Gauss to Olbers

Brunswick

May 4, 1802

Translated from the German by Peter Martinson and Michael Kirsch

At last, I can congratulate you on the ninth planet. I shall indicate to you my continued work on *Pallas* chronolologically.

I had completely left it alone until May 1st. Late in the evening of April 30th-my birthday-your previous letter with your new observations and the three from Paris were delivered to me, and on the 1st of May, I immediately made the sharpest comparison with those elements I had already sent to you.[1] It was found that neither the six observations of von Zach nor the three Paris observations deviate by more than 15", yet the elements are bound to be affected *very strongly* by these deviations, in part because of the smallness of the time interval (15 days) and, in part, becaue of the disadvantageous position in the first half of April, which has already been noted by you. Indeed, I soon found that the variation comes out to be very considerable, and hence, the method of correction would require more trials. Hence, I felt it best, rather, to begin the calculations anew, according as I had freed the observations of aberration, parallax, and probable observation errors, which can be readily concluded from the comparison of the differences of measurement. The *first attempt* immediately gave the following new elements, which I have not yet corrected further because, upon verification, they agreed very well with the observations. Imagine my delight when the eccentricity came out to be very much smaller, and surpasses that of *Mercury* by only a little bit; also, the inclination was a few degrees smaller, but the *very great* similarity to the orbit of *Ceres*appears to fall away, by a rough calculation. Moreover, this appears to confirm that peculiar enclosure, like two links fastened to one another.

The elements of *Pallas*, from observations in Seeburg and Paris during the 4th-19th of April 1802:

Normal Ellipse

[1] These elements are displayed in Gauss' letter to Olbers on April 20, 1802.

Epoch in Seeburg, March 31, 1802, Noon.....	$166^\circ\ 1'\ 37.2''$
Daily Tropical Motion.....	800.77" Period =1618 $\frac{1}{2}$ Days
Logarithm of the Semi-Axis Major.....	0.4310494 Semi-Axis = 2.698
Aphelion for the above Epoch, Sidereal Resting	$304^\circ\ 36'\ 29.7''$
Longitude of the Ascending Node.....	$172^\circ\ 9'\ 58''$
Eccentricity.....	0.215708
Inclination.....	$33^\circ\ 39'\ 16.6''$

The differences with the nine observations underlying these amount to only a few seconds, and will have little reguarility; I am not yet finished with all of the comparisons, and will send them to you very soon.

Your latest letter was arrived last night. However, because of a chance delay, it was first delivered to me early today. Imagine the impatience with which I tested the elements against these observations. My method, with the various operations for the determination of geocentric positions, is such, that only very little attention is needed with calculation, and indeed it is almost impossible that an error of calculation would not be immediately apparent. [2] Even now, I have just calculated von Zach's and your latest [observations] of the 1st of May, without aberration and parallax:

		Right Ascension	Error	Declination	Error
April	26^{th}	$181^\circ\ 12'\ 8.9''$	$+7.1''$	$19^\circ\ 1'\ 51.4''$	$+\ 2.0''$
$''$	31^{st}	$180^\circ\ 59'\ 37.3''$	$+4.3''$	$19^\circ\ 43'\ 44.8''$	$-13.8''$

Aberration and parallax make the error of the declinations negative with Zach's observations, and reduce them with yours more severely; the error in AR will increase a little bit through the aberation.

It is too risky to venture a judgement about the reliability of the elements purely at ones own discretion; if I had first polished the same a little more, I would have arrived at an exact calculation with as much error as must be presumed with the observations, if the elements were wrong by a definite magnitude. Indeed, in the meantime, it can no longer be comfortably doubted that *Pallas* were really a planet. I am even inclined to hold the eccentricity barely over .02. It can still not be easily denied with certainty, whether perhaps the future improvement of the elements will bring it closer to the mean motion of *Ceres* or will make them quite equal. I am extemely curious about whether this is possible. To what sort of beautiful investigation would such phenomena, unique in its type, not give opportunity? The motion of the orbit from the 4th of April until the 1st of May is $7^\circ 37'$, which is already a decent-sized arc. If this motion could be continued throughout the rest of this month, then I hope the orbit can certainly be found fairly reliably; if you think that an ephemeris can facilitate the observations, then I am happily ready for the calculation. The meridian observations will now already be concluded, and hence now nobody will be able to make more remarkably exact observations than you.

Moreover, you could now proceed as you please with these elements, I merely request that you first compare them with your latest observations made since May 1st. Perhaps I will make it known in a periodical to satisfy the public curiosity. Should von Zach send me his observations with the morning mail, then I will send them to him next Friday, so that he will recieve them on the 11th. To my suprise he has still not yet sent them to me, like his three first from among those from April 8th; since then he has entirely broken off his almost daily correspodence.

Bode has demanded my method of determining celestial bodies for his 1805 yearbook; however, I can not comply with him in this, because, to me, it currently lacks a formal, thorough working-out in time. Also, it would be much too strong for the yearbook since it would be filled with pure formulas lacking derivation, and with the scanty directions for only a single arc. Furthermore, I wished not to rush too much, but, rather, to give the working-out of a particular part that I see as elegant and simple, and therefore I first wished to put this before your opinion. Perhaps I will devote one special work to it, which, with the general interest which the public has taken in *Ceres* and *Pallas*, would hopefully not have the fate of my *Disquisitiones Arithmeticae*, for which no publisher will have paid the printing cost. I have not communicated anything to

[2] Even though the problem, to determine the geocentric position from the elements, has now already been solved with ⚳ and ⚴ some hundred times, it is very rare that I run across an *Error calculi*, and then, only with the heliocentric positions.

anyone about this yet except for Mr. von Zach, and even then just a few of the most essential points. I will communicate it completely to you first, as soon as I can come to it. Pardon my great haste.