OCCULTATION DETECTION OF A NEPTUNE RING SEGMENT;

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In the stellar occultation technique. planetary astronomers use high-speed photometers to observe a star as it passes behind a planetary system. The star acts as a distant beacon to trace material near the planet and in the planet's atmosphere. Material which is located between the star and the observer causes an interruption of the starlight. Observers at different locations on the earth trace different paths through the planet's neighborhood, and their data can be combined to build up an "image" of the occulting material. Small objects close to planets can frequently be readily detected by this technique. even though such objects are difficult or impossible to image directly because they tend to be lost in the glare of light from the planet itself.

A stellar occultation in 1977 revealed the rings of Uranus, and astronomers immediately sought to apply the same technique to a search for material around Neptune. The first good opportunity for Neptune came in 1981, when worldwide observations of three stellar occultations were used to probe for Neptune rings. But no ring material was found. With one exception, there were no interruptions of the starlight by anything except the planet. The one exception was an 8-second interruption of the light observed in two experiments operated by University of Arizona scientists at observatories near Tucson. But a continuous ring like the Uranus or Saturn rings would have to interrupt the light twice (once when the star went inside the ring, and once when it came back out). The Arizona group didn't observe a second occultation, and so they decided that the single event was caused by an unknown small satellite with a diameter of about 100 km, probably located in an orbit at a distance of about 75,000 km from Neptune's center (three planetary radii). Some scientists were bothered by the low probability of getting such an occultation by a single small satellite, and wondered if there might be more than one such occulting body.

In 1982, a group of astronomers from Villanova University examined some old Neptune occultation data, and argued that their results indicated a close-in Neptune ring system extending from about 1.14 to about 1.31 Neptune radii. The 1981 data hadn't probed this region. But the Villanova observations weren't confirmed by other observatories, and have not been accepted as definitive for this reason.

More observations were made in 1983, this time including the region occupied by the proposed "Villanova ring", but no occultations by the ring were seen. Planetary scientists concluded that Neptune had no ring system. at least none which could be detected from the earth.

Another opportunity to search for Neptune rings occurred in July, 1984. The occultation was potentially visible from the western hemisphere, although the initial prediction indicated that the shadow of Neptune would pass only over the southern part of the earth. A further refinement to the prediction indicated that the shadow was even farther south, so that not even South America would be included in the path. There seemed to be little opportunity to learn anything new about Neptune, but nevertheless planetary astronomers set up experiments at two observatories in Chile. A group from Paris Observatory and other European institutions monitored the star from two telescopes at the European Southern Observatory (ESO). About 100 km to the south, Faith Vilas from the University of Arizona observed at three different wavelengths from a single telescope at Cerro Tololo Inter-American Observatory (CTIO).

Both of the ESO telescopes detected a strong occultation event when the star was approaching the planet, at a distance of about three Neptune radii. The European astronomers issued a bulletin to other observers, noting that the event was "less than two seconds long", and that the star light dropped by about 35%. They saw no other event. Vilas was not monitoring her data in real time at a rate fast enough to reveal such an event, and did not immediately confirm it. She brought her data back to Tucson in the form of a magnetic tape which contained a record of the stellar intensity at the three wavelengths at 1/100 second intervals.

The theorist in charge of the Arizona experiment, William Hubbard, examined the CTIO data in detail in December. He found that Vilas' data actually did contain a very similar event to the one reported by the ESO group earlier, and he contacted the theorist in charge of the ESO group, Andre Brahic of the University of Paris. Hubbard and Brahic met in Tucson in January, and exchanged their data. They have obtained the following results from comparison of the data sets from the two Chilean observatories. These results will be presented at the Lunar and Planetary Science Conference in a paper authored by the above-listed personnel, and given by Hubbard. A detailed paper is in preparation and will be submitted shortly for publication elsewhere.

The Chilean observatories (ESO and CTIO) detected a segment of occulting matter which is at least 100 km long, and which is about 15 km across. It is in an orbit which is probably in the Neptune's equatorial plane, approximately 75,000 km from the planet's center. Matter is not densely packed in the occulting segment, which is about 70 per cent transparent. The event occurred 0.13 seconds earlier at ESO than at CTIO, and from the time difference it can be determined that the position angle of the segment is nearly the same as the predicted position angle of an equatorial ring segment. The profiles measured at ESO and CTIO appear to be identical. The multichannel data from CTIO prove that only the star and not Neptune was occulted during the event, adding further credibility to the detection. Since the segment was observed by three telescopes in all, there can be no doubt about its reality.

Nothing is seen on the other side of Neptune, where a complete ring should have been crossed a second time. It thus appears that the object is not a complete ring, but rather a localized swarm of particles which follows a ring orbit over a limited range of longitudes. In order to avoid confusion with the standard use of the word "ring", Brahic and Hubbard suggest that the feature be called an "arc" (which has the same meaning in English and French).

It is not yet clear how the 1984 arc detection is related to previous observations, in particular to the 1981 8-second event. The latter could also be interpreted as an arc, but if so, it is quite different from the 1984 event. If it was an arc, it was nearly completely opaque, and had a width of about 75 km.

The distance of the arc zone from Neptune is not precisely known because so far there has been no confirmed occultation by both an arc and the planet. Hubbard has reported a possible very weak, broad, occultation from 1983 Neptune data at a distance of about 76,400 km from the planet's center, but this feature lacks confirmation. In any case, it is clear that the arc zone lies outside the conventional Roche limit of Neptune. Within the Roche limit, tidal forces from Neptune prevent the aggregation of small particles into moons, while outside the Roche limit, the mutual gravity of the particles should ultimately prevail, causing them to form satellites. Perhaps the arcs are an intermediate stage in this process.

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