites, of the small inclination of these orbits to the solar equator, and of the identity in the direction of the motions of rotation and revolution of all those bodies with that of the rotation of the Sun, follow from the hypothesis which has been suggested, and render it extremely probable. If the solar system was formed with perfect regularity, the orbits of the bodies which compose it would be circles, of which the planes, as well as those of the various equators and rings, would coincide with the plane of the solar equator. But we may suppose that the innumerable varieties which must necessarily exist in the temperature and density of different parts of these great masses, ought to produce

the eccentricities of their orbits, and the deviations of their motions, from the plane of this equator.

"In the preceding hypothesis, the comets do not belong to the solar system. If they be considered, as we have done, as small nebulæ, wandering from one solar system to another, and formed by the condensation of the nebulous matter, which is diffused so profusely throughout the universe, we may conceive that when they arrive in that part of space where the attraction of the Sun predominates, it should force them to describe elliptic or hyperbolic orbits. But as their velocities are equally possible in every direction, they must move indifferently in all directions, and at every possible inclination to the ecliptic; which is conformable to observation. Thus the condensation of the nebulous matter, which explains the motions of rotation and revolution of the planets and satellites in the same direction, and in orbits very little inclined to each other, likewise explains why the motions of the comets deviate from this general law.

"The great eccentricity of the orbits of the comets, is also a result of our hypothesis. If those orbits are elliptic, they are very elongated, since their greater axes are at least equal to the radius of the sphere of activity of the Sun. But these orbits may be hyperbolic; and if the axes of these hyperbolæ are not very great with respect to the mean distance of the Sun from the Earth, the motion of the comets which describe them will appear to be sensibly hyperbolic. However, with respect to the hundred comets, of which the elements are known, not one

appears to move in a hyperbola; hence, the chances which assign a sensible hyperbola are extremely rare relatively to the contrary chances. The comets are so small, that they only become sensible when their perihelion distance is inconsiderable. Hitherto this distance has not surpassed twice the diameter of the Earth's orbit, and most frequently it has been less than the radius of this orbit. We may conceive, that in order to approach so near to the Sun, their velocity at the moment of their ingress within its sphere of activity, must have an intensity and direction confined within very narrow limits. If we determine by the analysis of probabilities, the ratio of the chances which in these limits assign a sensible hyperbola to the chances which assign an orbit, which may without sensible error be confounded with a parabola, it will be found that there is at least six thousand to unity that a nebula which penetrates within the sphere of the Sun's activity so as to be observed, will either describe a very elongated ellipse, or an hyperbola, which, in consequence of the magnitude of its axis, will be as to sense, confounded with a parabola in the part of its orbit which is observed. It is not, therefore, surprising that hitherto no hyperbolic motions have been recognised.

"The attraction of the planets, and perhaps also the resistance of the ethereal media, ought to change several cometary orbits into ellipses, of which the greater axes are much less than the radius of the sphere of the solar activity. It is probable that such a change was produced in the orbit of the comet of 1759, the greater axis of which was not more than thirty-five times the distance of the

Sun from the Earth. A still greater change was produced in the orbits of the comets of 1770 and of 1805.

"If any comets have penetrated the atmospheres of the Sun and planets at the moment of their formation, they must have described spirals, and consequently fallen on these bodies, and in consequence of their fall, caused the planes of the orbits and of the equators of the planets to deviate from the plane of the solar equator.

"If in the zones abandoned by the atmosphere of the Sun, there are any molecules too volatile to be united to each other, or to the planets, they ought in their circulation about this star to exhibit all the appearances of the zodiacal light, without opposing any sensible resistance to the different bodies of the planetary system, both on account of their great rarity, and also because their motion is very nearly the same as that of the planets which they meet.

"An attentive examination of all the circumstances of this system renders our hypothesis still more probable. The primitive fluidity of the planets is clearly indicated by the compression of their figure, conformably to the laws of the mutual attraction of their molecules; it is, moreover, demonstrated by the regular diminution of gravity, as we proceed from the equator to the poles. This state of primitive fluidity to which we are conducted by astronomical phenomena, is also apparent from those which natural history points out. But in order fully to estimate them, we should take into account the immense variety of combinations formed by all the terrestrial substances which were mixed together in a state of vapour,

when the depression of their temperature enabled their elements to unite; it is necessary likewise to consider the wonderful changes which this depression ought to cause in the interior and at the surface of the earth, in all its productions, in the constitution and pressure of the atmosphere, in the ocean, and in all substances which it held in a state of solution. Finally, we should take into account the sudden changes, such as great volcanic eruptions, which must at different epochs have deranged the regularity of these changes. Geology thus studied under the point of view which connects it with astronomy, may, with respect to several objects, acquire both precision and certainty."

The foregoing is from the *Systeme du Monde.* The principles contained in it are capable of other very striking applications to the phenomena of the planetary bodies; but as these have much more of a *special* character, I have placed their exposition in the second volume of this series, which is now passing through the press.

It may not be improper to state here, that since the second chapter of this work was printed, I have received authentic notice of the most satisfactory progress of Lord Rosse's great disc of six feet. The superb telescope of which it is the mirror, will, in all probability, be completed in July,—and there cannot be a doubt, that the most important revelations will be the immediate consequence.

With regard to the Nebulæ, I mean their shape and condition as to condensation, a vast amount of new infor-

mation must result. I doubt not that many of them, whose shapes now seem regular, will appear very different, just as that in Orion shows an almost infinity of branches in a large telescope, which are invisible to a small one. We shall therefore be obliged to class as ovals, or as ragged masses, many that have hitherto seemed round; and probably these irregularities may lead to some interesting speculations, as to the nature of the original masses, and of the forces which are still acting in antagonism of the condensing energy.

I may be permitted to suggest, that an opportunity certainly has occurred of accomplishing the task of separating decisively large masses of those dim spots into the class of pure Nebulæ, considering these as apart from remote clusters. The principle on which this may be done is very evident. It may easily be made out by a careful induction from particulars, as to whether there is any general relation between the telescopic power required to see a stellar cluster as a nebulous spot and that which is needful to resolve it. I believe there is such a relation, and that its reality may, by a multiplicity of proofs, (with scarce any exception,) be placed beyond doubt. In the present state of our knowledge, then, those spots which wholly defy the energy of the requisite resolving power (as that in Orion has done, and many others) ought all to be taken as pure Nebulæ.

—As I close the sheets of this work, a new comet has darted like an apparition within our sphere, and again withdrawn itself! It was more a nebulous streak than a comet, for its nucleus had no proportion to its superb

elongated train. No one who witnessed it, can I should think doubt that the nebulous bodies with which it has affinity, must, in the profound recesses whence it so unexpectedly came, act some great part in the Economy of the Universe.

NOTE C.

LOCALITIES OF THE PRINCIPAL CLUSTERS AND NEBULÆ.

I subjoin a statement of the exact places of the more important objects represented in the foregoing plates; so that the possessors of good telescopes may have the opportunity of examining such as are within their reach. I give their Right Ascensions and Declinations, by means of which their localities among the stars may easily be detected upon a celestial globe, and thus found without difficulty in the Heavens.

	Right Ascen. H.	M.	Declinations. Deg.	Min.	
Plate I. Cluster in Hercules,	16	35½	36	45	N.
Plate III., . . .	13	22½	46	14	N.
Plate IV. Fig. 1, . .	15	10	2	44	N.
Fig. 2, . .	21	25	1	34	S.
Plate VI. Fig. 1, faintest of the two rings, .	20	9½	30	3	N.
Fig. 2, brightest of the two rings,	18	47	32	49	N.
Fig. 3, oblong hoop,	2	12	41	35	N.

	Right Ascen. H.	M.	Declinations. Deg.	Min.
Plate VI. Fig. 4, oval figure beside the hoop,	12	48	22	37 N.
Fig. 5, large figure,	19	52	22	16 N.
Plate X. Nebula in Orion,	5	27	5	30½
Plate XI. Fig. 1, Nebula in Andromeda,	0	33½	40	20
Plate XII.				
Fig. 2, . .	20	38½	30	6 N.
Fig. 3, . .	20	49	31	3 N.
Plate XIII., . . .	18	11	16	15 S.
Plate XIV. Double Nebulæ,	9	22½	22	15 N.
	7	15	29	49 N.
	22	51	13	43 S.
Two stars on faint bed of light,	18	7	19	56 S.
Plate XVII. Nebulous stars,	17	0	23	7 N.
	19	40	50	6 N.
	3	58½	30	20 N.
Plate XVIII. Reticulated form,	20	50	29	34 N.
Nebulous matter connected with stars,	12	51	35	47 N.
	20	56	11	24 N.
	6	30	8	53 N.
	8	46½	54	25 N.

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