

ASTRONOMY

Eros: Asteroid 433

"A Classic of Science"

Its Discoverer Outlines Early Observations Made of the Strange Little Planet Which is Now Near the Earth

"This little planet, insignificant in size but of great astronomical interest, deserves special attention. It was discovered in August, 1898, photographically, by Witt, of Berlin, and at once attracted attention on account of its short period. Thanks to the numerous observations which have since been made, its elements are now known with very great precision. Its sidereal period is 643.23 days, or very nearly $1\frac{3}{4}$ years, and its synodic period 845 days,—the longest known.

"Its mean distance from the sun is 1.458 times the earth's, or 135,430,000 miles; but the eccentricity of its orbit, 0.223, is so considerable that at aphelion it is 165,630,000 miles from the sun, well outside the orbit of Mars and within the asteroid region, while at perihelion its distance is 105,230,000 miles. The inclination of the orbit is $10^{\circ} 49'$, the perihelion within little more than 2° of the descending node and only 21° from the earth's perihelion, so that the least possible distance between the two planets is only 13,840,000 miles. This is only a little more than half the least distance of Venus, and at such positions (which always happen about January 22) the parallax of Eros is nearly 60."

"Observations made on the planet at such time of close approach determine its parallax, and hence with the aid of our knowledge of its orbit the parallax and distance of the sun, with a far smaller proportional error than any other direct method.

"Unfortunately these favorable appositions are very rare; and, by worse luck, one happened in 1894, just before the discovery of the planet. The nearest approach since then occurred in 1901, when the minimum distance was a little less than 30,000,000 miles. Thousands of observations, visual and photographic, were made at that time at many observatories, and their discussion has

led to one of the most accurate values of the solar parallax ever determined.

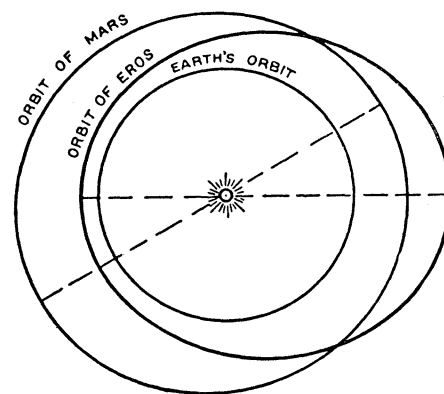
"There will be a better chance in 1931, when the least distance will be about 16,200,000 miles (on January 30). The planet will be favorably placed and is likely to be extensively observed."—from "Astronomy," vol. I, by Russell, Dugan and Stewart.

UNTERSUCHUNG UBER DIE BEWEGUNG DES PLANETEN (433) EROS. Inquiry into the Motion of the Planet (433) Eros. By Gustav Witt. Berlin: 1905. Translated from the German for the SCIENCE NEWS LETTER.

OBSERVATIONS of the planet Eros have been made over a period of almost ten years, from October 28, 1893, to June 30, 1903. Nevertheless a definite determination of its orbit is at the present time neither urgent or justifiable. During the opposition at the time of discovery and during the years 1899-1900, the planet has been observed comprehensively. But from the third opposition, there exist only two observations by Mr. Millosevich at Rome, which had been carried out on account of the appreciable southern declination of the planet at a zenith distance of almost eight degrees. The known positions of the planet before its visual discovery are based exclusively on photographic plates so that these plates need a very careful examination with reference to their exactness and immediate usefulness.

Nevertheless we can and will attempt, by making use of these data, to insure our knowledge of the elements of the planet to such an extent that they can serve in the future as the basis of further calculations and of the deduction of possibly definite improvements of these elements.

This is the first and foremost purpose of the present investigation. We also attempted to utilize the circum-



THE ECCENTRIC ORBIT

Of Eros occasionally carries the small planet nearer the earth than any other heavenly body except the moon.

stance that at the especially favorable appositions the disturbance of the earth, which in general is very moderate, quickly increase and must influence the geocentric place of the planet. From this point of view it appears at least hopeless to investigate just to what extent even now one can attempt an improvement of the mass of the system earth plus moon and with that to attempt indirectly an independent determination of the sun parallax. In this connection one can realize what hopes one can entertain for the future with reference to further observations of the path of Eros.

A not unimportant part of the preliminary investigations were carried out by Mr. Millosevich and were published chiefly in A. N. 3609 Vol. 151 p. 129 ff. Especially in this paper all the normal positions are fully published, a process that was made possible by the utilization of nearly the entire observational material from the opposition at the time of discovery. We saw no reason to modify this description; six of them were used by me without any further ado. Furthermore the article quoted above also contains a table on the influence of the disturbances by Venus, Earth, Mars, Jupiter and Saturn. I hesitated however to incorporate in the present work these data which served Mr. Millosevich to relate his improved elements to the date of the second opposition, Octo-

ber 31, 1900 since it seemed questionable whether we can assign the deviations with the necessary exactness for calculation of a definite disturbance.

In A. N. 3678 Mr. Millosevich published further improvements of the elements which harmonize better with the observations of the second opposition and finally he published the result in N. A. 3741 of a repeated calculation with reference to four normal positions which are distributed during the span of time from October 31, 1900, to March 20, 1901. The calculation of the disturbances up to this later date I could not take into account for the reason already mentioned above; on the other hand the two extreme normal positions, which by the way are not yet entirely definitive, were accepted unchanged.

For the period from March 20, 1901 to June 8, 1903 the disturbances of 433 by five planets, namely Venus, Earth, Mars, Jupiter and Saturn, were calculated by Mr. Wedemeyer on behalf of the Royal Recheninstitut in Berlin according to the method of the variation of the constant with 20 day intervals; a resumé of the end results is to be found on page 534 of the Berlin Astronomical Yearbook for the year 1905. Since the bases of this calculation were the elements deduced by Mr. Millosevich which were undoubtedly of sufficient exactness, a repetition appeared unnecessary, in spite of the fact that the calculation of the Ephemeride for the opposition of 1903 did not agree as closely with the already quoted observations at Rome as might be expected.

Now we have only to make a few general remarks concerning the photographic position of the planet Eros in the years 1893-4 and 1896. Twenty-one plates, twelve photographed in Cambridge and nine in Arequipa (Peru), were measured. Since we could not use the original plates, from each photograph two enlargements were prepared on which one millimeter represented about ten " gr. Kr. The position of the planet resulting from the measurement of these enlargements, the more or less close agreement of which permits an approximate estimate of exactness of the measurements, were published by Mr. Edward C. Pickering et al. A. N. No. 3652. . . .

The distribution of the observations from the years 1893 and 1894 permits the assumption of five normal positions; two isolated positions made November 26, 1893 and May 19, 1894 may be overlooked for at least the present. Of the six observations in the year 1896 five may be concentrated into two normal positions; a single solitary position on April 6, 1896 can not be utilized at the present time.

It appeared uncertain to carry out the definite calculation of the disturbance to the oldest date of observation at a single operation. The planet came into the closest proximity of the earth with 0.125 a.E. January 20.5, 1894. The elements must be very exact if one can not expect to find the disturbances by the Earth faulty around this date in appreciable quantities. For this reason I decided to carry out an improvement of the elements with the exclusion of the observations of 1893-4.

Here follow the tables of Witt's calculations.

From this I conclude that the numerical results at this time indicate that observation of the planet at a favorable opposition similar to that of 1893-94 would yield valuable material for an independent determination of the mass of the earth with greater precision, and that from this point of view it is worth while keeping (433) Eros under observation.

Science News Letter, January 24, 1931

PHYSICS

Relativity Passes Three Crucial Tests

From Page 52

graphic telescopes, designed and constructed anew to apply with great efficiency upon the Einstein test. The weather and sky conditions were essentially perfect. Hundreds of star images were recorded on the plates, all in excellent focus. The images of about a hundred stars whose light had passed the sun at varying distances were selected for measurement. The ten results from the ten plates were each in good and satisfactory accord with Einstein's prediction, and the mean of all the results was essentially in precise accord with the prediction.

Test No. 3.—If the positions of the thousands of dark lines in the spectrum of the sun, representing the gases and vapors of the chemical elements composing the surface strata of the sun be measured very accurately, it should be found, Einstein said, that the lines are displaced by an exceedingly small but definite amount toward the red end of the spectrum, because the strong gravitational pull of the sun upon the radiating materials in the sun's surface would affect the outgoing waves of light in such manner as to lengthen them slightly; and we know that a lengthening of the wave lengths shifts a spectrum toward the red end of it.

Several astronomers endeavored to observe this phenomenon but by far the most comprehensive and successful program was that conducted by Dr. St. John, a member of the staff of the Mount Wilson Observatory, based upon photographs secured with the powerful tower telescopes on Mount Wilson. Although several influences are known to be capable of displacing the lines of the solar spectrum very slightly toward the red, yet St. John's results after eliminating the other influences as well as

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