

A syllabus of a course of lectures on astronomy; illustrated by ... the new dioastrodoxon; or, grand transparent orrery ... With an epitome of that branch of science ... and a short account of that beautiful machine / [Robert Evans Lloyd].

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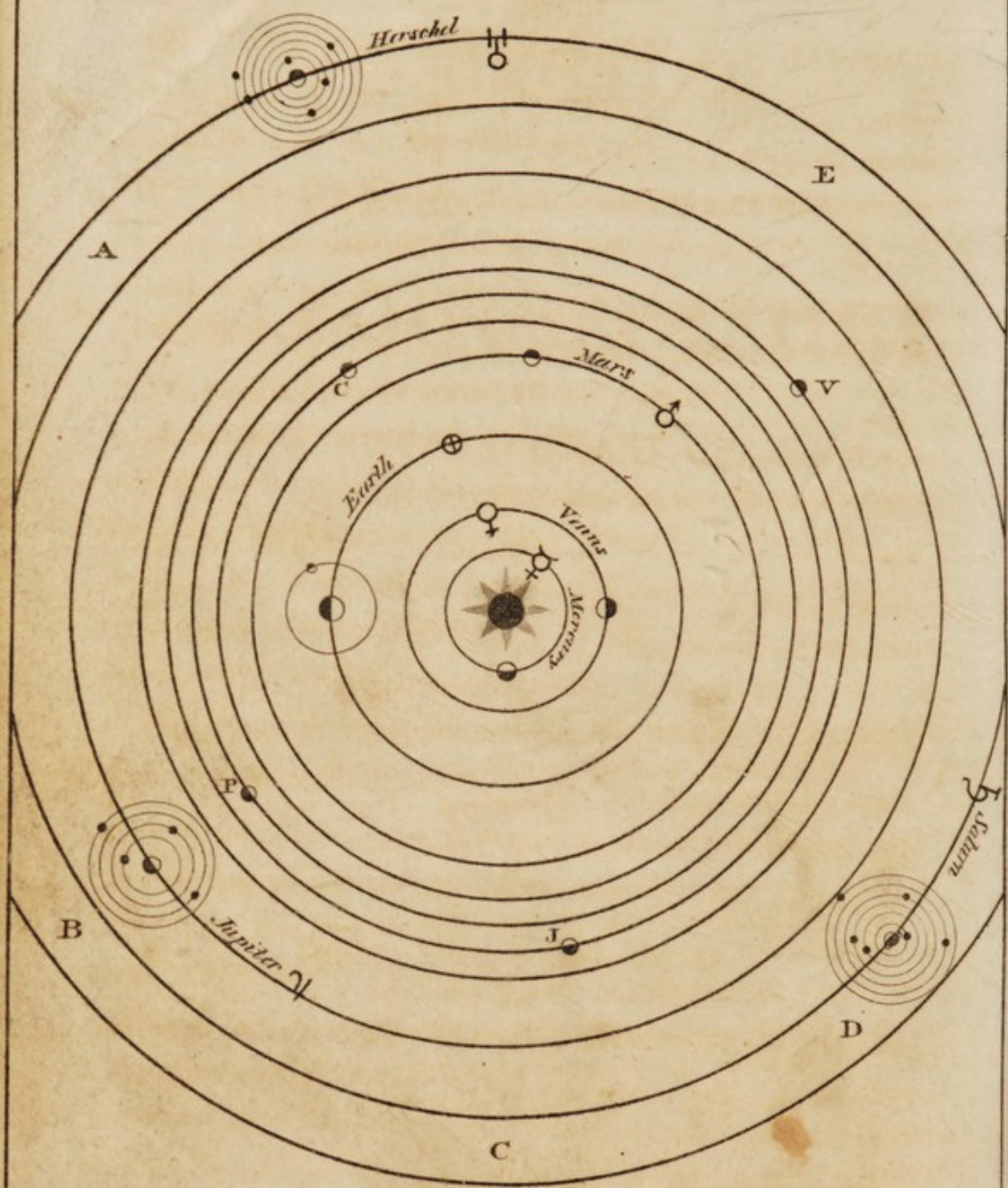
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Lloyd,

Astronomy

SOLAR SYSTEM



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A
SYLLABUS
OF A
COURSE OF LECTURES
ON
ASTRONOMY;

ILLUSTRATED BY

That Magnificent and Highly improved Apparatus

THE NEW

DIOASTRODOXON;

OR,

GRAND TRANSPARENT ORRERY,

TWENTY-ONE FEET DIAMETER.

BY

R. E. LLOYD,

THE ONLY LEGITIMATE PROPRIETOR,

FROM THE THEATRE OF ASTRONOMY, THE THEATRE ROYAL,
HAYMARKET, LONDON; AND THE SURREY THEATRE.

WITH AN

EPITOME OF THAT BRANCH OF SCIENCE,

ITS ORIGIN AND PROGRESS,

AND A

SHORT ACCOUNT OF THAT BEAUTIFUL MACHINE.

“OMNIBUS NUMEN ADEST.”

OXFORD:

PRINTED BY MUNDAY AND SLATTER.

1812.

ADDRESS.

THE highly improved Orrery which R. E. LLOYD has the honour of reading upon, together with the superb auxiliary aid, has been constructed and selected, with much care and attention, to astronomical propriety, under his own immediate direction, at the expense of upwards of 500 guineas, for the purpose of illustrating a variety of curious and important astronomical discoveries, which are to constitute the subjects of his Lectures.

A scientific acquaintance with Astronomy is not attainable without a previous knowledge of the Mathematics; such an acquaintance with that sublime and useful science he will, therefore, leave to those who have leisure, abilities, and inclination to engage in the pursuit of, to acquire at the college, or in the closet.

His aim is to communicate the results of astronomical observations and calculations, in a plain, familiar, and popular language, and by means of his machine and an explanation of the various objects which it will present to the eye, to aid the imagination in forming clear conceptions of astonishing phenomena existing in nature.

If just and enlarged ideas of those striking and beautiful objects tend to exalt and delight the human mind, he would indulge the hope, that the attempt to communicate such ideas will not be deemed, by a generous Public, unworthy their liberal patronage and support.



A SYLLABUS, &c.

LECTURE I.

INTRODUCTION.—The use and advantage of Astronomy in conveying to the mind just and enlarged ideas of beautiful and astonishing phenomena existing in nature. The Sun ; his place in the system ; revolves round his axis ; solar spots, their magnitudes how ascertained.—The Earth and its motion explained.—Rising and setting of the heavenly bodies.—Phenomena apparently the same, whether the Earth revolves on its axis, or not.—Obliquity of the ecliptic ; vicissitude of the seasons ; precession of the equinoxes ; shewing, that in process of time the longest day will be when the Earth enters Capricorn.—Orbit elliptical ; perihelion ; aphelion ; summer $8\frac{1}{2}$ days longer than winter ; Sun nearer the Earth in winter than in summer ; hotter in summer than in winter, and why.—The Moon ; her phases ; periodical, synodical month ; length of day and night ; orbit inclined to the ecliptic.—Common centre of gravity of the Earth and Moon, describes the great orbit round the Sun ; diurnal, menstrual, and annual libration, in latitude and longitude.—Atmosphere ; its density and how discovered. The great length of moonlight at the poles, and a description of that phenomenon called the harvest-moon.—The inferior planets, Mercury and Venus, their periodical times, relative distances, proportional magnitudes ; motions, direct, retrograde, stationary ; transits.—The phenomena of the heavens as seen from different parts of the Earth, and from the Sun.—The whole solar system, with the appearance of the fixed stars which constitute the Zodiac.

LECTURE II.

THE Ptolemaic and Tyconic systems examined, and

refuted, and the Copernican, or solar system demonstrated to be the true system of nature.

The causes of eclipses, both solar and lunar, their periods ascertained; their limits, number, and duration illustrated, and perfectly familiarized, even to those who have not previously thought on the subject.

The true time of the birth and death of our *blessed Saviour* accurately determined by astronomy and chronology; a beautiful delineation of an eclipse will take place both solar and lunar, demonstrating that the great darkness at his crucifixion was supernatural, and could not arise from an eclipse.

The phenomena of the superior planets, with their satellites, viz. Mars, the four Asteroids, Ceres, Pallas, Juno, and Vesta; Jupiter, and his four moons, with their occultations or eclipses; Saturn, with his seven attendant moons; and that wonderful phenomenon, the double ring; diurnal motion of the planet and ring; the Georgium Sidus with six moons; their revolutions, oppositions, conjunctions, and harmonic phenomena, illustrated and clearly explained; remarks on the astronomy and chronology of the Chaldeans, Chinese, and Egyptians: the origin of the cause, names, and figures, of the twelve signs of the zodiac, and their uses; a few observations on the galaxy, or milky-way; and the astonishing discoveries made in that extensively illuminated track of the heavens.

The telescopic appearance of the planets, and fixed stars.

LECTURE III.

A FURTHER investigation of the theory of the Earth, and its motion; the difference between real and apparent time, and the causes. Orbits of all the planets ellipses; anomalies arising therefrom; the universal system of gravitation or attraction; an investigation of this occult principle of sympathy and union, which gives life and motion to inanimate things, and invigorates the whole frame of nature. The moon retained in her or-

bit by a force which decreases, as the square of the distance increases; retained in her orbit by gravity; confirmed by the tides; the theory of the tides illustrated and explained, and the deviations from the general rule, which proceed from local causes, the nature of the soil, rarefaction, &c.—Remarks on the theory of St. Pierre.—Phenomena which arise from the division of time and the eccentricity of the Earth's orbit.—Progressive motion of light: its velocity ascertained.—Aberration of the Stars; have no sensible parallax—Comets, orbits of, very eccentric; variously inclined to the ecliptic; describe equal areas in equal times; account of the most remarkable ones; particularly the Comet of 1807, and that beautiful Comet which appeared in the Arctic Sky in 1811; their nature, uses, and influence on our planetary system: with an apology for a new theory. A dissertation on the probable cause of the Deluge; its universality proved from modern Geology. The structure of the earth examined; its various mutations of primitive and alluvial strata; the phenomena of earthquakes, &c.—Observations on the nature of Light and Heat; the composition of the Sun, with Dr. Herschell's remarks on that luminary and the sidereal system to which we belong, together with the infinite systems of stars which compose the universe.



A CONCISE ACCOUNT OF THE

DIOASTRODOXON.

This splendid machine stands perpendicular to the spectators, and the globes are so large that the smallest phenomenon may be distinctly seen in the most distant part of a large theatre.

THE FIRST SCENE opens with the Sun and the Earth.—The Sun in the centre of the system, with the spots on its disk; its rays diverge in all directions.

The earth in the ecliptic, represented by a large glass globe, 6 feet in circumference, magnificently appears, beautifully adorned with meridians, land, and water; its axis inclined $23\frac{1}{2}$ degrees from a perpendicular to the plane of its orbit, keeping its parallelism, by which its northern and southern hemispheres alternately address themselves to the Sun, clearly pointing out that when it is summer in one hemisphere it is winter in the other, and *vice versa*: the Earth at the same time revolving round its axis, exhibits the causes of day and night, the rising, southing, and setting of the heavenly bodies. A bare inspection of the machine is sufficient to convey the clearest ideas of these phenomena.

THE SECOND SCENE consists of the Sun, Earth, and Moon, exhibiting the various phases of the Moon in its diurnal and annual motion round the Earth and Sun; the Earth projects a conical shadow opposite to the Sun during its journey round him, the Moon borrowing her light from the Sun; as she revolves round her axis in 29 days, 12 hours, and 44 minutes, in the 12 revolutions she will make round the Earth, while the Earth moves round the Sun, it will evidently appear that the Earth is a Moon to her; the Moon will cross the plane of the Earth's orbit in two places, which points of intersection, (called the Moon's nodes, an imaginary path in the heavens) move backwards 19 deg. 1-third every year, and revolve round the ecliptic in 18 years, 225 days. The shifting of the nodes regulates the eclipses of the Sun and Moon. When the Moon changes in one of these nodes, an eclipse of the Sun is produced; when at the full in one of these nodes, an eclipse of the Moon is produced; at other times she passes above or below the Earth's shadow and eclipses do not take place.—Eclipses are produced in this scene as they take place in nature, and are perfectly evident on inspection.

THE THIRD SCENE displays the whole Copernican or Solar System, with every planet and satellite in diurnal and annual motion. By this truly intelligent

and comprehensive scene, the periods, distances, and various phenomena of the superior planets, Mars, Jupiter, Saturn, the Georgian planet, with their attendant moons, and Saturn's ring, are familiarly demonstrated. In this sublime and awful view of the creation, the union of celestial and sublunary nature is eminently conspicuous; the infinitely refined gradations, the mutual dependance of the constituent parts, the benevolent organization of the whole frame of nature, silently reveal the emanation of the DEITY, in proclaiming, that *subordination and dependance constitute the divine harmony of the universe*; "Order is heaven's first law." A conviction of the importance of this sublime and sacred truth produced that beautiful and animated apostrophe we find in the Psalmist, *The heavens declare the glory of God, and the firmament sheweth his handy-work.*

THE FOURTH SCENE also consists of the Sun, Earth, and Moon. This scene shews in a perspicuous manner, how the Earth and Moon agitate each other round their common centre of gravity. The Earth's three-fold motion appears; that round its axis producing day and night; that round the Sun producing the year and the seasons; and that round the common centre of gravity, with the Moon, producing spring and neap tides, by their combined and opposite forces.—At the full Moon the Earth is nearer the Sun than at the change by 12,000 miles, and their influences are equally united. At the quarters the Sun's influence on the waters under and opposite to him, diminishes the Moon's influence on the waters, under and opposite to her, and two tides are produced in about $24\frac{3}{4}$ hours opposite to each other, as the earth turns round its axis; the effect of centrifugal force and its influence on the tides, are perfectly evident to sight.—In this scene, the grandeur, simplicity, and frugality of nature in the effects produced from the simple principle of gravitation, which pervades the universe and sets every wheel and spring of it in motion, are admirably pourtrayed and familiarised.

SCENE V. the unbounded view of creation which every starry night presents to the inquiring eye of mortals, excites our admiration and wonder!

“What read we here?”—“The existence of a GOD!”

In this extensive volume the Astronomer discovers the laws of nature; not by tracing them up to their principles, which are known to God only, but by descending into their results, destined to the use of man. Here harmonic principles are so luminous, that they present each star a sun, the centre of a system similar to our own, each system intimately connected; these systems dependant on a system of stars, over which presides one infinitely superior to all the rest, round which they all move, and obey him as a centre, or lord. This magnificent scene is an humble attempt to convey to the eye a view of that exquisitely refined relation, the medium by which we are enabled to perceive certain principles of the corresponding harmonies which govern the universe.—The appearance of the Comet of 1680 is represented in the Orrery. It descends from the top of the machine towards the Sun, increasing in length and velocity till it arrives at the Sun, and decreasing as it ascends from the sun till it finally disappears.

† In addition to the aforementioned scenes, these Lectures receive wonderful assistance from auxiliary aid to confirm the principles of planetary motion. The nature of refraction; how ships and mountains appear at sea; maps of the Earth and Moon, particularly a beautiful map of the face of the Moon, with the mountains and vallies on its surface, as seen by a telescope of very great magnifying power, and accurately delineated (by permission) from the patent lunar globe invented and made, after 30 years observation, by J. Russell, Esq. R. A. with an index; telescopic views of Jupiter, and Saturn with his ring surrounding him, as seen to the greatest possible advantage; an illustration of the constellations of Orion, Ursa Major, Andromeda, Perseus, Sirius, and a number of others equally important; which will materially assist the imagination in forming just conceptions of the real appearances of the celestial bodies.

ASTRONOMY,

ITS ORIGIN AND PROGRESS.

ASTRONOMY, or that part of physics which teaches the admirable construction of the universe and the economy of the Earth and Sun in pointing out the seasons, appears to have been a popular science even in the primeval world.—Gen. viii. 4. 5.

After the flood, when Noah and his family quitted the Gordian Mounts and began to form a numerous nation on the wide plains of Shinar, (between the Tigris and the Euphrates) the same phenomena were insensibly fixed upon for a renewal of the seasons, because the returns were regular and obvious to every eye. Tradition has handed down to us the ingenious method made use of by the first men to know exactly the line which the Sun describes in the perpetual change of place in the heavens, and to divide the year into 12 equal portions. The Chaldeans* seem to have been the first masters of this science, and appear to have cultivated it in an eminent degree.

Abraham, who descended from Shem, first taught the Egyptians, and Berosus, as cited by Josephus, records him to have been skilled in the science of the stars; and when Abraham and the Egyptians are spoken of it is said expressly that he ingeniously communicated to them the sciences of Arithmetic and Astronomy, for the Egyptians knew nothing of either before he came among them.

Astronomy was transplanted from the East by Pythagoras of Samos, 500 years before the Christian era; but appears to have gradually declined till the 15th century, when it was again restored by Nicholas Copernicus, a native of Thorn, in Poland. His system

* Ur, in Chaldea, a city in Mesopotamia, built by Ashur, the son of Shem.—Gen. xi. 28. Isaiah xviii. 13.

has been followed by the greatest Mathematicians and Philosophers who have since lived, as Kepler, Galileo, Huygens, and Sir Isaac Newton.

But modern Astronomy stands much indebted to the indefatigable exertions of Dr. Herschell, whose telescopes have enabled him to contemplate the regions of space with an accuracy unknown to the ancients.

A BRIEF ACCOUNT OF

THE SOLAR SYSTEM,

Upon Sir ISAAC NEWTON's Principles.

THE Sun, and the Planets and Comets which move round him as their centre, constitute the Solar System. Those Planets which are near the Sun not only finish their circuits sooner, but likewise move faster in their respective orbits, than those which are more remote from him. Their motions are all performed from west to east in orbits nearly circular. Their names, distances, bulks, and periodical revolutions are such as follow.

The Sun ☉,* an immense globe of fire, is placed near the common centre, or rather in the lower focus of the orbits of all the Planets and Comets, and turns round his axis in 25 days, 6 hours,† as is evident by the motion of spots seen on his surface. His diameter

* The Sun, according to Dr. Herschell, is like the planets, an opaque body, but surrounded by an atmosphere of a phosphoric nature, composed of various transparent and elastic fluids, by the decomposition of which light is produced, and lucid appearances formed of different degrees and intensity. He has also assigned very forcible reasons for concluding that the opinion commonly received of the Sun's being a body of real fire, is futile and erroneous. That the Sun is a luminous and not an igneous body, has been thought highly probable by other modern philosophers; an opinion which every new step in Philosophy gives great support to.

† Twenty-five days, ten hours, M. de la Lande.

is computed to be 893,760 miles ; and by the various attractions of the circumvolving Planets, he is agitated by a small motion round the centre of gravity of the system. All the planets as seen from the Sun move the same way, and according to the order of signs in the circle which represents the ecliptic in the heavens.

The circle is divided into 12 equal parts, called signs : each sign into 30 equal parts, called degrees ; each degree into 60 equal parts, called minutes ; and every minute into 60 equal parts, called seconds, (a second being the 60th part of a minute : a minute the 60th part of a degree ; and a degree the 360th part of a circle, or 30th part of a sign.)

The axis of a planet is a strait line conceived to be drawn through its centre, about which it revolves as if on a real axis. The extremities of this line, terminating in opposite points of the planet's surface, are called its poles. That which points towards the northern part of the heavens, is called the north pole, and the other, pointing towards the southern part, is called the south pole.

By the planets' orbits, all that is meant is their paths through the open and unresisting space in which they move ; in which paths they are kept by the attractive power of the Sun, and the projectile force impressed upon them at first ; between which power and force there is so exact an adjustment, that they continue in the same tracks without departing from them.

The phenomena of the heavens as seen from different parts of the Solar System ; and the motions and phases of Mercury and Venus explained.

Mercury ☿, the nearest planet to the Sun, goes round him in 87 days, 23 hours, or a little less than 3 months, which is the length of his year ; but being seldom seen on account of his nearness to the Sun, and no spots appearing on his surface or disk, the time of his rotation on his axis, and the length of his days and nights, are as yet unknown. His distance from the Sun is computed to be 36,841,648 miles, dia-

meter 3,100. In his course round the Sun he moves at the rate of 109,000 miles in an hour.

Venus ♀, the next planet in order, is computed to be 68,890,486 miles from the Sun; and by moving at the rate of 76,000 in an hour, she completes her annual revolution in 224 days and 17 hours, or about 7 months and a half. Her diameter is 9,360 miles, and her diurnal rotation on her axis is performed in 23 hours and 22 minutes; her surface is irregular like the moon, and she is surrounded by an atmosphere.

So vastly great is the distance of the starry heavens, that if viewed from any part of the solar system, or even many millions of miles beyond it, the appearance would be the very same to us. The Sun and Stars would all seem to be fixed in one concave surface of which the spectator's eye would be the centre. But the planets being much nearer than the Stars, their appearances will vary considerably with the place from which they are viewed. If he is on a planet which has a rotation on its axis, not being sensible of his own motion, he will imagine the whole heavens, Sun, Planets, and Stars, to revolve about him in the same time that his planet turns round, but the contrary way; and he will not easily be convinced of the deception. Whether within or without the orbits of the planets, their motions would seem irregular, intricate, and perplexed, unless he is in the centre of the system, and from thence, the most beautiful order and harmony will be seen by him.

The apparent magnitudes of the planets continually change as seen from the Earth, which demonstrates that they approach nearer to it, and recede farther from it by turns. This clearly shews that the Earth is not quiescent in the centre of the Universe. For if this hypothesis were true, Mercury and Venus could never be hid behind the Sun, as their orbits are included within the Sun's; and again these two planets would always move direct, and be as often in opposition to the Sun, as in conjunction with him. But the con-

trary of all this is true; for they are just as often behind the Sun as before him, appear as often to move backward as forward, and are so far from being seen at any time in the side of the Heavens opposite to the Sun, that they were never seen a quarter of a circle in the Heavens distant from him.

These two planets, when viewed at different times with a good Telescope, appear in all the various shapes of the Moon; which is a plain proof that they are enlightened by the Sun, and shine not by any light of their own: for if they did they would constantly appear round as the Sun does; and could never be seen like dark spots upon the Sun when they pass directly between him and us. Their regular phases demonstrate them to be regular bodies.

Venus, from her superior conjunction to her inferior conjunction, is seen on the east side of the Sun, from the Earth, and therefore she shines in the evening after Sun sets, and is called the evening Star; for the Sun being then to the westward of Venus, he must set first. From her inferior conjunction to her superior she appears on the west side of the Sun, and therefore rises before him, for which reason she is called the morning Star, being in each situation alternately for about 280 days; and during the whole of her revolution, she appears through a good telescope to have all the various phases and appearances of the Moon.

When Venus appears bisected, she is so near the Earth, and shines so bright, that bodies cast shadows in the night time.

The Earth is the next planet above Venus, in our system; its distance from the Sun, is 95,173,127 miles, and by travelling at the rate of 68,000 miles in an hour, its annual revolution is performed in 365 days, 5 hours, and 49 minutes, from an equinox or solstice to the same again; but from any fixed Star to the same again, as seen from the Sun, in 365 days, 6 hours, and 9 minutes; the former being the length of the tropical, and

the latter the length of the sidereal year ; which motion, though 120 times swifter than that of a cannon ball, is little more than half the velocity of Mercury in his orbit. The Earth's diameter is 7,970 miles, and by turning round its axis every 24 hours, from west to east, it causes an apparent diurnal motion of all the heavenly bodies, from east to west in the same time. By this rapid motion of the Earth on its axis, the inhabitants about the equator are carried 1042 miles every hour, while those on the parallel of London are carried only about 580, besides the 68,000 miles before mentioned, which they and all others on earth are carried, in space, every hour.

The Earth's axis makes an angle of $23\frac{1}{2}$ degrees with the axis of its orbit, and keeps always the same oblique direction, inclining towards the same fixed stars throughout its annual course, which causes the returns of spring, summer, autumn, and winter.

Astronomical characters of the Zodiac explained.

Aries φ , Taurus δ , Gemini π , Cancer $\♋$,
 Leo Ω , Virgo ♍ , Libra ♎ , Scorpio ♏ , Sagittarius ♐ , Capricornus ♑ , Aquarius ♒ , Pisces ♓ .

THE SEASONS.

Were we to take a view of the general harmonies of this globe, to dwell only on those which are best known to us, behold how the *Sun* constantly encircles with his rays one half of the earth, while night covers the other with her shades !

How many contrasts and concords result from their ever changing oppositions ? There is not a single point in the two hemispheres in which there does not appear by turns, a dawn, a twilight, an aurora, a noon, a setting of burnished gold, and a night, sometimes studded with stars, sometimes clothed in a sable mantle.

The seasons walk hand in hand under *his* eye, like

the hours of the day. Spring, crowned with flowers, precedes his flaming car; summer surrounds it with her golden sheaves; and autumn follows it, bearing her cornucopia running over with glossy fruit.

In vain would winter and night, retiring to the poles of the world, attempt to set bounds to his majestic career: in vain do they raise out of the bottom of the polar seas of the north, and of the south, new continents with their vallies, their mountains, and their icy corruscations: the father of day, with his fiery shafts, overturns the fantastic fabric, and without descending from his throne, resumes the empire of the universe; nothing can screen itself from his prolific heat.

From the bottom of the ocean he raises into the air the rivers which are afterwards to flow through the old and new worlds. He gives commandment to the winds to distribute them over islands and continents. These invisible children of the air transport them from place to place, under a thousand capricious forms. Sometimes they are spread over the face of heaven like veils of gold and streamers of silk; sometimes they are rolled up in the forms of frightful dragons and roaring lions, vomiting out torrents of fire and thunder. They pour them out on the mountains in as many different ways, in dews, in rains, in hail, in snow, in impetuous torrents.

However extravagant the mode of performing their services may appear, every part of the earth annually receives from them neither more nor less than its accustomed portion of water. Every river fills its urn, and every Naiad her shell. In their progress they impress on the liquid plains of the sea, the variety of their characters. Some hardly ruffle the smooth expanse, others swell it into billows of azure, and others turn it up from the bottom with a dreadful noise, and dash it foaming over a dreadful promontory.

Every place presents harmonies peculiar to itself, and every place presents them in rotation. Run over at pleasure a meridian or a parallel, you will find on

it mountains of ice and mountains of fire; plains of every kind of level, and hills of every curve; islands of all forms, and rivers of all currents, some spouting up as if they issued from the centre of the earth, others precipitating themselves down in cataracts, as if they were descending from the clouds.

Nevertheless the globe agitated with such a variety of convulsive movements, and loaded with such a variety of burdens, apparently so irregular, advances in a steady and unalterable course through the immensity of the heavens.

The Earth is round like a globe, as appears by its shadow in eclipses of the Moon, (which shadow is always bounded by a circular line;) by our seeing the masts of a ship while the hull is hid by the convexity of the waters; and by its having been sailed round by many navigators. The hills take off no more from the roundness of the Earth, in comparison, than grains of dust do from the roundness of a common globe.

The seas and unknown parts of the Earth, (by a measurement of the best maps) contain 160,522,026 square miles; the inhabited parts 38,990,569; Europe 4,456,065; Asia 10,768,823; Africa 9,654,807; America 14,110,874. In all 199,512,595; which is the number of square miles on the whole surface of the globe.

THE ATMOSPHERE.

The Earth is surrounded by a thin, transparent, invisible substance, called the Atmosphere, which gravitates to the Earth, revolves with it, in its diurnal motion, and goes round the Sun with it every year.

The Atmosphere refracts the Sun's rays, so as to bring him in sight every clear day, before he rises in the horizon, and to keep him in view for some minutes after he has really set below it. For, at some times of the year, we see the Sun ten minutes

longer above the horizon than he would be if there were no refractions ; and about six minutes every day at a mean rate.

ATMOSPHERIC AIR.

That transparent, colourless fluid, which every where invests this globe, possessing permanent elasticity and gravity, is composed of 78 parts of nitrogen, and 22 of oxygen gas in bulk ; and its weight of about 74 nitrogen, and 26 oxygen ; and is soluble in about 30 times its bulk of water ; 100 cubic inches weigh 31 grains. On the surface of the earth it is compressed by the weight of the superincumbent atmosphere : its density therefore diminishes according to its height above the Earth. It is dilatable by heat.

As respiration and combustion depend on the presence of oxygen, these processes will be affected by the proportion in which the oxygen gas exists in the air.

The atmospheric air differs very little in the proportion of its ingredients in different parts of the World ; that of Europe, Asia, America, and Africa, being all found to contain 0,22 of oxygen in volume.

LIGHT.

Light is a substance, the particles of which are small, repulsive of each other, and elastic : being *reflected* from bodies which they cannot penetrate, in an angle of reflection equal to the angle of incidence. It is projected in every direction from radiant bodies passing through 167,000 miles in a second. In its passage near any other substance, it is affected by attraction, and suffers a greater or less degree of inflection. In its passage from one medium, into another of a different degree of density, it suffers refraction,

or a change in its direction. Combustible bodies possess the greatest power of producing this refraction. From their possessing this refracting power, the immortal Newton concluded the diamond to be of a combustible nature, and that even water contained combustible matter.

It is also possessed of chemical affinities, by which it enters into combination with other substances, and becomes one of their constituent parts.

Dr. Herschell has discovered that the coloured rays of light are possessed of a heating power, and that the least refrangible rays possess this power in the highest degree: this power diminishing as the refrangibility increases; the red rays possessing therefore the greatest, and the violet the smallest power.

ON GRAVITATION.

The globe which we inhabit, the sun, and all his attending planets and comets, are continually moving in curved line paths. And these curvilinear motions are compounded with all the other motions that are performed on the surface of this globe. When a cannon bullet is discharged in a southerly direction with the velocity of 1500 feet in a second, it is at the same time carried eastward, nearly at the same rate, by the rotation of the Earth; and by its revolution in a year round the Sun, it is moving eastward more than sixty times as fast. Such being the condition of the visible universe, it appears that the deflecting forces, by which all these bodies are kept in their curvilinear paths, must be acknowledged to have the most extensive influence.

This deviation from uniform rectilinear motion is considered as an *effect*, and it is of importance to discover the cause.

In the most familiar instance—the fall, or pressure of a heavy body: we ascribe the fall, or pressure, in-

dicating a tendency to fall, to its heaviness. But we have no other idea of its heaviness, than the very thing that we ascribe to it as an effect.—The feeling the heaviness of a piece of lead, that lies in our hand, is *the sum of all that we know about it*.—But we consider this heaviness as a *property* of all terrestrial matter, because all bodies give some of these appearances which we consider as indications of it. All move towards the Earth if not supported, and all press upon the support. The feeling of pressure, which a heavy body excites, might be considered as its characteristic phenomenon, for it is this feeling which makes us think it a force.—We must oppose our force to it, but we cannot distinguish it from the feeling of any other equal pressure.—It is most distinguishable as the *cause* of motion, as a moving or accelerating force; in short, we know nothing of gravity, but the phenomena, which we consider not as gravity, but as its indication. It is, like every other force, an unknown quality.

A force has been discovered pervading the whole system, and determining or regulating the motion of every individual body in it; and as gravitation is universal, the regular elliptical motion of any individual planet produced by its gravitation to the Sun, must be constantly disturbed by its gravitation to the other planets. This disturbance is proportional to the square of the distance from the disturbing planet inversely, and to the quantity of matter in that planet directly.

The questions which occur in this department of the study are generally of a most delicate nature, and require the most scrupulous attention to a variety of circumstances. It is not enough to know the direction and intensity of the disturbing force in every point of a planet's motion, we must be able to collect in one aggregate, the minute and almost imperceptible changes that have accumulated through perhaps a long tract of time, during which the forces are continually changing both in direction and in intensity, and are frequently combined with other forces. For the seeming anoma-

lies that are observed in the solar system, are, all of them, the consequences of the universal operation of one simple force, without the interference of any other, and are susceptible of the most precise measurement, and comparison with observation; so that what we chuse to call anomalies, irregularities, and disturbances, are as much the result of the general pervading principle as the elliptical motions, of which they are regarded as the disturbances. They are all periodical and compensated in opposite points of every period.

Thus then we have proof that the atoms of matter have all a mutual tendency to approach each other, and the laws are explained by which this tendency is regulated; but every hypothesis which has been formed for the purpose of finding a *mechanical cause* of the phenomenon has been inadequate. We may therefore justly conclude that such a form and such a rotation have, by infinite wisdom, been given to each planet, primary and secondary, as was suitable to its destination.

The Moon D is not a planet, but only a satellite or attendant on the Earth, going round the Earth from change to change in 29 days, 12 hours, and 44 minutes; and round the sun with it every year. The Moon's diameter is 2180 miles, and her distance from the Earth's centre is 240,000. She goes round her orbit in 27 days, 7 hours, and 43 minutes, moving about 2290 miles every hour: and turns round her axis exactly in the same time that she goes round the Earth, which is the reason of her keeping always the same side towards us; and that her day and night, taken together, are as long as our lunar month.

The Moon is an opaque globe like the Earth, and shines only by reflecting the light of the Sun; therefore while that half of her which is towards the Sun is enlightened, the other half must be dark and invisible. Hence, she disappears when she comes between us and the Sun, because her dark side is then towards us; when she is gone a little way forward, we see a little

of her enlightened side, which still increases to our view, as she advances still forward, until she comes to be opposite to the Sun, and then her whole enlightened side is towards the Earth, and she appears with a round illumined orb, which we call the Full Moon.—From the full she seems to decrease gradually as she goes through the other half of her course, shewing us less of her enlightened side every day, till her next change or conjunction with the Sun, and then she disappears as before.

This continual change of the Moon's phases, demonstrates that she shines not by any light of her own; for if she did, being globular, she would always appear with a round full orb like the Sun.

Our Earth is a Moon to the Moon, waxing and waning regularly, but appearing thirteen times as large; and affording her thirteen times as much light as she does to us. When she changes to us, the Earth appears full to her; and when she is in her first quarter to us, the Earth is in her third quarter to her, and *vice versa*.

The Moon's gravitation to the Sun is more than twice her gravitation to the Earth. The consequence of this is, that even when the Moon is in conjunction, at New Moon, between the Earth and Sun, her path in absolute space is concave towards the Sun, and convex towards the Earth. Even there she is deflected, not towards the Earth, but towards the Sun; this is a very curious and seemingly paradoxical assertion. But nothing is better established. The tracing of the Moon's motion in absolute space is the completest demonstration of it. It is not a looped curve, but a line always concave towards the Sun. At new Moon she appears to be moving to the left, and we see her gradually passing the stars, leaving them to the right; and calculating from the distance 240 thousand miles: and the angular motion about half a degree in an hour, we should say, that she is moving to the left at the rate of 38 miles in a minute. But the fact is, that she

is then moving to the right at the rate of 1,100 miles in a minute. But, as the Earth from whence we view her, is moving at the rate of 1,140 miles in a minute, the Moon is left behind. The Moon is diversified with hill and valley, and according to Mr. Shroeter, surrounded by an atmosphere 5376 feet high.

Next above the Earth's orbit is Mars $\text{\textcircled{♂}}$, whose distance from the Sun is computed to be 145,000,000 miles; he moves at the rate of 55,000 miles in an hour, and completes his revolution round the Sun in a little less than two of our years. His diameter is 5150 miles. This planet is surrounded by an atmosphere similar to our Earth's, and sometimes appears gibbous, but never horned like the Moon, which plainly shews that his orbit includes that of the Earth, and that he shines not by his own light. The obliquity of his equator is 28 degrees, diurnal motion 23 hours, 39 $\frac{1}{2}$ minutes.

Jupiter $\text{\textcircled{♃}}$, the largest of all the planets, is still higher in the system than Mars, being about 494,990,796 miles from the Sun, and by going at the rate of 29,000 miles in an hour, completes his annual revolution in eleven of our years, 314 days, and 12 hours. He is above 1000 times as big as the Earth; for his diameter is 94,000 miles, which is more than ten times the diameter of the Earth, and by a prodigiously rapid motion round his axis, performs his diurnal rotation in 9 hours and 56 minutes. This planet has four moons, some bigger and some less than our Earth, which revolve round him; so that there is scarcely any part of this huge planet, but what is, during the whole night, enlightened by one or more of these moons.

Saturn $\text{\textcircled{♄}}$, thought the remotest of all the planets, till the discovery of the Georgium Sidus, is 907,856,130 miles from the Sun; and by travelling at the rate of 22,000 miles in an hour, he performs his annual circuit round the Sun in 29 $\frac{1}{2}$ of our years. His diameter is computed to be 79,000 miles.

Saturn, according to Dr. Herschell, is attended by seven Moons and a double ring. The ring turns round

its axis in about 10 hours ; the Moons all going round him on the outside of the ring, and nearly on the same plane with it.

The planet Saturn is considerably flattened at its polar regions. The axis of the planet's equator, as well as that of the ring, keeps its parallelism during the time of its revolution about the Sun, therefore an alternate periodical change takes place in the extent and brightness of the north and south polar spots of the planet, which may be owing to a vivid reflection of light from frozen regions more on one side than on the other, according as either of them may be more or less inclined towards the Sun. The brightness which remains on the polar regions is not uniform ; but is here and there tinged with large dusky-looking spaces of a cloudy atmospheric appearance. From these observations on the change of the colour at the polar regions of Saturn, arising most probably from a periodical alteration of temperature, we may infer the existence of a Saturnian atmosphere, as certainly we cannot ascribe such frequent changes to alterations of the surface of the planet itself ; and if we add to this consideration the changes observed in the appearance of the belts, or even the belts themselves, we can hardly require a greater confirmation of the existence of such an atmosphere. Observations testify the probability that the *ring* of Saturn has also its atmosphere.

The singular changes of this planet cannot be observed unless the telescope can bear a distinct magnifying power of 500 times.

The Georgium Sidus, discovered by the ingenious Dr. Herschell, on the 13th day of March, 1781, is still higher in the system than Saturn, its distance from the Sun being 19 times greater than that of the Earth ; its magnitude about 39 times greater ; it revolves round the Sun in an orbit nearly circular, in about 82 years and a half.

The Dr. has discovered six Satellites belonging to

this planet, and it is probable that there are two or three others which have not yet been discovered.

Piazzi or Ceres, discovered January 1st, 1801, revolution 4 years, 7 months, 10 days; diameter 161 miles.

Olbers, or Pallas, discovered March 28, 1802, revolution 4 years, 7 months, 11 days; diameter 100 miles. These two planets are situated between Mars and Jupiter.

Dr. Herschell has endeavoured to find out a leading feature in the character of these new bodies, and as planets are distinguished from the fixed stars by their visible change of situation in the Zodiac, and Comets by their remarkable comas; so, the quality in which these objects differ considerably from the two former species, is, that they resemble small stars so much, as hardly to be distinguished from them even by very good telescopes. From this their asteroidal appearance, he calls them Asteroids, reserving to himself the liberty of changing that name, if another more expressive of their nature should occur.

These bodies will hold a middle rank between the two species that were known before, so that Planets, Asteroids, and Comets, will in future comprehend all the primary celestial bodies, that either remain with, or only occasionally visit our solar system.

The Dr. then gives a definition of his new Astronomical term, as follows.

Asteroids are celestial bodies which move in Orbits, either of little, or of considerable eccentricity, round the Sun, the plane of which may be inclined to the ecliptic in any angle whatsoever. Their motion may be direct or retrograde; and they may, or may not have considerable atmospheres, very small comas, disks, or nuclei.

The Asteroids, *Juno* and *Vesta*, have neither of them a sensible disk, even with very high magnifying powers.

The Comets, agreeable to Sir Isaac Newton, are solid opaque bodies, with long transparent tails, or trains,

issuing from that side which is turned away from the Sun. They move about the Sun in very eccentric ellipses, and appear of a much greater density than the Earth. Their revolutions are performed in certain stated times, like those of the planets. This has been demonstrated by Dr. Halley, who, from the theory of Newton, has calculated tables for determining the orbits of the Comets, which, in several instances, have been found agreeable to observation. The Comet of 1661 is supposed to have a period of 129 years; the Comet of 1759 has a period of 76 years; and that remarkable Comet which appeared in the year 1680 is supposed to have a period of 575 years. The number of Comets belonging to our system is unknown, but it is ascertained, that more than 450 had been seen previous to the year 1771, and when the attention of Astronomers was called to this object, by the expectation of the return of the Comet of 1759, no less than seven were observed in the course of as many years. From this circumstance, therefore, and the probability that most of the Comets of small apparent magnitudes were overlooked by the ancients, it is reasonable to conclude that their number is considerably beyond any estimation that can be made from the observations we now possess.

THE COMET OF 1807.

The Comet discovered in the month of September was the most beautiful that has been seen for 30 years. Its nucleus appeared like a star of the first or second magnitude, but its light paler; its tail not very extensive, only a few degrees. Its light however, and that of its nucleus very striking.

Its motion one degree per day towards the north, and rather more than a degree towards the east. It was surrounded by a nebulosity of about six minutes in diameter, and had a tail of about a degree and a

half in length. This resembles none of the orbits of any Comet hitherto observed. It passed its perihelion the 19th of September.

An account of the Comet which appeared in the Arctic Sky, in 1811.

ANNEXED is a sketch of the situation of the Comet, as it appeared to the eye on the 14th of September 1811, at about 8 p. m.

The Comet's place is laid down from the actual distances measured by an exceedingly good sextant made by Messrs. W. and S. Jones; the distances set down are the mean of three observations to each distance, and can be depended on to within a few seconds.—They are as follow; viz.

8^h 0' 7" mean time Comet at Alioth...18° 46' 48"
 8 3 22 ditto..... do. at Dubhe..19 9 40

Longitude and Latitude of the Comet deduced from the Observations made at the Royal Observatory,
GREENWICH.

Sept. 1811	Mean Time.	Longitude.	Latitude.
5	8 ^h 0'	4 ^s 25° 3' 10"	28° 36' 39"
6	8 0	4 25 36 12	29 28 26
7	8 0	4 26 10 5	30 10 13
8	8 0	4 26 47 12	30 52 38
9	8 0	4 27 23 7	31 41 4
10	8 0	4 28 2 53	32 30 43
11	8 0	4 28 42 47	33 20 48
12	8 0	4 29 25 35	34 9 31
13	8 0	5 0 10 21	34 57 27
14	8 0	5 0 57 24	35 53 15
15	8 0	5 1 42 59	36 44 28
16	8 0	5 2 32 7	37 37 49

Boston Gazette, Tuesday, Sept. 3, 1811.

On Thursday evening about 8 o'clock, a person* of this town had the pleasure of discovering a very beautiful luminous object, which sheds a sweet influence like that of the Pleiades over the hitherto desolate track of Ursa Major. We have not heard that any nebula have ever been observed in that barren expanse similar to those which may sometimes have been seen in Orion, in Cancer, in Perseus; or to those which appeared so bright in Andromeda, as to be by some mistaken for a Comet in the Winter of 1808. We therefore conclude that this object is the Comet which (the *Courier*, received on Friday, informs us) was seen at Paris, early in the morning of Wednesday, August 21st.

It will not perhaps, for some evenings to come, appear so luminous as it did on Thursday, on account of the Moon's superior splendor, by which it is at present shorn of its beams. It is considerably below the seven very bright conspicuous stars† known by the name of Charles's Wain, and may be seen every evening, when the sky is clear from 8 till past nine o'clock: in the morning from 3 till the dawn of day.

Dec. 19. The first part of a paper by Dr. Herschel on the Comet. This astronomer, in the course of his observations on the Comet, noticed something like a distinct luminous body about the centre of its head, or what some astronomers would call its nucleus. He observed this luminous part change its relative position in the head, sometimes appearing nearer, at others further from the side next the sun; at the same time he discovered considerable difference in its brilliancy. Hence he was led to infer that the Comet enveloped a real planetary body: and after a series of observations on the 16th of October when the Comet was 114 millions of miles from the Earth, he ascertained that this

* The Rev. Wilson Banks, a gentleman of very considerable literary acquirements.

† Mr. W. B. had no quadrant to determine the exact position.

body was 428 miles in diameter, and surrounded with a cometic atmosphere. For this purpose he viewed it with seven, ten, and twenty feet telescopes, containing magnifiers of various powers from forty to those which magnified 600 times. The reading of the remainder of this curious paper was deferred till a future meeting, and the Society adjourned till Thursday, January 9th, 1812.

January 9th and 16th, the conclusion of the Dr.'s paper was read. The Doctor entered into a very minute investigation of the nature and extent of the luminous matter, which surrounded it at some distance from the planetary body in its centre; this matter he supposed to be of a phosphoric nature; the length of the tail he estimated at an average, about the beginning of October, to be above 100 millions of miles; he described it as very variable both in length and breadth, and as being a hollow cone, emitting light on all its sides; the inner side he supposed might illumine the planetary body in a manner somewhat similar to that in which the ring does Saturn. The planet which he discovered in the place of its nucleus he concludes shines with its own light, and not with one borrowed from the Sun. His chief reason for this conclusion, was the extensive dark space which intervened between the cometary envelope and the planetary body. From the great alterations which took place in the nature and dimensions of the tail he was inclined to conjecture that comets may be formed of nebulæ, that those nebulæ undergo condensation in their approach to our sun, or to some of what are called the fixed stars, and that in process of time they may become regular planets. On contrasting the appearance of the late Comet with that of 1807, he was inclined to suppose that of 1811 a much younger Comet than the former.

THE COMET OF 1811.

By Dr. URE, *Andersonian Professor at GLASGOW.*

SIR,

Having continued to observe the Comet with various instruments, on every favourable occasion, since the 1st day of September, I selected from thirty observations five which could be confided in as very nearly accurate. The days of the observations were the 1st, 8th, 15th, 23d, and 30th September. From these five, reduced to latitudes and longitudes, it was conceived that the elements of the orbit might be pretty correctly determined according to the celebrated formula in the *Mechanique Celeste* of *La Place*. The task of observing, continued frequently through the greater part of the night, as well as the labour of reducing and comparing the observations, made me gladly avail myself of the co-operation of Mr. Cross, my Mathematical Associate in the Andersonian Institution. It is to this gentleman's familiarity with the transcendental calculus, and eminent facility of computation, that I am enabled, at the interval of above a month after our first view of the Comet, to announce the elements of its orbit being ascertained. All that the first five observations, however accurate, can possibly give, is the approximated values of the quantities. I believe however that the following numbers will be found little removed from the truth, and whatever inaccuracy may exist will be corrected by subsequent observations.

Perihelion distance, or nearest approaching of the Comet to the Sun, 94,724,260 miles—time of its Perihelion passage, September 9.

Comet's distance from the earth, Sept. the 15th, 142 millions 500,000 miles.

Comet's distance from the Sun, on the 15th, 95 millions 258,810 miles.

Distance of the Earth from the Sun at that time, 93 millions 505,932 miles.

Length of the tail, 33 millions of miles.

Motion of the Comet, retrograde, or, its real motion from East to West, being the reverse of what it appears to be at present to a spectator on the Earth.

The real size of the Comet, as deduced from its appearance in the grand Herschelian telescope, is about that of our Moon. The brilliant central nucleus is invisible, even in the ten feet Herschelian, and in every smaller instrument.

The three other elements, besides the Perihelion distance and time of the passage through this point are neither interesting nor intelligible to the general reader. We shall take an early opportunity of laying them before the world, accompanied by the whole series of observations made on the Comet at this establishment. For illustrating in a popular manner, the real motion of the Comet, Mr. Cross is preparing a solid figure, by which its actual path, together with that of the Earth, will be accurately represented. The orbit of this Comet differs entirely from that of 1661; nor does there seem, in any of the 98 Comets whose orbits are calculated and recorded, sufficient resemblance to establish identity between them.

Glasgow Observatory, Oct. 3, 1811.

SIR,

Since my communication of the 4th, relative to the Comet, announcing the determination of the elements of its orbit made at this establishment, I perceive in the London papers, the result of Burckhardt's 2d approximation. Between his time of the Perihelion passage and ours there is a difference of no more than three days, and the whole period of the Comet's revolution, I am satisfied exceeds considerably 100 years. It is to be remarked too, that Burckhardt never ventured to

give to the public his first trials; and therefore, whatever differences exist between his numbers and ours may have been obtained at his second calculation. I wish it to be understood, however, that the appearance of his statement has not shaken, in the least degree, the confidence I humbly conceive due to our own results. The observations from which these are derived were performed with the instruments of TROUGHTON; instruments unquestionably superior to any other in the world. But we have still more direct assurance of the accuracy of our observations, by comparing them to the numbers which have been published from the highest authority (the Astronomer Royal) in the Philosophical Magazine of this month. The longitudes of the Comet, determined at Greenwich and Glasgow Observatories, coincide to the fraction of a minute.

The time of the perihelion passage may be considered as pretty accurately fixed, either for Sept. 12 or 9, or as is more probable, at some intermediate period.— From this we can fully explain some of the phenomena generally remarked. From the 9th, as stated in the Glasgow papers, by a correspondent, the Comet was observed to increase considerably both in brilliancy and in the apparent magnitude of the Coma, but particularly of the tail, in the course of eight days.— This verifies very happily the observation of Sir Isaac Newton, that it is not till immediately after the perihelion passage, Comets acquire their maximum of lustre and of size. The enlargement, therefore, uniformly takes place at that time, whether the Comet is coming nearer us, or moving in the opposite direction. The quantity of increase due to its approximation alone, in six or eight days, cannot be calculated; and we know that there is no instrument in Scotland capable of measuring the change of apparent magnitude produced by this cause. Whether the exquisite Micrometer of TROUGHTON, applied to our great Herschelian telescope, may shew any difference, I shall be able to ascertain in a few days, as that instrument is lately dis-

patched from London for us. I must acknowledge however, that I entertain very slender hopes of success in this kind of observation on a minute body surrounded with such a nebulosity, and at a distance from us much greater than that of the Sun. It has been said, that this Comet was ascertained to be the same with that of 1661. The two are as different as can be imagined, in every respect; hence we may see how much safer, in the event, scientific investigation is than vague conjectures. I subjoin the elements of the Comet of 1661, and those now given by Burckhardt :

	<i>Comet 1661.</i>	<i>Burckhardt.</i>
Long. of Node	82 deg. 30 min.	140 deg. 13 min.
Inclination	32 deg. 35 min.	72 deg. 42 min.
Place of Perihelion	115 deg. 58 min.	74 deg. 42 min.
Perihelion distance	42,600,000 miles	96,000,000 miles.

Glasgow Observ. Oct. 7th, 1811.

Glasgow Observatory, Oct. 16.

I had the honour of submitting to the public on the 5th of October last, the results of the joint labours of Mr. Cross and myself, for the preceding month, on the Comet, at the Glasgow Observatory. In the Star newspaper of October 11, appeared for the first time, the elements of the orbit, as determined by the celebrated Burckhardt, member of the National Institute.

It is a duty which I owe to the skill and unwearied exertions of my associate Mr. Cross, to this patriotic establishment, and also to this country, hitherto considered by the French Mathematicians and Astronomers unequal to the primary solution of this difficult problem, to state the following facts :—On October 8, at eight hours, 15 minutes, by observations made here, with every precaution to insure the utmost accuracy, the Comet had deviated 42 degrees 18 minutes from the longitude which Burckhardt's elements assign for that instant. On October 14, at two o'clock in the

morning, the longitude, as deduced from a most satisfactory transit, was 206 degrees 42 minutes. By the French computation it ought to have been 248 degrees 1 minute, differing from nature by 41 degrees 19 minutes. By our elements, which have received a partial correction from my observations since the 5th, the coincidence on the 8th, at the same time, was within 15 minutes, and on the 14th, within 13 minutes. Our computed latitudes on the 13th agree to a minute with observation, while those of Burckhardt differ by 3 degrees or 180 times that quantity.

The examination of both has been made by the excellent tables of the parabola, constructed by Delambre, imperial observer at Paris. It is in the longitude of the perihelion that the chief discordance exists between the French elements and ours, and this amounts to about 81 degrees; the former being, in our judgment, too small by this quantity.

The Comet has been continually approaching the Earth for many weeks. From September 15th till October 14th, its decrease of distance amounted to 25 millions of miles, yet its brilliancy and the magnitude of its tail have gone on diminishing, as Burckhardt properly remarked. Persons ignorant of Astronomy would naturally infer from this diminution the recede of the Comet from us, as, from its increase, they conjectured its approach. Astronomers laugh at such idle dreams when applied to a demonstrative science, in which conjecture has found no place since the days of Newton. Its first principles teach, that these phenomena arise from the Comet's varying distance from the Sun. At the period of the perihelion passage these bodies are known uniformly to attain their maximum of size and brightness.

If Glasgow has been justly ridiculed on the present occasion for the dexterous appropriation of every floating error about the Comet, I trust this communication will, in some measure, redeem its former scientific character. It is to be hoped that some of our eminent

philosophers will take the trouble of comparing Burckhardt's elements with our observations, and that they will speedily give the result of their comparisons to the public. Nothing could have induced us to enter the lists against so able a competitor, but the conviction of the justice and importance of the cause which public duty assigned.

I am, Your obedient Servant,

ANDREW URE.

The following observations on the Comet were made at Gottingen, and published there on the 20th of September:—

“The Comet which is now visible on the horizon in the northern part of the heavens, is one of the most remarkable which has ever been observed. None has ever been so long visible, and consequently, none has ever afforded such certain means of information with respect to its orbit. Accordingly, since the end of March last, when it was first perceived by M. Flauguergues in the south of France, its course has been regularly traced; nor shall we lose sight of it till the month of January, 1812. Its train, which occupies a space of 12 degrees, exhibits several curious *phenomena*. It is not immediately connected with the Comet, as if it were an emanation from it, but forms at a distance from the *nucleus* a wide belt, the lower part of which girds without coming in contact with it, much in the same manner as the ring of Saturn; and this belt extends in two long luminous fascies, one of which is usually rectilinear, while the other, at about the third of its length, shoots forth its rays with a slight curve like the branch of a palm tree; nevertheless this configuration is subject to change. It has been observed that the space between the body of the Comet and its train is occasionally filled, and of the two fascies, that which is generally rectilinear sometimes arches its rays, while those of the other assume the form of right lines. Finally, rays, or, as it were, plumes of ignited matter

have been seen to issue from the lower extremities of the fascies or flakes, and again unite.

“ Such fluctuations and accidents in that sort of luminous atmosphere which must occupy in the regions of space a scope of about eight millions of leagues, are immense, and may well impress the imagination with astonishment. The celebrated astronomer of Lilienthal, Mr. De Schroetter, remarked variations of the same kind in the tail of the last comet of 1807, and inserted, in the work he published with respect to it, plates of successive configurations.

“ Professor Harding has also observed and delineated with care the present comet under its various aspects, and his design will appear in one of the succeeding numbers of the ‘ Geographical and Astronomical Correspondence,’ edited at the Observatory of Gotha, by the chamberlain De Lindenau.

“ They will show that when the comet first appeared, and was yet at a distance from the sun, the two flakes of its train were separated so as to form a right angle; but as that distance decreased, they approached each other till they become parallel. This phenomenon, however, may be nothing more than an optical illusion.

“ As to the *nucleus*, or the comet itself, it has been found impossible, as yet, even with the aid of the best telescopes, to make observations on its disk, as on that of a solid body and of determined circumference. We can only discern a vague circular mass, more luminous than the train, particularly towards the centre; but the verge of which is doubtful, furnishing to the eye no fixed line of demarcation.

“ This mass is without doubt composed of a very subtle substance, as is probably that of all comets.— This hypothesis receives much support from the fact, that one of these stars, of very considerable magnitude, (the first comet in 1770,) passed and re-passed through the very middle of the satellites of Jupiter, without occasioning amongst them the slightest disorder.—

There is every reason to believe, that the *nucleus* of the present comet is nothing more than a conglomeration of vapours of very little density, so little perhaps as to be transparent. Whether this be the case or not, might be easily ascertained, if those who are in the habit of observing it would watch the moment of its *transit* athwart the disk of some star, the rays of which would have sufficient power to perforate it, if transparent. Such a body might very possibly be an incipient world, just past its *gaseous* state, and which was to derive solidity from the precipitation and condensation of the matter surrounding it. The successive observation of some comets, in which it may be possible to distinguish the different stages of chaos and progressive formation, can alone furnish any knowledge with respect to this point."—*Moniteur*, 4th October.

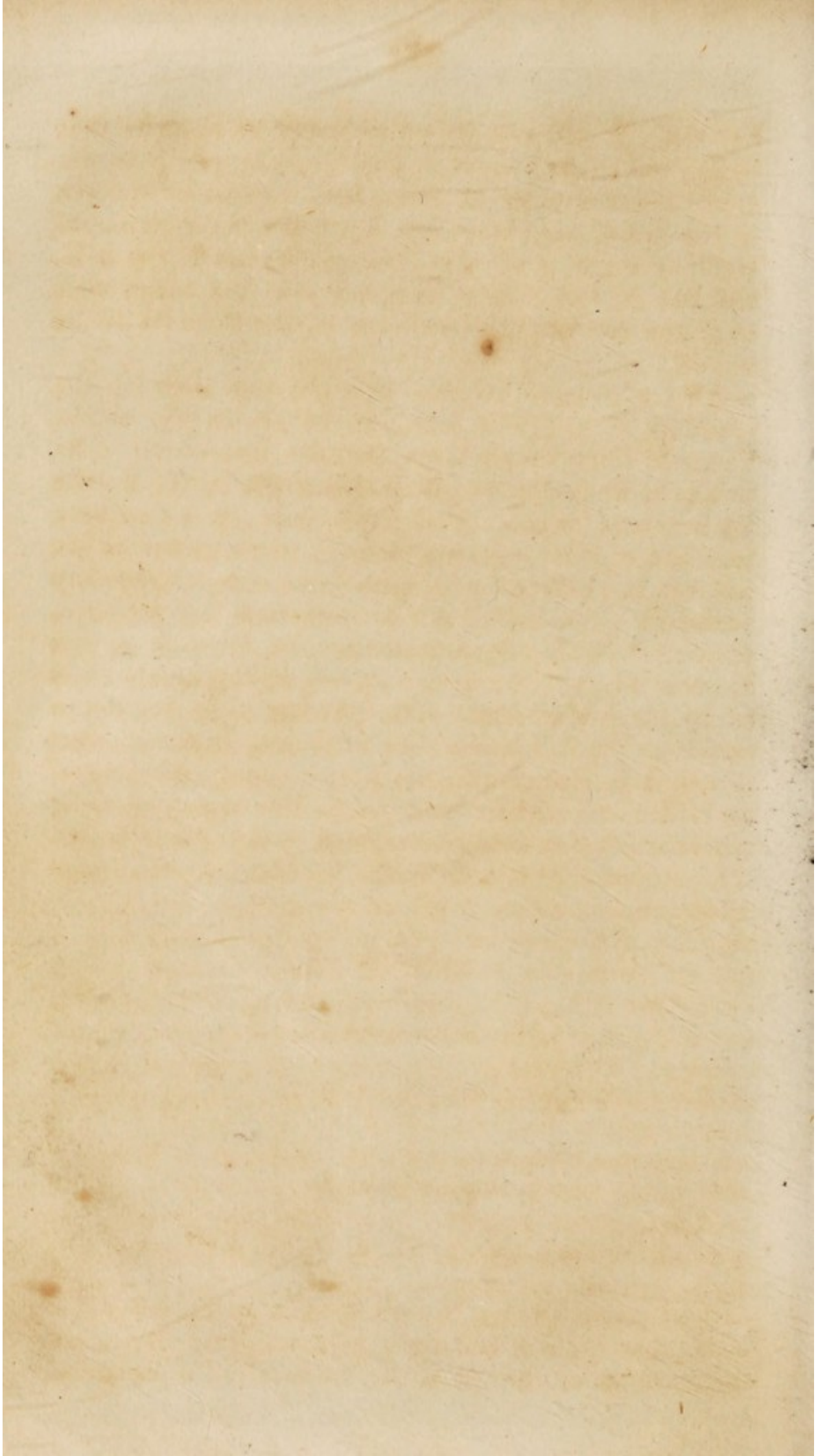
NEW COMET.

“*Imperial Observatory, Paris, Dec. 9, 1811.*”

“A new comet has just been seen in the constellation of Eridanus—it was seen by M. Pons, at *Marseilles*, on the 16th ult. The thick weather did not permit its being seen at Paris before the 5th inst. On that day, at 11 hours 1 minute of mean time, its right ascension was 64. 23. and the declination was 13. 34. S. The apparent motion of the comet in right ascension, is retrograde and very slow, and the motion in declination carries it toward the northern hemisphere. It is not visible by the naked eye; with very good glasses, its nucleus, the light of which is vivid, is seen surrounded with a light cloud, but not the slightest trace of a tail is to be seen.

“It was announced that, on the 4th of November, at 7 P. M. there was seen at *Berne*, in the direction of E. N. E. a comet above the horizon; and it was added, that the tail was turned directly on the side of the





horizon. It will not be unnecessary to remark, that these indications cannot in any measure relate to the comet discovered by M. Pons, first, because on the 4th of November this comet was still below the horizon at eight at night, and next, because it rises in the S. E. and has no tail. It is probable that the astronomer at Berne mistook the nebulus of Andromeda for a comet."

This additional sublime stranger was seen on the evenings of the 22d and 23d of December, at the Glasgow Observatory. Its position has varied considerably in declination from that given by the French astronomers for the 5th of December. It is now very near the equator. Its appearance, when viewed in the ten feet Herschelian, with a power of 250, is extremely beautiful. The nebulous cometary mass is condensed, appears bright, notwithstanding the vicinity of the moon. There is at present a fine double star a little to the south-west of it. The rapidity of its motion is evident, even in the common telescope, in the interval of one day. Its situation has been carefully determined on both evenings by a series of azimuths and altitudes with the great astronomical circles constructed by Mr. Troughton. It is still in the extended constellation Eridanus.

OF ECLIPSES.

All opaque and dark bodies, when they are exposed to the light of the Sun, cast a shadow behind them in an opposite direction; and as the Earth is a body of this kind, whose shadow extends over a large space, and to a great distance, it is plain that the Moon in passing through this space must be deprived of her light, or suffer an eclipse.

The figure of the Moon's shadow is also that of a cone, and when it falls upon any part of the Earth, the inhabitants of that part will be involved in darkness,

and the Sun will be eclipsed as long as the shadow covers them. There can be no Lunar Eclipse but at the time of full moon, or when she is opposite to the Sun; and an eclipse of the Sun can never happen but at the time of a new Moon, or when she is in conjunction with that luminary; for it is only at those times that the Earth and Moon are in a straight line with the Sun, or that the one can fall upon the other. If the plane of the Moon's orbit were coincident with that of the Earth's, the moon would pass through the middle of the Earth's shadow, and be eclipsed at every full; and, in like manner, the Moon's shadow falling upon some part of the Earth, would occasion an eclipse of the Sun at every change. But one half of the Moon's orbit being elevated about five degrees and a third above the plane of the ecliptic, and the other half as much depressed below it, the Moon can never be in the same plane with the Earth, but when she is in the nodes, or one of the two points where the orbits intersect each other; and, therefore, as the Moon may make a number of revolutions round the Earth, before a new or full moon takes place in one of these points, it is plain there may be no eclipse either of the Sun or Moon for the space of several months.

The Sun commonly passes by the nodes but twice a year, therefore, there can be only two ecliptic seasons in a year, and the Moon's orbit containing 360 degrees, of which 17, the limit of Solar Eclipses, on either side of those points, and 12, the limit of the Lunar Eclipses, being but small portions, it is easy to perceive there must be many new and full Moons without Eclipses.

OF THE HARVEST MOON.

In this instance, as well as in many others, the wisdom and beneficence of the Deity is abundantly conspicuous, who commanded the course of the Moon to

be such as to afford more or less light, on all parts of the Earth, as their several circumstances or seasons render it more or less serviceable. These phenomena arise from the different angles made by the horizon and different parts of the Moon's orbit, it being demonstrable that there can be but one conjunction, or opposition of the Sun and Moon in a year, in any particular point of the ecliptic.

The Moon can never be full but when in opposition to the Sun, which is never in Virgo and Libra, but in our autumnal months. It is, therefore, extremely plain that the Moon is never full in the opposite signs Pisces and Aries, but in these two months, consequently we can only have two full Moons in the year, which rise so near to Pisces or Aries. The former is called the Harvest and the latter the Hunter's Moon.

The Moon rises with the same difference of time once in every lunation, as in harvest time; but in winter these signs rise at noon, being then in her first quarter, and the Sun above the horizon at the same time, it is not noticed. In spring these signs rise with the Sun, at the time of the change of the Moon when she is quite invisible. In summer they rise about midnight, the Moon being in her third quarter, and giving very little light, her rising passeth unnoticed. In autumn these signs being opposite to the Sun, and the Moon being at the full, render her rising very conspicuous.

OF THE NATURE OF TIDES.

Gravity, or attraction, like all other virtues or emanations, either drawing or impelling a body towards a centre, decreases as the square of the distance increases; that is, it attracts towards such a centre, a body at any given distance from it with four times less force than it does another at half that distance from it, and with 16 times less force than it does a body a 4th

part of that distance from it; and so on. This is confirmed from observation, by comparing the distance which the Moon falls in a minute from a right line, touching her orbit.

This will appear exceedingly clear when it is considered that it is not the centre of the Earth that describes the annual orbit round the Sun, but the common centre of gravity of the Earth and Moon together.*

At the conjunction or change of the Moon, the Sun and Moon acting in a direct line with each other, their attractive force being united, they diminish the gravity of the waters under the Moon, and are productive of spring or high tides; and the gravity on the opposite side of the Earth is diminished by means of the centrifugal force. At the full, while the Moon raises the tide under and opposite to her; the Sun, acting in the same line, raises the tide under and opposite to him, whence their conjoint effect is the same as at the change, and in both cases occasions what we call Spring Tides. But at the quarters, the Sun's action on the waters under and opposite to him, diminishes the effect of the Moon's action on the waters under and opposite to her, making what is called the Neap Tides, because the Sun and Moon then act cross-wise to each other.

The Sun being nearer the Earth in winter than in summer, is of course nearer to it in February and October, than in March and September; and, therefore, the greatest tides happen not till some time after the autumnal equinox, and return a little before the vernal.

In open seas, the tides rise but to very small heights

* This centre is as much nearer the Earth's centre than the Moon's as the Earth is heavier, or contains a greater quantity of matter than the Moon, namely about 40 times. If both bodies were suspended on it, they would hang in *equilibrio*; so that dividing 240 thousand miles, the Moon's distance from the Earth's centre, by 40, the excess of the Earth's weight above the Moon's, the quotient will be 6,000 miles, which is the distance of the common centre of gravity of the Earth and Moon from the Earth's centre.

in proportion to what they do in wide-mouthed rivers, opening in the direction of the stream of tide. For in channels growing narrower gradually the water is accumulated by the opposition of the contracting bank.— Like a gentle wind, little felt on an open plain, but strong and brisk in a street, especially if the wider end of the street be next the plain, and in the way of the wind.

The tides answer not always to the same distance of the Moon from the meridian of the same places, but are variously affected by the action of the Sun, which brings them on sooner when the Moon is in her first and third quarters, and keeps them back later when she is in her second and fourth; for in the former case, the tide raised by the Sun alone, would be earlier than the tide raised by the Moon; and in the latter case later.

THE FIXED STARS.

In these remote regions, the Deity has displayed himself in such indelible characters, as must rouse the most insensible spectator, and fill his mind with admiration and astonishment. The Stars are more bright and luminous than the Planets, and never change their situations in respect to each other. The revolution of the Earth round its axis from west to east, causes the apparent motion of the Stars from east to west.

The Stars are probably as distant from each other as Sirius, (called the Dog Star) and our Sun. Here then are data to pronounce each Star a Sun, the centre of a system analogous to our system, and a spectator placed on one of the Planets which revolve round that brilliant Star, would, if his eyes corresponded with ours, see our Sun of the same size and brightness as we behold that Star. Astronomy tells us that the heavens are decorated with innumerable clusters or systems of Stars, each individual Star equal, or perhaps supe-

rior to our Sun, and every Star that glitters in the firmament has its attendant Planets, Satellites, and Comets.

These as they change, Almighty Father these
 Are but the varied God. The rolling year
 Is full of Thee. Forth in the pleasing spring
 Thy beauty walks, thy tenderness and love
 Wide flush the fields; the softening air is balm;
 Echo the mountains round, the forest smiles;
 And every sense and every heart is joy.
 Then comes thy glory in the Summer months,
 With light and heat refulgent. Then thy Sun
 Shoots full perfection through the swelling year;
 And oft thy voice in dreadful thunder speaks;
 And oft at dawn, deep noon, or falling eve,
 By brooks and groves, in hollow-whispering gales.
 Thy bounty shines in Autumn, unconfined,
 And spreads a common feast for all that lives.
 In Winter awful thou! with clouds and storms
 Around thee thrown, tempest o'er tempest roll'd,
 Majestic darkness, on the whirlwind's wing,
 Riding sublime, thou bid'st the world adore,
 And humblest Nature with thy Northern blast.
 Mysterious round; what skill, what force divine,
 Deep felt in these appear! a simple train,
 Yet so delightful mix'd, with such kind art,
 Such beauty and beneficence combined:
 Shade, unperceived, so softening into shade;
 And all so forming an harmonious whole;
 That as they still succeed, they ravish still.

THOMSON.

AN ESSAY

ON THE NATURE AND APPEARANCE OF COMETS.

(With an attempt to point out the errors of the present Theory)
 and an apology for an inquiry into a new and more
 rational Hypothesis.

In the first volume of the American Philosophical Transactions, there is an Essay on the use of Comets, by Hugh Williamson, M.D. which was read before the Society, Nov. 16, 1779.

After having mentioned the general properties, in which Comets evidently agree with other planets, and rejected, for reasons which he assigns, the opinions of others concerning their uses, the Doctor says, "they are doubtless inhabited." This he infers to be the case from the acknowledged perfections of God, and from what we have opportunities of observing, with respect to the extension of life and enjoyment.—He then proceeds to shew, how Comets may be fit abodes for (material) intelligent beings.

The great vicissitude of climates, he observes, is the only plausible objection that has been made to this opinion. This objection, he says, is founded on a proposition, advanced by philosophers, which he conceives to be false. Philosophers have taken for granted that the heat of every planet in our system is inversely as the square of its distance from the Sun. This proposition he apprehends to be contrary to experiment.—Were heat a certain body proceeding immediately from the Sun, he allows, that the quantity of heat in any space would be inversely as the square of its distance from the Sun. But he sees *no* reason for believing that heat comes from the Sun; while there is *much* reason for thinking that it does not. We perceive, he observes, that light comes from the Sun. We also perceive that heat is produced in the bodies, on which the rays of the Sun's light fall; hence we are apt to confound light and heat together, though it is demonstrable, that light is not heat, and that heat is not light. He proceeds to observe, that experience teaches us, that different quantities of heat are produced by the same cause, according to the medium on which it operates; that the particular aptitude of any body, to be heated, is nearly as the elasticity of that body, or the cohesion of its parts, and that whatever produces a tremulous motion in the particles of any body, excites heat in that body; and *vice versa*, whatever excites heat, produces a tremulous motion in the particles of the body. He then goes on to prove, that in the five methods enumerated by philosophers, by which heat is

produced, viz. by attrition, by chemical mixture, by fermentation, by inflammation, and by the Sun, the heat depends on the tremulous or vibratory motion, which by one means or another, is excited in the particles of the heated body. Having shewn that heat is generated in bodies, which are subject to our examination, by a tremulous or vibratory motion, excited in the particles of which they are composed, he proceeds to apply this theory of the generation of heat, to the purpose of proving, that Comets may be fit for the residence of (material) intelligent creatures.

The more plainly to illustrate the manner in which the Doctor's theory may be employed to shew how Comets may be habitable globes, it may be proper to apply it in accounting for a fact, which comes under human observation. Within the Torrid Zone a person feels extreme heat at the foot of a high mountain, at the top of which the air is always in a freezing state. At the foot of the mountain, the air which is a very elastic substance, being much compressed, *i. e.* the particles of it being brought very near to one another, by the weight of the incumbent atmosphere, is there capable of receiving a great degree of tremulous motion from the impulse of the Sun's rays, and of thereby exciting the sensation of great heat in a human body; whereas the air at the top of the mountain being not so compressed, but the particles of it in consequence of its elasticity, and of the small degree of pressure from above to counteract that elasticity, being much farther removed from one another, is capable of receiving a proportionably less degree of tremulous motion from the impulse of the Sun's rays; and therefore in that situation, the person feels no heat, but extreme cold, and in a short time would be frozen to death. In the latter situation, however, the person might be miles nearer to the Sun, than in the former. This fact then serves to shew, that heat does not depend on the distance alone of a body from the Sun, but partly at least, if not principally, on the quantity and depth of the elastic medium on which its rays fall, and which they put

into a vibratory motion. If we keep this observation in our minds, we shall see how the Doctor's theory of the generation of heat may serve to explain how Comets may be no inconvenient places of residence for such creatures as are before mentioned.

The height of the atmosphere of a Comet is frequently 8 or 10,000 miles, while that of the atmosphere of the Earth is hardly supposed to exceed 60 or 70. The particles of this atmosphere, much more than 100 times as high as ours, may also be smaller, more subtle and elastic, and much more easily heated, than the particles of our atmosphere; whence the Sun's rays may be able to agitate and warm such an atmosphere, compressed together by the weight of 8 or 10,000 miles, at a distance from the Sun, in which we having over us an atmosphere of only 60 or 70 miles, should feel the most extreme cold.

It is observable, that, as a Comet moves towards the Sun, it acquires a tail, which increases its length the nearer the Comet comes to the Sun, and is longest when the Comet is nearest to it. This tail the Doctor supposes to consist of a quantity of the Comet's atmosphere, driven behind it by the impelling force of the Sun's rays, which force in regions near the Sun he observes must be great. In proportion as the tail, consisting of the atmosphere of the Comet, lengthens behind it, the quantity of the same atmosphere on the side turned towards the Sun grows less and less, and is least when the Comet is nearest to the Sun. As, on the side turned towards the Sun, the quantity of atmosphere continually decreases, the nearer the Comet approaches to the Sun; and again continually increases, the farther it recedes from it; there may be always so much of it on that side, as is sufficient by being put into a vibratory motion, by the action of the Sun's rays upon it, for the purpose of keeping up a proper degree of heat in the bodies of the inhabitants, in every part of the orbit, which the Comet describes.— Thus does the Doctor's hypothesis concerning the manner in which heat is generated, enable us to conceive

how a Comet may be like the Earth, inhabited by rational beings, who may never suffer any destructive extreme of heat or cold, but enjoy, like us, a comfortable existence.

The Doctor accounts for the luminous appearance of the tail of a Comet, by observing that every particle near the surface of the immense stream of air, which is driven behind it by the impelling force of the Sun's rays, must be enlightened by the refraction and reflection of those rays, and thence exhibit the faint appearance of a blaze.

The whole of the paper, of which the preceding use has been made, to throw some light on a very curious subject, deserves an attentive perusal. I leave those who see reason for adopting the Doctor's supposition, that Comets are inhabited by rational creatures, to pursue some pleasing and sublime speculations, which such a supposition is evidently calculated to suggest.

EXPLANATION OF TERMS

MADE USE OF IN THIS

COURSE OF LECTURES.

ABERRATION, an apparent change of place in the fixed stars, which arises from the motion of the Earth combined with the motion of light.

ÆRAS, certain periods of time from whence Chronologers and Astronomers begin their computation.

ANGLE, the inclination or opening of two lines meeting in a point.

ANTIPODES, those inhabitants of the Earth who live diametrically opposite to each other, or walk feet to feet.

APHELION, that point in the orbit of a planet in which it is at its greatest distance from the Sun.

ATMOSPHERE, that collection of vapours, or body of air, which surrounds or encompasses the Earth.

ATTRACTION, a property of matter by which bodies are made to approach each other, without any sensible agent either drawing or impelling them.

Axis, of the Earth, or a planet, an imaginary line passing through

the centre from one pole to the other, or that round which they are supposed to perform their diurnal rotations.

BISSEXTILE, or *leap year*, so called by the Romans, on account of their reckoning the 6th day of the calends of March twice over.

CENTRIFUGAL FORCE, that force by which any revolving body endeavours to fly off from the centre of motion, in a tangent to the circle which it describes.

CENTRIPETAL FORCE, that force by which any revolving body is made to tend towards the centre of its orbit.

COLURES, two great circles, or meridians, one of which passes through the solstitial points, Cancer and Capricorn, and the other through the equinoctial points, Aries and Libra.

CONJUNCTION, is when two stars, seen from the Sun or the Earth, appear in the same point of the Heavens, or answer to the same degree of the ecliptic.

DAY, (natural) that portion of time in which the Earth completes an entire revolution upon its axis.

DAY (artificial) the time between the Sun's rising and setting; to which is opposed night, or the time between his setting and rising.

DAY (astronomical) the time between two successive transits of the Sun's centre over the same meridian; which always begins and ends at noon.

DECLINATION, of the Sun, Moon, or Stars, is the distance north or south from the equator, reckoned in degrees, minutes, &c. upon a circle which is perpendicular to it.

DIURNAL, daily.

ECCENTRICITY, the distance between the centre of an ellipsis, and either of its foci.

ECLIPTIC, a great circle of the sphere, in which the Sun always appears to move; so called because eclipses generally happen when the Moon is in or near this circle; the obliquity of the ecliptic is the angle it makes with the equator, which is now about 23 degrees, 28 minutes.

ELONGATION, the angular distance of a planet from the Sun as it appears to a spectator on the Earth.

EQUATOR, a great circle which separates the northern from the southern hemisphere, and being referred to the heavens is called the equinoxial.

EQUINOXES, the two points where the ecliptic cuts the equator; so called, because when the Sun is in either of these situations, the days and nights are equal to each other.

HORIZON, (sensible) a circle which separates the visible hemisphere from the invisible one, or that which is the boundary of our sight.

HORIZON, (rational) a great circle which is parallel to the former, and whose two poles are the Zenith and the Nadir.

HYPOTHESIS, a supposition, a system formed upon some principle which has not been proved.

INCLINATION, the angle which the orbit of one planet makes with that of another.

LATITUDE, of a place, is its distance from the equator, reckoned in degrees, minutes, &c. upon the arch of a great circle which is perpendicular to it.

LONGITUDE, of a Star or planet, is its distance from the first point of Aries, reckoned in degrees, minutes, &c. upon the ecliptic.

MICROMETER, an instrument by which the apparent magnitudes of objects viewed through telescopes or microscopes, are seen with great exactness.

NADIR, that point of the Heavens which is directly opposite to the zenith, or immediately under our feet.

NEBULÆ, clusters of small Stars which have been discovered by the telescope in different parts of the Heavens, and are so called from their cloudy appearance.

NODES, the two points where the orbit of a planet intersects the plane of the ecliptic.

OCCULTATION, is when a star or planet is hid from our sight by the interposition of the Moon, or some planet.

PARALLAX, the difference between the places of any celestial object, as seen from the surface of the Earth and from its centre.

PARALLAX, of the Earth's annual orbit, is the angle at any planet which is subtended by the distance between the Sun and Earth; or it is that change of place in the planets, which arises from their being seen from different points of space as the Earth moves round the Sun.

PERIHELION, that point of a planet's orbit, in which it is at its least distance from the Sun.

PRECESSION, of the equinoxes, a slow motion of the two points where the equator intersects the ecliptic, which are found to go backwards about 52 seconds per year.

QUIESCENT, a body at rest, opposite to motion.

SIDEREAL, of or belonging to the stars or planets.

SYSTEM, a number of bodies revolving round a common centre, as the Planets and Comets move round the Sun.

TROPICS, two small circles of the sphere which are parallel with the equator, and 23 degrees, 23 minutes from it.

ZODIAC, a zone or girdle, surrounding the Heavens, of about 18 degrees broad, in the middle of which is the ecliptic, and in which the orbits of all the planets are included.

THE END.