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Baron Von Zach

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may be, and to leave no doubt in regard to the observations, I have again examined them; and in some places which were rather uncertain, and which I employed in my first calculations, I substituted others. I have also made an allowance for the deviation of the instruments, and employed all those precautions which are usual when great precision is required. The result of all these has been only a small difference in some of the right ascensions, which can have little or no influence on the ultimate results of the calculation, and for which reason I did not think great exactness necessary in the first reductions. According to this last rigorous examination, $1^{\circ}5''$ are to be deducted from the first four right ascensions, and $1^{\circ}5''$ to be added to those of the 10th, 11th, 14th, 19th, 21st, 23d, 28th, 30th, and 31st of January, and the 1st of February; and $3''$ must be taken from those of the 5th and 8th of February. With the transit instrument the observations were made, different times, with all the five threads; and these I always preferred to those made with the circle. I used those by the circle when I failed with the transit instrument; as on the first four days; and on the 13th of January, when the observations were not made with all the five threads, I took a mean of the observations made with the circle, and another of those made with the transit instrument. The difference between those with the former instrument and those with the latter, was never greater than 0.2 in time, except on the 19th of January, when I found $1''$ in time more by the circle. In regard to the declinations, I have found no corrections to be made. Should any astronomer, for his greater satisfaction, be desirous to see the original observations, I shall be happy to communicate them to him. They will be published in the sixth book of the *Specola Astronomica*, together with all my other observations made since 1794.

XIII. *Reflections on the new Primary Planet supposed to exist between Mars and Jupiter, and now in all Probability discovered. By Baron VON ZACH, Lieutenant-Colonel in the Service of the Duke of Saxe-Gotha, and Director of the Ducal Observatory at Seeberg*.*

THE existence of a primary planet, which, on account of the faintness of its light and small size has hitherto remained undiscovered, was, as far as I know, first conjectured, or at

* From *Monatlich Correspondenz zur Beförderung der End-und Himmelkunde*, June 1801.

least publicly mentioned, about forty years ago by the immortal Lambert. In his Cosmological Letters on the Universe, which appeared at Augsburg in 1761 *, the following remarkable passage occurs towards the end of the first letter: "And who knows whether some planets may not be lost, from the wide space between Mars and Jupiter?" This idea was no doubt suggested to Lambert by comparing the different distances of the planets; and he must soon have found that the distance between Mars and Jupiter is too great in proportion to the rest. To fill up this vacancy he placed in it a new primary planet; and as it had not been observed during the course of two centuries, that is, since the invention of the telescope, he supposes it to have been torn from the powerful influence of the sun by a destructive comet, round which it revolves in infinite space as a satellite; and concludes with this observation: "Is the case the same among the celestial bodies as on the earth, that the stronger exterminate the weaker; and, are Jupiter and Saturn destined merely to prey upon others?"

What might tend more and more to confirm astronomers in the idea of the existence of such a planet, was a certain relation which they had observed in regard to the distances of the six primary planets from the sun, and which was confirmed, in an unexpected manner, by a seventh primary planet beyond the orbit of Saturn discovered by Dr. Herschel in 1781. This remarkable relation was first adopted by professor Bode in the second edition of his Introduction to the Knowledge of the Starry Heavens, published in 1772, from professor Tilius's translation of Bonnet's *Contemplation de la Nature*, Amst. 1764. To represent this relation by small numbers, which can be easily compared if the distance of Saturn from the sun be divided into 100 equal parts, the distances of the planets from the sun in such parts will be as follows:

1. Mercury - 4 such parts from the ☉
 2. Venus - 4 + 3 = 7
 3. Earth - 4 + 2.3 = 10
 4. Mars - 4 + 2.2.3 = 16
 5. Hera or Juno 4 + 2.2.2.3 = 28
 6. Jupiter - 4 + 2.2.2.2.3 = 52
 7. Saturn - 4 + 2.2.2.2.2.3 = 100
 8. Uranus - 4 + 2.2.2.2.2.2.3 = 196, &c. &c.
- or more generally the n^{th} planet, reckoning from the sun, is

* A French translation of these letters, by Darquier of Toulouse, was printed at Amsterdam in 1801 by Hult van Keulen, with notes respecting the latest discoveries by J. M. C. Utenhove, of Utrecht. This edition was undertaken in consequence of my recommendation.

distant from that body $4 + (2^{n-2} \cdot 3)$: or, if we express, as professor Wurm has done*, the mean distance of the first planet by a , the difference between the distance of the first and second by b , and the mean distance of the earth from the sun by 1, the mean distance of the n^{th} planet from the sun will be $= a + (2^{n-2} \cdot b)$.

This law is founded on no known theory, at least it has never yet been demonstrated *mathematically*, and is merely deduced *empirically* from *analogical conclusions*. In no science have the powers of the human mind, merely by mathematical reasoning and the acuteness of geometrical reflection, produced so many, so certain, and so pure truths as in astronomy. When we consider the immensity and exalted nature of the objects on which this science is employed, and the insignificance of man and his terrestrial habitation, together with the endless variety and concatenation of the celestial phenomena, which all take place in consequence of one general very simple law of nature, that of gravity, diffused throughout the whole creation; and when we reflect what abstruse mathematical formulæ and methods must be invented to subject these so variously combined phenomena to calculation, and to obtain a uniform and continual correspondence of these calculations with what actually takes place in the heavens, it must be acknowledged, that no science does more honour to the human genius; that in no science have more discoveries been made *à priori*; and that no science is founded on more incontrovertible proofs than the exalted science of astronomy†.

The mathematical astronomers, for there are some who are not so, do not readily adopt any thing that cannot be mathematically proved. However great, therefore, might be the probability that the above-mentioned relation, in regard to the distances of the planets, taking it at least as an approximation, existed in nature, there were astronomers who doubted the consequences of this undemonstrated law, and the existence of an invisible planet between Mars and Jupiter.

* Berlin Astron. Jahre Buche, 1790, p. 168.

† La Place, that eminent analyst, in the preface to his excellent work, speaking of the progress of the modern chemistry, says: Et ce ne sera qu'au moment où les lois des affinités chimiques seront suffisamment observées, pour y appliquer l'analyse, que cette science (la chimie) aura le degré de perfection auquel l'astronomie s'est élevée par la découverte de la gravitation universelle. *Théorie du Mouvement et de la Figure elliptique des Planètes*, 1784.

It is worthy of remark, that the astronomers of no nation but Germany adopted this conjecture in their astronomical books, or wrote any thing on the subject. How is this to be accounted for? Does the spirit of an eminent German, the spirit of a Kepler, still hover over Germany? I do not here mean to assert that the Germans believed unconditionally in the existence of this planet, or acknowledged it as proved. Professor Bode has mentioned it in all his valuable works on astronomy, and in all the editions of them published since 1772; but he always speaks of its existence as founded on conjecture or analogy, and not as a demonstrated truth.

About sixteen years ago I employed myself in analogical calculations of the elements of the orbit of this latent planet, as may be seen by the letters I wrote to professor Bode from Dresden, in September 1785, which were printed in the Berlin Astronomical Almanac for 1789. But I spoke of these researches as mere *dreams*, and called my calculations *chimerical*. I even ridiculed them, and compared them to the researches of the adepts who endeavour to find the art of gold-making. In the year 1798, when, in consequence of Lalande's visit to Gotha, I had the pleasure of seeing my highly esteemed friend Bode, this subject formed part of our conversation. That worthy veteran Lalande had no great faith in the existence of this planet; he has not said a word of it in any of the three editions of his Astronomy which have been published: and I used to call those who entertained a strong belief of its existence, *astronomical adepts*.

In the year 1787 professor Wurm was engaged with similar thoughts on the possibility of other planets and comets existing in our system. These ideas he communicated to the public in the Berlin Astronomical Almanac for 1790, and in that of the following year, where he extended them to the system of the satellites. But he observed at the same time, that he was far from wishing to make any one adopt his astronomical *visions*, as he expressly terms them.

Astronomers had the greater reason for being on their guard against analogical conclusions, as the remarkable instance of our great master may serve to show that too much confidence must not be placed in a lively imagination. Poets may be allowed some latitude in this respect; but we must refuse the same indulgence to a certain class of naturalists and philosophers, who think they can catch nature in the slippery paths of mysticism; who substitute an unintelligible jargon for a language generally understood; and who attempt to explain a difficulty by obscurity.

Kepler, who often indulged in such astronomical dreams,
VOL. XII. E and

and gave full scope to his ardent imagination, thought he had made a great discovery by supposing that the five regular bodies would fit exactly into the vacuity between the six planets known at that time; and their distances indeed, according to the latest observations, correspond very well with this rule. But unfortunately, as has been remarked by professor Wurm, Euclid and Nature left no regular body for Uranus; and I may add, that none remains for Hera: so that Kepler's ingenious idea falls at once to the ground.

Should the question proposed on the discovery of Uranus be here asked—Why was not this planet discovered long ago? we might give the same answer to it as given by Lichtenberg*, who considered it of the same kind as that of Lelio's servant in Lessing's *Treasure*, who wished to know why his father had returned on a certain day, and not a year sooner or later; which he thought would have been much less incomprehensible.

The most natural way is, as professor Bode has done in his *Illustration of Astronomy*, to conjecture that this planet, being smaller than Mars, and at a considerable distance beyond it, reflects too little light from its surface; and hence it has escaped the keenest-sighted observers. But who knows what the nature of its surface may be? We are acquainted with celestial bodies which exhibit different colours, shades of red and green; as for example Mars, and the double star γ in Andromeda, the light of which increases and decreases; and others which even disappear from our view.

Kant and Wunsch, in their *Cosmological papers*, assert therefore that this planet does not exist by itself, but that it is incorporated with Jupiter; which is therefore of greater size than it ought to be according to the supposed rule, and consequently supplies the place of two planets. Kant ascribes the small size of Mars, and its want of satellites, to the same cause. But this hypothesis was not necessary to explain the invisibility of this planet, as it can be done in a much better manner, and more agreeable to the laws of nature. How long did Uranus remain concealed from our sight! And yet it was not only in the heavens, but, as we now know, was seen and observed 20, 30, and 90 years before Herschel's discovery of it, by a French, a German, and an English astronomer. How then could professor Wunsch, in the second edition of his *Cosmological Conversations*, published in 1791 †, consequently ten years after the discovery of Uranus, ask the following question: "What kind of a body must that be which, though

* Götting. Taschenbuch, 1783.

† Vol. i. p. 599.

so near, cannot be found by the best telescopes, though every small spot in the heavens is every night examined with the greatest diligence? But if this planet should once be discovered, or if it be really discovered, it will be easily comprehended why, as a telescopic star, it could have remained so long concealed among the innumerable multitude with which the heavens are covered*. Professor Wunsch thinks, that as the satellites of Saturn and Uranus, which shine only with a pale faint light, can be seen by means of good telescopes, this concealed planet might also have been seen. But professor Wunsch does not reflect, that to search for an exceedingly small moveable luminous point, that changes its place in the immensity of the heavens, is much more difficult than to search for a satellite, which always remains in the neighbourhood of its primary planet, and must even be found in the field of the observer's telescope. As professor Wunsch is a good mathematician, he may calculate the probability and possibility of the discovery of a satellite and of such a planet. It is possible that this planet, as was the case with Uranus, may have been seen several times; but it is also possible that it is not always visible. For, since it appears only as a telescopic star during the time of its nearest approach to the earth, at its greatest distance from us it may escape the best instruments and disappear entirely; which renders the finding of it still more difficult and uncertain.

All these impediments might in part have been foreseen; and it was only by an accident, or systematic regulation, that the discovery of this planet amongst the immense number of telescopic stars was possible. In the year 1787, when I undertook, at Gotha, a new revision of the starry heavens, my view was to search for this planet, to which I was particularly encouraged by the august founder of the observatory of Gotha. I therefore confined myself merely to the zodiacal stars, and made a catalogue containing the right ascension of these stars, under a conviction that it was possible by these means alone to fall upon this concealed planet.

In the autumn of last year, when I had the pleasure of undertaking a short astronomical tour to Celle, Bremen, and Lilienthal, and of spending a few agreeable weeks in the company of some of the ablest German astronomers, these

* On the discovery of Uranus Lalande made the following reflection: Le nombre des étoiles de septieme grandeur est si prodigieux qu'on auroit regardé comme impossible et inutile de les observer toutes, et à plusieurs reprises; cela eût été cependant nécessaire pour savoir s'il n'y en avoit pas quelqu'un qui eût un mouvement. *Ephemer. des Mouv. celest.* vol. viii. p. 88.—Lalande here alludes to stars of the 7th magnitude, but Hera appears as a star of the 8th or 9th.

eminent men were of opinion that it was not possible for one or two astronomers to examine all the telescopic stars of the whole zodiac in search of this concealed planet. Six astronomers then assembled at Lilienthal resolved therefore, on the 21st of September 1800, to establish a society of twenty-four practical astronomers dispersed throughout different parts of Europe, for the express purpose of searching out this planet supposed to exist between Mars and Jupiter. They elected Mr. Schröter as their president; and I had the honour of being chosen their perpetual secretary. The plan of the society was to divide the whole zodiac among the twenty-four members, each of whom was to have assigned to him, by lot, a zone of 15° of longitude, and of from 7 to 8° of north and south latitude. Each member was to construct a new celestial chart of his department, comprehending the smallest stars, and, by repeated examination of the heavens, to ascertain the true state of his district, and whether it contained that wandering body. By this institution we entertained hopes that this star, which had so long eluded our researches, would be at length traced out. In the name of the society I wrote to several of the most celebrated practical astronomers in Europe, inviting them to concur in this general object; and almost all of them agreed to the invitation with great readiness*. Some of the members, who have already begun their labours with great diligence, have transmitted, for our inspection, very interesting information; and though our infant society may be deprived of the honour of first discovering this planet, not only is the supposed discoverer of it among the number of its members, though the uncertain state of conveyance by post or by sea, in consequence of the war, has hitherto prevented us from transmitting our invitation to Palermo, but the society has already contributed a great deal, and will still contribute more, towards correcting our catalogues of the stars: and as this is not the only object of the society in the extensive province of astronomy, its labours, by being continued, must be of considerable utility.

In the month of February, this year (1801), I received a letter from Lalande at Paris, in which he informed me, that Piazzi, astronomer at Palermo, had discovered, on the 1st of January, a small comet in the shoulder of Taurus; it appear-

* The only astronomers who begged to be excused were professor Snia-decki of Cracow, and professor Wurm of Blaubeuern. The former, because, the university of Cracow being suppressed, he was consequently obliged to leave the observatory: the latter, on account of the want of instruments. But this difficulty was removed by princely munificence. The duke of Gotha sent professor Wurm a 7 feet reflector by Herschel, and the ducal an astronomical clock.

ed like a star of the 8th or 9th magnitude, without any nebula or tail: but as nothing else was said of its position or course, it was not possible to find it; and therefore, in expectation of more correct information, I paid no further attention to it.

In April I received a letter from Bode of Berlin, dated the 14th of that month, in which he told me that he had received a letter from Piazzi, dated Palermo, January 24, stating, that on the 1st of January he had discovered a small comet in $51^{\circ} 47'$ right ascension, and $16^{\circ} 8'$ north declination. On the 11th of January, from being retrograde, it had become direct; on the 23d, its right ascension was $51^{\circ} 46'$, and its northern declination $17^{\circ} 8'$. He hoped he should be able to observe it during the whole of February; it was very small, like a star of the 8th magnitude, and without any nebulous light. Professor Bode added: "On reading Piazzi's letter, I was much struck with the appearance and motion of this supposed comet; and I immediately wrote to him to send me the sequel of his observations. In the mean time I cannot help mentioning that I have found, by a well-known and easy calculation, that the two observations of the 1st and 23d of January, and the stationary state of the star on the 11th of the same month, agree excellently with the supposition that it is not a comet, but perhaps the hitherto unknown planet between Mars and Jupiter, taking its distance at from 2.75 to 2.80. What do you say of it? It is much to be regretted that we have not a third observation. But, as the stationary state agrees very well with the given places, it has become to me a matter of great importance. Send me a few words by the next post respecting your opinion. I may err, and wish for information; but the correspondence is very remarkable. Do you know any more observations respecting this singular comet?"

On reading this letter, I immediately had recourse to my old calculations of the years 1784 and 1785, and showed to professor Pasquich, who was present when I received the letter, that my elements of the orbit of this planet, calculated from analogy in the year 1785, and inserted in the Berlin Astronomical Almanac for 1789, gave as its distance from the sun 2.82, and as its period of revolution 4.74 years, or 4 years 9 months. Professor Bode, from Piazzi's observations, had found the distance 2.75, and the revolution the same as I had deduced from analogy, viz. 4 years 9 months. I immediately sent an answer to professor Bode's letter, and informed him, that my two elements of the orbit of this so long concealed planet, calculated, provisionally, sixteen years before, amidst my analogical dreams, and which I had deposited in his hands in a sealed

note in October 1785 *, when I had the pleasure of forming a personal acquaintance with this worthy friend at Berlin, corresponded perfectly with his own, and consequently with those of Piazzi. I was therefore not only of opinion that the supposed comet might be the invisible planet so long sought for in vain, but found that Oriani of Milan, from whom I received a letter two days after, entertained the same opinion, that this star was the planet supposed to exist between Mars and Jupiter. Piazzi himself, even in January, (Piazzi's letter to Oriani is dated on the same day as that to Bode, viz. the 24th,) informed Oriani that he considered this star, which he first supposed to be a comet, as a real planet. The honour, therefore, not only of having first discovered this star, but that also of having first ascertained it to be a planet, cannot be refused to Piazzi; and one might almost suspect (though we can hardly ascribe such a motive to him) that he wished to retain to himself likewise the honour of having first calculated its orbit, as he communicated his observations in so sparing and imperfect a manner.

Professor Bode announced this discovery and conjecture to the Royal Academy of Sciences at Berlin, and caused it to be published in the Berlin Gazette of May 12, the Jena Literary Gazette of May 6, and in the Hamburg paper of the 13th, from which it was copied into other journals.

Two days after I received professor Bode's letter, and before I could return an answer I received one from Oriani, dated April 7, in which he says: "I have received a letter from Piazzi at Palermo, which contains information highly worthy of your attention and of all astronomers. He writes me, that on the 1st of January 1801 he had observed a star, of the 8th or 9th magnitude; in the shoulder of Taurus. On the 2d of January he found this star had advanced *about* 3' 30'' further towards the north, and about 4 min. towards α Aries. The two following days, the 3d and 4th, he found nearly the same motion. On the 5th, 6th, 7th, 8th, and 9th, the heavens were so obscured that he could make no observation. On the 10th and 11th he again saw the star; and afterwards on the 13th, 14th, 17th, 18th, 19th, 21st, 22d, and 23d of January. From the 10th to the 11th its motion, from being retrograde, had become direct. He adds, that on the first day of observation (Jan. 1st) its right ascension was $51^{\circ} 47'$, and its declination $16^{\circ} 8'$ north. On the 23d of January he found R. A. $51^{\circ} 46'$, and N. D. $17^{\circ} 8'$. He writes also, that he first announced this star as a comet; but, as he always

* These elements had been communicated also to the duke of Gotha, to count Brühl at London, and Köhler at Dresden.

observed

observed it to be without any nebulous ring, and to have a very slow motion, he had several times conjectured it might be a planet. This letter, written on the 24th of January, was unfortunately 71 days on the road; it was therefore difficult, from the only two positions given by Piazzi, to conjecture the place of this wandering star after so long a period. I have, however, endeavoured to take advantage of the circumstance, that on the 10th of January the star from being retrograde had become direct, and, on the supposition of a circular orbit, have found that its distance from the sun must be three semi-diameters of the earth's orbit; so that this star may be a new planet, the orbit of which will fall between those of Mars and Jupiter. There is reason to think that the orbit of this planet, like those of all the rest, will have a perceptible eccentricity*, and consequently the hypothesis of a circular orbit, which I supposed, must be improper for representing its motion and geocentric place after so long a period: we must therefore wait for the remainder of Piazzi's observations, which he no doubt has continued. The heavens with us, since the receipt of Piazzi's letter, have been always overcast: you, perhaps, have a sky more favourable for astronomical observations than ours†. In this persuasion, I send you my elements of the orbit, calculated, as you will see, from these imperfect observations, by which you will be able to calculate the planet's place nearly. Heliocent. long. of the star at noon, Dec. 31, 1800, $2^{\circ} 6' 54''$; heliocent. motion in long. in 100 days $18^{\circ} 19'$. Longitude of the ascending node, $3^{\circ} 8' 32''$. Inclination of the orbit, $3^{\circ} 50'$. But, as already said, these results are subject to great doubts; for they are founded only on two very imperfect observations, and on the very insufficient hypothesis of a circular orbit. I, however, flatter myself that this letter will soon reach you; and, before the star be lost in the sun's beams, you will perhaps be so fortunate with your superior instruments as to find it, and to be able to give me more correct information respecting it."

Immediately after I received Oriani's letter, I calculated the place of the planet with its elements, and searched for it in the heavens on several serene evenings; but, unfortunately, the information had arrived too late. This small star had already advanced too near to the sun, so as to be lost in its

* According to my *conjectural calculations*, a very great one, 0.14 ; the greatest next to that of Mercury. Time will show whether I was right.

† At the bottom of the Thuringian forests, two hundred per cent. worse than Milan! How badly my friend was informed respecting our April weather! It is a common proverb at Gotha, that during the brightest and finest weather one must not go abroad without a great coat or umbrella.

rays and the vapour of the horizon. I afterwards found that Oriani, in consequence of his great haste and anxiety to communicate to me the intelligence as soon as possible, must have committed an error in the calculation of these preliminary elements, particularly in the Ω , and in the inclination of the orbit. But even had there been no error I should not have found this small wandering star; for when I received the information the obscurity was too great, and the star too near the horizon. Professor Bode also, as he informed me in a letter dated May 12, had searched for it several evenings, but in vain.

As no hope now remained of being able to observe this singular and remarkable body till its return from the sun in August or September, I made a calculation of its orbit as well as possible from so imperfect and scanty observations, not with a view of finding it again in the course of two or three months (for before that time I hoped Piazzi, by continuing his observations, would give us better and more determinate data and conclusions), but merely that I might have by me some conjectures to enable me with better grounds to believe in the actual existence of a planet between Mars and Jupiter.

The observations given by Piazzi for calculating the orbit are partly imperfect and partly insufficient. 1st, His two observations which are known, are only for minutes, and announced as *nearly*. 2d, For calculating the orbit of a planet or a comet, *three* observations at least are necessary. 3d, The times of the observations are not assigned. In regard to the first, we may admit, that at least the *nearest* minutes of the observation are given right. In regard to the second difficulty, Piazzi perhaps, as already said, may have purposely withheld the *third* observation, that he might calculate first himself the orbit of this planet*; for he considered it as such before the 24th of January. But if this were the case, he betrayed, in some measure, his having made a third observation; as he mentions that the planet from the 10th to the 11th of January was stationary. Oriani and Bode took advantage of this circumstance, and I employed it myself to calculate an approximate orbit of this planet from these scanty observations. The third difficulty was obviated by the following conjectures:

Piazzi, as is well known, is employed in the construction

* The celebrated French astronomer J. N. de l'Isle went still further. Having discovered, at the observatory of Paris, the long announced, long expected comet of 1759, he kept it a long time secret, observed it in private, and ordered his pupil Messier to say nothing of his discovery.

of a large celestial chart *. He had also, in part, the good fortune which I hoped to enjoy while preparing my catalogue of the stars, and with the view of which the Lillienthal Astronomical Society was formed; and the planet would certainly not have escaped them, even if it had not been discovered by Piazzi †. Piazzi is furnished at his observatory with an excellent transit instrument, and a complete meridian circle by Ramsden, by means of which he no doubt fell upon this small wandering star. This star must have culminated on the 1st of January, the day when discovered, about nine in the evening. At that time of the year and hour it is perfect night at Palermo; and therefore Piazzi could very well observe this small star, of the 8th or ninth magnitude, with a day telescope. It was, however, full moon; and as the moon had risen three hours above the horizon of Palermo, the night must have been very bright. But the moon was four hours, or about 68° distant from the star; and this circumstance alone converts my conjecture into certainty, that Piazzi must have found this supposed comet not with a comet-searcher, but with his meridian instrument. The above-mentioned right ascensions of the wandering star, converted into time, were consequently the time of its culmination in sidereal time: these I again converted into mean solar time, and thus brought out the true moments of the observations of the star. By these, and the obliquity of the ecliptic $23^\circ 28' 10''$, I have obtained the following data for calculating the orbit:

1801.	Mean Time at Palermo.	Geocent. Long. of the Plan.	Geocent. Lat. South.	Place of $\odot$ + 20''	Log. Dist. $\odot \oplus$
Jan. 1st	8h 43' 15''	$1^s 23^o 29' 40''$	$2^\circ 37' 5''$	$9^s 11^o 1' 40''$	9.9926158
23d	17 16 41	1 23 43 40	1 38 20	10 3 22 28	9.9932251

As the star on the 10th of January became stationary, I found its elongation for that time $7^s 26^\circ 41' 41''$, and, by means of Keil's proposition, that the tangent of the elongation is equal to the semidiameter of the orbit divided by the square root of that semidiameter, + 1. I found this semidiameter = 3.071 , and, by Kepler's principle, the revolution

* Last year he published his large catalogue, comprehending 5500 stars.

† It was really fortunate that Piazzi discovered his star on this day; for, had he fallen upon it eight days later, it is possible it might have escaped him; for, as this wandering star about that time became stationary, he would not, from the observations of next day, have remarked its motion. It is very singular that this new planet, if its being such be really confirmed, was discovered and seen in the shoulder of Taurus, as Uranus was 20 and 110 years ago.

$$(3.071)^{\frac{3}{2}}$$

$(3.071)^{\frac{2}{3}} = 5.3817$ years. By the usual methods I obtained the following approximate elements of the orbit :

Epoch of the mean heliocentric longitude				
for the commencement of 1801				
Long. of the ascending node	-	-	2° 6' 55" 40'	
Mean annual motion	-	-	2 22 0 50	
Inclination of the orbit	-	-	2 6 54 25	
	-	-	7 47 40	
Semidiameter of the orbit	3.071			
Synodical revolution	-	5.3806		

Those who attentively consider and compare these elements will no doubt remark, that the distance and periodical time of Piazzi's star are exactly the same as those of the celebrated comet of 1770, the calculation of which gave so much employment to astronomers, and the orbit of which Lexel could no otherwise represent than in an ellipse of $5\frac{1}{2}$ years. Pingré also found its distance = 3.09, and the period of revolution $5\frac{1}{2}$ years*. Burckhardt, who lately obtained the second prize proposed on this subject by the National Institute, could not reduce this singular body from new observations into any other than an elliptical orbit of $5\frac{1}{2}$ years. Was the comet of 1770 the so long concealed planet? or was Piazzi's star the comet of 1770? In either case, whether it was a comet or planet, Why was it not oftener seen, or before discovered? The causes, some of which we have already mentioned, may have been various. But to confine myself to a probable way of explaining this point, let the reader only look into Schröter's Observations on the Comet of 1799, published in the third volume of his Collections in regard to the latest Astronomical Discoveries†. The most singular phenomena of the accidental variable modifications of the nebulous light surrounding the comet, and also the well-known atmospheres of the planets, and even the sun, will be found there explained. In the nebulous light which surrounded the comet of 1799, Mr. Schröter observed not only occasional, but sudden and disproportionably great changes both in the extent and strength of the photosphere. Dr. Herschel not long ago presented to the Royal Society a paper on the structure of the sun, in which this eminent astronomer explains the solar spots by supposing an elastic and not luminous gas disengaged from the opaque surface of the sun's body, which divides the surrounding luminous fluid or photosphere, by which means we then see dark parts of the body, which we consider as spots.

Is it not therefore possible that we see stars at one time

* Cometographie, part ii. p. 89.

† Allgem. Geograph. Ephemerid. vol. iii. p. 432.

which

which disappear at another? We are acquainted with many which have periodical changes of light of greater or longer duration; as, for example, those numerous changeable stars called *Stellæ mirabiles*. What has become of the celebrated Tycho Brahe's star in Cassiopeia of the year 1572, which at one time shone as bright as Sirius, and even exceeded Venus and Jupiter when in their perigeum; so that it could be seen in the day with the naked eye; since which time not the smallest traces of it have been found? We learn by the old chronicles, that in the time of the emperor Otho I. about the year 945, and also in 1264*, a new and motionless star appeared between Cassiopeia and Cepheus. Some astronomers, therefore, conjectured that this might be the star of 1572, which appeared periodically in the course of about 300 years†. Had it any affinity with the celebrated star discovered by Kepler in 1604 in the foot of Serpentarius, which seemed at one time so bright that it exceeded in splendour stars of the first magnitude, became invisible next year, and has never since appeared? What are Herschel's planetary nebulae? Did not Schröter‡ find that whole tracts of luminous nebulae disappeared from the heavens? What are our large fire-balls, which move with a velocity a hundred times greater perhaps than that of a cannon bullet, emit a bright light, burst, and then disappear? It is proved that they are bodies belonging to the universe, and not to our atmosphere. This was the opinion of Montanari§ in 1676, who, in his *Fiamma volante*||, calculates that one of these fire-balls, seen throughout all Italy in the above year, was at the height of forty Italian miles. All our readers must remember the large fire-ball seen in the year 1783 in every part of Europe, and pretty well observed. It was calculated by some of the English astronomers that the height of this immense body of fire was 60 English miles, and that its greatest diameter was $1\frac{1}{4}$ th mile. In seven minutes it would have passed over a space equal to the semidiameter of the earth.

Why may not comets appear sometimes luminous and at

* Leovit. apud Tychon. lib. i. p. 441. Licet. lib. v. cap. 12.

† See Laplace's hypothesis on this subject in his *Exposit. du Système du Monde*, liv. 7. p. 347. an. 7. the only real edition in quarto acknowledged by the author.

‡ Beytrage, p. 232.

§ Halley and Hevelius considered them also as cosmical bodies.

|| La Fiamma volante, gran Meteora veduta sopra l'Italia la sera de 31 Marzo 1676, Speculazioni fisiche et astronomiche esposte dal Dott. Geminiano Montanari in una Lettera all' Ill. Ecc. Sgr. Marchese Federico Gonzaga, Bologna 1676. 95 pages quarto: a very scarce work, for which I am indebted to the kindness of professor Blumenbach, and which Dr. Chladni, who has collected on this subject with so much care, was never able to obtain.

other

others dark? The comet of 1770, therefore, might exist sometimes in an opaque, and sometimes in a phosphorescent state; and hence perhaps, and from the perturbative power of the larger and more dense bodies, the unfrequency of their return may be explained. They come back, and we do not see them; they are present, and we do not observe them. To draw conclusions, from the identity of the elements of the orbit of a body, respecting the identity of the body itself, gives, as all astronomers know, but a high degree of probability*, among the ninety-one comets, confirmed by only one hypothesis†, which certainly may be true taken *directly* but not *inversely*. Two comets, however, whose orbits have not the identical same elements, may be one and the same body. This, as far as I know, has never been explicitly asserted by any one: but Lexel mentioned it implicitly, when the following objection was made to him on account of the five years elliptical orbit of the comet of 1770: Since the period of the revolution of this comet is so short, why was it not seen oftener, and long ago? Lexel was of opinion, and perhaps so was the great Euler his master, under whose inspection he laboured, that the influence and perturbation of the large body of Jupiter, to which this comet approached very near on the 27th of May 1767, and the 23d of August 1779, might have entirely changed its orbit‡. Burckhardt was of the same opinion in his memoir written on the subject of the prize already mentioned.

But how frightful is the mere idea of calculating the perturbation of such a body! Would not such a calculation exceed the powers of our analysis? The difficult theory of the moon would be mere elementary calculation compared with the variable orbit of such a body. It were to be wished that so striking a phenomenon would produce the necessity of giving to our calculation, in regard to perturbation, a new direction, that the theory of so complex an approximation might be more improved, and that the influence of the successive integrations on neglected quantities might be better and more accurately determined. But the geometrician, who can represent all the co-ordinates of the motion of each celestial body in speedily approximating series of sines and cosines of the angle depending on its real motion, does not, perhaps, exist on our earth.

* Monat. Correspond. vol. iii. p. 414.

† The so called Halley's comet, the fifth and last observed return of which took place in 1759, and which will appear again in 1835.

‡ "M. Lexel pense, que son orbite peut avoir été *totale*ment changée par l'action de Jupiter." Pingré Cometograph. part ii. p. 90. See also Mém. de Paris 1776. p. 648.

Many

Many no doubt will consider the tail which, according to Messier's express observation *, attended the comet of 1770, as a proof that it could not be a planet. But, is it proved that planets cannot have a tail? We have planets with satellites, and others without these attendants; why therefore should there not be planets with tails, to prove, in a visible manner, that they are nothing else than planets? This difference in the appellation originated in the periods of ignorance, and must now be admitted into our language to distinguish those bodies, the appearance of which is of shorter duration, and which do not remain visible throughout their whole orbit †, from those which are always visible, except when they approach too near to the sun. The circumstance which seems to be peculiar only to comets, that some of them move retrograde, while all the planets move direct, is only apparent. The reader is referred to the explanation which Laplace and Lalande have given of this point in regard to the retrograde satellites of Uranus ‡. Lalande says the word *retrograde* imposes by its expression, but in reality is nothing. Kant, in his *Allg. Nat. und Theorie des Himmels*, original edition, published in 1755, conjectured that the retrograde motion of some comets might be only an optical illusion, like that of the geocentric motion of the planets.

Every newly discovered object must have a new appellation. Though a name in itself is of no great importance, we have seen in regard to Uranus how difficult it is for all mankind, from the Thames to the Neva, to be unanimous in this respect. If the star lately discovered by Piazzi be really the supposed planet between Mars and Jupiter, a great and august patron of astronomy, the founder of the observatory of Seeberg, gave it, in my opinion, a very appropriate name fifteen years ago. Uranus has afforded us a strong right, on the score of uniformity, to assign to this new planet, as has been the case with the old ones, a name borrowed from the heathen mythology. The duke of Gotha proposed, therefore, that of *Hera*, *Ἥρα*, or of the deity styled by the Romans Juno, the daughter of Saturn, and the sister and wife of Jupiter §: Jupiter therefore would have his father and grandfather above him, and his wife and children below him.

* Mém. de Paris 1776. p. 597.

† The new planet, perhaps, is not visible in apogæum, as already observed.

‡ Allgem. Geograph. Ephemerid. vol. ii. p. 170 and 259. See also Laplace's *Exposit. du Système du Monde*, p. 342.

§ Called also *Saturnia*. The duke at first proposed *Rhea*, the wife of Saturn; but this name has already been applied to the Earth.

The Greek name *Hera* is to be preferred to the Latin name Juno, 1st, Because the latter has been already applied to the planet Venus. Pliny says *, “*Infra solem ambit ingens fidus, appellatum Veneris Alii enim Junonis, alii Ifidis, alii matris Deum appellavere.*” St. Augustine † calls Venus, *Stellam Junonis*; and Apuleius ‡ says, “*Junonia, immo Veneris stella censetur.*” *Hera* is always involved in clouds, and our planet kept itself a long time concealed. This name, therefore, will still be appropriate even if the new star should not be the supposed planet: in that case, instead of the deity we have embraced a cloud §. 2d, *Hera* is at the same time the name of a city in Sicily, by which means the discovery made on that island, and the celebrated name of the discoverer of this eighth primary planet, will be eternized and preserved as long as tradition and history exist on the earth. The city of *Hera*, situated, as well as Palermo, on the coast of Sicily, was called also *Hybla Minor*, and is the same mentioned by Pausanias, Cicero in his Letters to Atticus, and Antoninus in his Itinerary. In the last place, *Hera* is the mother of Vulcan, who has his workshop in the burning mountain of *Ætna* in that island.

The objection already made in regard to Uranus, that all the planets have Roman and not Greek names, must be of less importance, as the Greek name *Οὐρανός* has been retained to that discovered by Herschel, though it would have been more agreeable to analogy to have called it *Cælus*. All the old planets, the discovery of which is lost in the obscurity of time, may retain their Latin names; but the new planets, the history of the discovery of which will be handed down to the latest posterity, with the names of the discoverers, ought, by way of distinction, to have Greek names. What seems here an interruption of analogy will be only harmony. Since the creation, like the Creator, has no bounds, should another planet be discovered beyond Uranus, its hieroglyphic appellation ought to be Greek.

It will be necessary also to invent an appropriate character for this planet. To a new planet we may assign the character of a new metal. This idea has been followed in regard to Uranus; but we have thereby committed an error, or rather established a monument of our ignorance respecting the component parts of platina. It was a much better proposal to distinguish this planet by ☿, the under part of which repre-

* Hist. Nat. lib. ii. cap. 6.

† De Civitat. Dei, lib. vii. cap. 15.

‡ De Mundo, p. 252. edit. Bipont.

§ Nubes et inania captare.

sents a planet, and the upper a fixed star: it should, indeed, denote a fixed star become a planet. But as this character has been already introduced in the *Vienna Ephemerides*, in order to prevent misconception it ought to be inverted. The characters of the Earth ♂, and Venus ♀, have the same affinity, as well as those of Mars ♂ and Uranus ♀.

POSTSCRIPT.

While the last sheet of this paper was printing we received from our worthy friend Dr. Olbers, of Bremen, the following elements of the orbit of Hera, which he calculated in a circle from the observations communicated to him by Piazzi:

Semidiameter of the orbit	-	-	2° 95'
Longitude of the ascending ☌	-	2°	21° 55'
Inclination of the orbit	-	-	7 56
Heliocent. long. Jan. 1st, 1801	-	2	7 45
Sidereal revolution	-	1851·6 days	= 5·0694 years.
Daily heliocent. motion	-	-	11' 39·95"
Yearly motion	-	-	71° 1'

This orbit is very insufficient, as it is calculated on the hypothesis of a circle: the very imperfect observations were only 22 days distant from each other; and, as Dr. Olbers very well observes, the lines of sight do not lie advantageously. Dr. Olbers is also of opinion that these elements are not sufficient to calculate a planet so long before, in order to be able to find it again on its reappearance in the morning in August. In the month of August it will pass through the whole sign of Cancer, and must be sought for in the equinoctial point. From the 1st to the 31st of August, a zone of the heavens from 115° to 130° of right ascension, and from 22° to 24° north declination, must be carefully searched; for this will be the district of the heavens where the planet will, in all probability, be found in that month.

In the oldest periods Latin verses have been invented to denote the order of the planets in regard to their distance from the sun. Thus, for example, we have the old well-known verses:

Saturni atque Jovis Sidus, Mars, Sol, Venus alma,
Mercurius, claudit ultima Luna chorum.

On the discovery of Herschel's planet, Poinfinet de Sivry wished to have it called *Cybele* or *Cybelle*, after the wife of Saturn, the nearest planet below it; and expressed the order of the seven planets in the following three Latin verses:

Ambit Solem Hermes, Venus hunc, mox Terra, Diana,
Mars sequitur. Pergit rex Jupiter. Hunc Saturnus.
Omnes hos orbes amplectitur alma Cubelle.

One of my friends, possessed of a poetical vein, has expressed the order of the planets, now increased to eight, in the following four lines, and not unhappily :

Mercurius primus: Venus altera: Terra deinde,
Mars posthac: quintam sedem sibi vindicat Hera.
Jupiter hanc ultra est. Sequitur Saturnus: at illum
Uranus egreditur, non ausim dicere furimus.

XIV. *Some Particulars respecting the new Planet Ceres Ferdinandea.*

IN the two preceding papers our readers are put in possession of every thing relative to the discovery of this planet. The following are some of the observed places of the Ceres Ferdinandea, upon its being rediscovered lately, and the times noted are mean time.

1801.

Dec. 7. Observed by Dr. Zach of Saxe Gotha, under some uncertainty of its being the planet.

M. T.	R. A.	Dec. N.
at 18 ^h 48 ^m 10 ^s	178° 33' 31"	11° 41' 30"

1802.

Jan. 5. By Dr. Olbers, at Bremen,

17 30	185 43	11 8 0
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11. Again, by Zach,

at 17. 3 17	186 45 50	11 10 0
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26. By Mechain, at Paris,

at 16 10 48	188 24 49	12 0 43
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Feb. 3. By the astronomer royal, Greenwich,

at 16 11 15	188 43 0	12 39 0
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4. at 17 25 46	188 43 0	12 44 0
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12. at 15 4 12	188 30 0	13 33 0
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On the 7th of February and subsequent days, it was observed by Dr. Herschel at Slough, and also by Alex. Aubert, esq. at his observatory at Highbury House.

The state of the weather at Slough did not admit of Doctor Herschel's seeing the new planet till Monday night the 8th current, he having previously received distinct notice as to its place from his friend Dr. Maskelyne, the astronomer royal, who for the first time observed it, like a star of the eighth magnitude, on the 4th current, in the morning. On the 9th and 10th of February at night, Dr. Herschel again traced the planet, and perceived its motion. It was not however till the morning of the succeeding day, that through a much clearer air, and at a more favourable altitude, with less obstruction