

Ongoing News
concerning the
Long Suspected New Primary Planet
of our Solar System

Monthly Correspondence
December 1801

translated by Peter Martinson

From the currently reigning bad weather, up to the encroaching frost and everlasting beautiful winter nights, especially in this northern part of Germany, the search for the new star of *Piazzi* will be very aggravated: thus, every relief from the weather, and each new hope, will be doubly welcome. What makes the search for this star so difficult in the present period, is that little can be reckoned from the continuous series of observations, which nevertheless will be required, to recognize the new wanderer on its own motion, since nothing peculiar distinguishes it from the other telescopic stars. In the winter months for our region, the observations can become interrupted for a long time, often 8, 14 or more days, on account of the covered sky, which is not unusual. This is why each search, after a long interruption, is resumed as if from the beginning.

A great hope of help and relief is granted by the investigations and calculations recently communicated to us by Dr. *Gauss* in Brunswick. At the same time, they give us a new and high degree of probability, that the new star discovered by *Piazzi* were actually a planetary body which moves between the orbits of Mars and Jupiter according to the laws of *Kepler*.

We hasten with the communication of his calculation all the more, since his new elliptical orbit is considerably different from the elliptical one of Dr. *Burckhardt*, and from the two circular orbits of Dr. *Olbers* and P. *Piazzi*, which we had communicated, along with other, previously calculated orbits of the planet, in our last issue. Their deviation, in the present month, from the *Gaussian* position can extend from 6 to 7 degrees in geocentric longitude. Hence, it is important that we communicate these investigations as soon as possible, for they indicate that the area of the sky in which the observational astronomers have been searching for this new, so elusive star, must necessarily be widened by 6 or 7 degrees towards the East. Then 1) according to Dr. *Gauss's* calculation, *Piazzi's* observations lie neither near the perihelion, nor near the aphelion, as Dr. *Burckhardt* and *Olbers* had assumed, but almost midway between both.

2) The eccentricity of the orbit, according to his [Gauss's] calculation, is not as insignificant, as P. *Piazzi* thinks. Therefore, according to the elliptical elements he had already calculated, the longitude in the current month could differ from that calculated from the circular elements by up to 7 degrees.

3) The elements of *Gauss* vindicate *Piazzi's* observations completely, and free them completely from the suspicion of a defect in accuracy, as Doctor *Burckhardt* and *Olbers* had conjectured, from an examination of their differences.

All of this proves the ellipse of *Gauss*. Thus, this will inspire Astronomers with confidence to recognize the precision represented by the collected observations of *Piazzi*. Dr. *Gauss* was brought to these calculations from a few investigations into physical astronomy, which had led him to some not insignificant additions to the theory of the determination of celestial orbits in conic sections of every type, some of which he was so kind to communicate to us. We hope to entertain our astronomical readers with these [additional investigations] another time, since this examination here would divert us too far from our subject; hence, we limit ourselves merely to that which has immediate bearing on the investigation of the orbit of *Ceres Ferdinandea*.

First, Dr. *Gauss* chose, for determination of the orbit, the three observations from the 2nd and 22nd of Jan., and from the 11th of Febr., which data he had taken up exactly as it is given in the Sept. issue of M. C., p. 280. According to his own procedure, he promptly found, on the fourth iteration, the following elements:

Aphelion	330° 14' 33"
(Asc. Node)	81° 8' 50"
Inclination of Orbit	10° 32' 19"
Logarithm of Semi – axis	
Major	= 0.4381058
Eccentricity	= 0.0832836
Epoch : Dec. 31, 1800	
mean noon in Palermo	
at Mean heliocentric	
Longitude	77°54'29"

Hence Follows :

Greatest equation of the mean
point = 9°32'57"
Semi – axis Major = 2.74226
Sidereal period = 1658 $\frac{2}{3}$ days
Daily sidereal mean
motion = 781".355

These elements exactly represent the two outer observations, the middle with 2 error in longitude and latitude. Aberration and precession were properly taken into consideration.

After this first happy attempt, Dr. *Gauss* undertook a second calculation of this orbit. He took the observations from Jan. 2 and 22 out, and chose in their places those from Jan. 1 and 21, in combination with that from Feb. 11, which he did not want to omit, in order that the intermediate times remained as large as possible. This calculation, on the fourth iteration, gave him the following elements:

Aphelion	330° 33' 20"
(Asc. Node)	81° 2' 35"
Inclination of Orbit	10° 36' 30"
Logarithm of Semi – axis	
Major	= 0.4370335
Eccentricity	= 0.0705553
Epoch as above	76°28'14".27

Hence Follows :

Greatest equation of the mean
point = 8°5'19"
Semi – axis Major = 2.73548
Sidereal period = 1652 $\frac{2}{3}$ days
Daily sidereal mean
motion = 784".25

Piazzi's observations, as quoted in the September issue, p. 280, agree with these elements as follows:

1801	Measurements		Errors in	
	Longitude	Latitude	Longitude	Latitude
Jan. 1	53° 22' 58". 42	3° 6' 42". 09	+ 0". 12	– 0". 01
2	53° 19' 37". 02	3° 2' 23". 78	– 7". 28	– 1". 12
3	53° 16' 43". 67	2° 58' 6". 70	– 14". 93	– 3". 20
4	53° 14' 14". 03	2° 53' 51". 16	– 1". 47	– 4". 44
10	53° 7' 54". 51	2° 28' 53". 13	– 4". 59	– 7". 47
13	53° 10' 18". 77	2° 16' 48". 78	– 18". 83	– 10". 92
14	53° 11' 55". 25	2° 12' 51". 23	– 5". 95	– 5". 47
19	53° 26' 0". 37	1° 53' 34". 19	+ 1". 17	– 4". 01
21	53° 34' 22". 68	1° 46' 5". 98	+ 1". 38	– 0". 02
22	53° 39' 7". 88	1° 42' 25". 06	+ 6". 08	– 3". 04
23	53° 44' 15". 74	1° 38' 46". 25	+ 0". 04	– 5". 85
28	54° 15' 20". 88	1° 21' 4". 07	+ 5". 18	– 2". 83
30	54° 30' 4". 25	1° 14' 13". 73	+ 5". 25	– 2". 27
31	54° 38' 11". 25	1° 10' 51". 99	+ 3". 95	– 2". 61
Feb. 1	54° 46' 28". 37	1° 7' 35". 09	+ 9". 07	+ 1". 19
2	54° 55' 5". 09	1° 4' 14". 25	+ 7". 19	+ 3". 75
5	55° 22' 50". 25	0° 54' 32". 88	+ 6". 85	+ 3". 98
8	55° 53' 23". 15	0° 45' 9". 20	– 6". 38	+ 4". 20
11	56° 26' 39". 97	0° 36' 2". 90	– 0". 03	+ 0". 00

As excellent as the agreement appears, yet Dr. *Gauss* himself considers it very possible, that his elements could differ from the true elements, considerably more than they deviate amongst themselves, since the part of the orbit covered is so small, and from the first to the last observation amounts to only 9°15'35". However, as this orbit [*Gauss's*] is, after all,

possible, if not highly probable, practical astronomers have double cause to take up the consideration of it in their search for this star, and to choose it as their most excellent guide, since, of all the hitherto tried and calculated orbits, not one appears to be in such close and exact agreement with all observations, as this *Gaussian* ellipse.

Besides, we yet remark that Dr. *Gauss* took into consideration with all of these calculations both the reported misprint in the October issue, p. 365, of a minute in the position of the Sun, and also the second one of January 13, likewise occurring in the longitude of the Sun, and assumed the second to $9^{\text{S}}23^{\circ}13'13.''8$.

Dr. *Gauss* was kind enough to communicate the extent of his calculations of the orbit of Ceres Ferdinanda to us. Meanwhile, we had received the treatise of *Piazzi*, together with his improved observations, a faithful abstract of which we had communicated in the November issue. But, even as small as these changes are - the most considerable of which being the Right Ascension from February 11, reduced by $15''$, the previous elements changing only a little - and though some considerable misprints and miscalculations snuck in with the reduction of these observations, and though these errors are easily eliminated, and the elements soon hereafter can be easily improved, we still communicated the set of *Piazzi's* observations to Dr. *Gauss* in the original Italian for his benefit. But, before he even received our letter, he had already begun the calculation of a new orbit. Even as little as the deviations of his second set of elements already were from the observations, yet they had a very striking regularity anyway, which allowed him to foresee with certainty that the errors could still be considerably reduced. He made the attempt, and, though his work had already been mostly completed upon receipt of the improved observations that were forwarded to him, which *Piazzi* had himself reduced and calculated, he regarded it all the more important to finish [the third set of calculations]. For, he had known in advance that the longitude for the new elements for the February 11 fall about $6''$ short, and thus, his was almost half the corrected statement of the observations, which had, of course, been unknown to him. From this method, he found the following 3rd set of elements:

		Hence Follows :
Aphelion	326° 53' 50''	
(Asc. Node)	81° 1' 44''	Greatest equation of the mean
Inclination of Orbit	10° 36' 21''	point = 9°23'57''
Logarithm of Semi - axis		Daily heliocentric sidereal
Major	= 0.4414902	mean motion = 772''.275
Eccentricity	= 0.0819603	Daily tropical heliocentric
Epoch	77°34'28''	motion 772''.413
		Tropical orbital period 1677.8 days

These elements represent the following observations of *Piazzi*, which were reduced by us and quoted in the September issue, p. 280:

1801	Measurement						Error in			
	Longitude			Latitude			Longitude		Latitude	
	°	'	''	°	'	''	''		''	
Jan. 1	53	23	2.34	3	6	43.63	+	4.4	+	1.53
2	53	19	41.24	3	2	25.68	-	3.6	+	0.78
3	53	16	48.50	2	58	8.97	-	10.35	-	0.93
4	53	14	18.47	2	53	53.79	+	2.97	-	1.81
10	53	7	58.37	2	28	57.12	-	0.73	-	3.48
13	53	10	21.60	2	16	52.89	-	16.0	-	6.81
14	53	11	57.70	2	12	55.36	-	3.50	-	1.34
19	53	26	0.59	1	53	38.10	+	1.39	-	0.19
21	53	34	21.99	1	46	9.53	+	0.69	+	3.53
22	53	39	6.69	1	42	28.45	+	4.89	+	0.35
23	53	44	14.80	1	38	49.44	-	1.62	-	2.66
28	54	15	17.11	1	21	5.91	+	1.41	-	0.99
30	54	30	9.76	1	14	15.12	+	0.76	-	0.88
31	54	38	6.44	1	10	52.81	-	0.86	-	1.79
Feb. 1	54	46	23.22	1	7	32.54	+	3.92	+	1.64
2	54	54	59.71	1	4	14.30	+	1.81	+	3.80
5	55	22	44.30	0	54	31.72	+	0.90	+	2.82
8	55	53	17.10	0	45	6.65	-	12.49	+	1.63
11	56	26	34.10	0	35	58.96	-	5.90	-	3.94

The errors and corrections reported by *Piazzi* provide the following alterations: Because of the reduction by 15 in Right Ascension from February 11, with $23^{\circ}28'13''$ slope of the ecliptic, the longitude becomes $56^{\circ}26'26''.1$, the latitude $35^{\circ}59'.7$ thus, longitude error $+8''.0$, and latitude error $-0''.74$. After checking the reduction of Right Ascension and Declination with the same observations, where *Piazzi's* statements deviate considerably from those of ours, Dr. *Gauss* found the longitude on February 8, $55^{\circ}53'17''.7$, giving an error of $-0''.7$.¹ Dr. *Gauss* found the remaining longitude on January 13 to deviate as strongly as found both by *Piazzi* and by us. Since this observation deviated most from the last and the previous elements, and cannot represent them exactly without forcing the remaining observations, Dr. *Gauss* suspected that a small mistake had occurred in the process. Besides, it is easily seen that the precision will be little changed by *Piazzi's* remaining small improvements (given in the November issue, p. 573), with which the observations will be represented through these last elements.

However, as trifling as all the errors are, *Gauss* still made a fourth try, to increase the precision yet more. The longitudinal errors are all positive in February with these last elements, if the small corrections of *Piazzi* are drawn into consideration; also, the latitude errors grow near the end quite a bit toward one side. This is why Dr. *Gauss* sought a new set of elements from which the calculated longitudes and latitudes in February become somewhat smaller, while the remaining approximations retain the same magnitude. However, if he did not reach complete agreement of these element with the set of observations, it is quite superfluous. He believed he could still be assured in advance, that they keep the mean among the observations, as far as they can, and that the errors have absolutely no regularity, but instead give a rather irregular change of signs, with no errors for any observation (taking those from January 3 and 13) going over $5''$ in longitude or latitude. [Dr. *Gauss* doubted, not without grounds, that, *with this data, a notably greater* agreement with other elements could be found. However, he definitely will not say, or will not make understood, why other considerably different elements could not impart a similar agreement — especially if, with this delicate calculation, where mere seconds already give a noticeable deflection, somewhat different determinations of the Sun were needed/required.] *Piazzi's* longitude of the Sun in February differed from that of ours by a half minute, although right here near quadrature, the influence of the Sun longitude is tiny, as compared with other positions. Hence, Dr. *Gauss* believed that it were not unsuitable if the errors of the Sun table were determined out of the very exact observations for these times, and the positions of the Sun determined after that. The *fourth* set of elements found now follow:

¹In *Piazzi's* original observations (p. 565 of the November issue), the longitude of the Sun is found to be about a minute too large on January 13 and February 8; all geocentric latitudes approach $10''$ too small, which, without doubt, comes from the fact that *Piazzi* used, with the reduction of his observations, a different slope of the ecliptic, of $32^{\circ} 28' 1''$, and probably all from the *Conn. D. tems Anné IX. — von Zach*

Aphelion	326° 27' 38"	Hence : Greatest equation of the mean point = 9°27'41" Daily heliocentric tropical mean motion = 770".914
(Asc. Node)	81° 0' 44"	
Inclination of Orbit	10° 36' 57"	
Logarithm of Semi – axis		
Major	= 0.4420527	
Eccentricity	= 0.0825017	
Epoch Dec. 31 1800	77°36'34"	

From these elements, Dr. *Gauss* had calculated the following future positions for *Ceres Ferdinandea*. The time for midnight in *Palermo* is mean.

1801	Geocentric Longitude	Geocentric Latitude North	Logarithm of the Distance from the (Node)	Logarithm of the Distance from the (<i>sun</i>)	Ratio of the Observed Luminosity
	<i>S</i> ° ,	° ,			
Nov. 25	5 20 16	9 25	0.42181	0.40468	0.6102
Dec. 1	5 22 15	9 48	0.40940	0.40472	0.6459
7	5 24 7	10 12	0.39643	0.40479	0.6835
13	5 25 51	10 37	0.38296	0.40488	0.7290
19	5 27 27	11 4	0.36902	0.40499	0.7770
25	5 28 53	11 32	0.35468	0.40512	0.8295
31	6 0 10	12 1	0.34000	0.40528	0.8869

Should the position of the planet be calculated according to these more exact elements, or from a longer time: thus, for this benefit, we set the following formulas here:

1) *Calculation of the Mean point Equation* = M

$$M = -34005''.494 \sin M[\text{ean}] A[\text{nomaly}] + 1750''.951 \sin 2 \text{ M.A.} - 124''.951 \sin 3 \text{ M.A.} \\ + 10''.192 \sin 4 \text{ M.A.} - 0''.901 \sin 5 \text{ M.A.} + 0''.083 \sin \text{ M.A.}$$

2) *For the Radius Vector* = r

$$= 2.776695 + 0.2373586 \cos M.A. - 0.0093752 \cos 2 \text{ M.A.} + 0.0005789 \cos 3 \text{ M.A.} \\ - 0.0000423 \cos 4 \text{ M.A.} + 0.0000034 \cos 5 \text{ M.A.} \\ - 0.0000003 \cos 6 \text{ M.A.}$$

$$\text{Or : } r = \frac{7.60570}{2.767278 \pm 0.2283053 \cos \text{ True Anomaly}}$$

3) *For the heliocentric Latitude* = λ

$$\log. \sin \lambda = 9.2653438 + \log. \sin \text{ Arg [ument] Latit [ude]}$$

4) *For the reduction of the heliocentric Longitude to the Earth's orbit* = ε

$$\alpha) \log. \text{ Tang. } \phi = 9.9925025 + \log. \text{ Tang. Arg. Latit.}$$

$$\beta) \epsilon = \text{Arg. Latit.} - \phi$$

5) *For the reduction of the Radius Vector, or curtate distance* = ρ

$$\rho = \cos. \text{ Helioc. Latit.} \times \text{ True Distance}$$

Or, *for the Logarithm of shortening* = Log μ

$$\log \mu = 10.000000 - \log. \cos \text{ Helioc. Latit.}$$

6) For optical aberration, in longitude, latitude, right ascension, and declination = α

$$\text{Log. } \alpha = \pm \text{Log. Dist. to N} + \text{Log. Mot. Horar. Geoc.} + \text{Log. } 7.751007$$

We close this report with a remark of Dr. *Gauss* on the inclination of the orbit of *Ceres*, which, because of its size, many astronomers have noted. Whether he is in complete agreement with most astronomers, that we are not justified by any physical grounds to expect all bodies of our Solar System to have a circular orbit as well as a small inclination to the ecliptic: all the same, it thus appears to him, that the paradox respecting this were considerably reduced, and the analogy can somewhat rescue itself anyway if the plane of this planetary orbit were made to coincide with the equator of the Sun, as had been done by *LaPlace* with the orbits of the Uranian satellites. If the planes of all planets were collectively compared with one another, it would then be shown that the orbit of *Ceres* is inclined against that of no other single planet, as much as against the orbit of Earth. We therefore compare the orbit of *Ceres* with the orbit of the Earth, thus comparing both extremes of our Solar System. However, imagine a plane, lying approximately midway amidst the collection of all *eight* planetary orbits: thus are the inclinations against that of *Ceres* all small enough. It appears noteworthy, that the equator of the Sun has just such an approximate situation; only with the restriction, that the orbit of *Ceres* is inclined least to that of Venus and Mercury, together, perhaps 3 or 4 degrees, and, on the other hand, the most to the orbit of only the Earth.