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18. We thank P. Model and M. Russel for providing us with a strain of f1, B. Schoenborn and A. M. Saxena for help and use of facilities at the Brookhaven Neutron Source, and K. Moffat for aid in synchrotron experiments. Supported by NIH grants GM29829 and GM34343.

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1981N1: A Neptune Arc?

W. B. Hubbard

An object in the vicinity of Neptune detected in 1981 by simultaneous stellar occultation measurements at observatories near Tucson, Arizona, was interpreted as a new Neptune satellite. A reinterpretation suggests that it may have instead been a Neptune arc similar to one observed in 1984. The 1981 object, however, did not occult the star during simultaneous observations at Flagstaff, Arizona. This result constrains possible arc geometries.

In 1981, simultaneous photometry of a stellar appulse to Neptune observed from two telescopes in Arizona 6 km apart revealed a previously undiscovered occulting object at a distance of about 3 Neptune radii (3 R_N) from the planet's center (*1*). The object, which was given the temporary designation 1981N1, was found to be essentially opaque, with sharp, well-defined edges (Fig. 1). The contribution of the star to the blue signal (Fig. 1, b and d) was negligible; thus no occultation is visible here. The events in Fig. 1, a and c, correspond to a drop of approximately 100 percent in the stellar intensity, although, since the star was only 3 to 4 percent of the total red signal, this is difficult to determine with great precision. The original interpretation of these events was that they were caused by a previously undiscovered third Neptune satellite with a diameter in the range of 100 to 1000 km.

No further confirmed detections of material near Neptune were reported until 22 July 1984, when observers at three telescopes in Chile carried out simultaneous observations of the appulse of a bright star (SAO 186001) to Neptune. All three stations recorded a nearly simultaneous event near 5 hours, 40 minutes universal time (U.T.) (*2*). The 1984 event did not have sharp edges, nor was the star fully occulted at any time, and therefore the occulter could not have been a single solid satellite with any plausible shape. The duration of the event and its nearly identical nature at stations separated by 100 km implied that the occulting object was an arc of a partially (about 68 percent) transparent ring centered on Neptune with a radial width of about 15 km (*3*). The 1984 object was azimuthally coherent over at least 100 km, but, like the 1981 event, it was clearly not a large-scale ring since no corresponding occultation event occurred at the expected second crossing point. The 1984 arc was at a radial distance of about 67,000 ± 4,000 km (2.7 R_N) from the center of the planet, assuming that it was in Neptune's equatorial plane. The radial distance was computed from photographic astrometric data on the relative positions of Neptune and the star, and the error bar reflects the uncertainty in applying these data to computation of the occultation track (*3*).

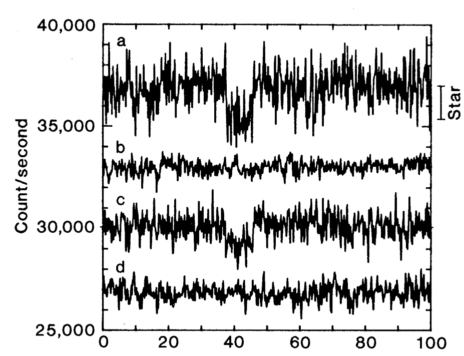

Fig. 1. Detections of 1981N1 from the 1.54-m Catalina Station telescope and from the 1-m Mt. Lemmon telescope 6 km distant on 24 May 1981, at a time resolution of 0.2 second (*1*). The traces show the combined signal of Neptune plus the uncataloged star as a function of time. Here (a) and (c) are, respectively, the red-channel signals at the 1.54-m and 1-m telescopes, multiplied by factors of 4.0 and 1.95; (b) and (d) are the blue-channel signals, multiplied by factors of 0.143 and 0.310.

1981N1 was originally interpreted to be a single satellite. However, the probability of the detection of a single small satellite by random occultation is clearly very small, whereas an extensive system of incomplete arcs would be likely to have a much higher probability of detection (perhaps of order 10 percent, judging from statistics on Neptune occultations observed to date). This circumstance suggests that the 1981 events may not have been caused by an isolated satellite but instead represented an early detection of a Neptunian arc.

Could the 1981 object have been a Neptune arc, much wider and more opaque than the 1984 arc? One way to test this hypothesis is to exploit the well-defined immersion and emersion times of the 1981 occultation events to calculate the location of the occultation points in the sky reference plane centered on Neptune, assuming that the occulting object has the same orbital velocity vector as Neptune. If the occulter was an arc, then the lines defined by the two immersion points and the two emersion points respectively should be parallel and should have a position angle consistent with that of an equatorial concentric arc. With a station

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separation of only a few kilometers as compared with the 100-km baseline of the 1984 observations, the immersion and emersion points respectively do not define position angles with great accuracy, but the timing uncertainties are sufficiently small to make the calculation a meaningful exercise.

Figure 2, which is a greatly expanded view of the vicinity of the occultation points in the sky plane, shows results of the astrometric solution from the 1981 timings (*1*). Also plotted are calculated loci of concentric equatorial rings. The computed radial distances are based solely on the prediction ephemeris (this observation was not supported by any astrometric plates near the time of the occultation, nor was there a planetary occultation), and thus are uncertain by at least ± 20,000 km. Nevertheless, from figure 2 of (*1*) the predicted position angle of equatorial concentric arcs at this position with respect to Neptune is insensitive to uncertainties in the star position (this was not the case for the 1984 events). The positions of the dashed lines in Fig. 2 are adjustable, but their slope is not.

The 1981 timings are therefore consistent with the hypothesis that the occulter was an opaque or nearly opaque arc with a radial width of about 80 km and at a similar radial distance from Neptune as the 1984 arc. If, on the other hand, the occulter was actually a small satellite with a diameter on the order of 10^2 km, then the occultation points in Fig. 2 must be remapped to correspond to the satellite's projected velocity vector with respect to the center of Neptune. For example, a satellite moving in an equatorial, circular, prograde orbit would have occultation points similar to those plotted in Fig. 2, but with the two immersion points shifted together to the left along the lower dashed line by about 100 km. This would imply that the occulting satellite has a peculiar, extremely noncircular profile. Similar conclusions are reached for other velocity vectors of the hypothetical satellite.

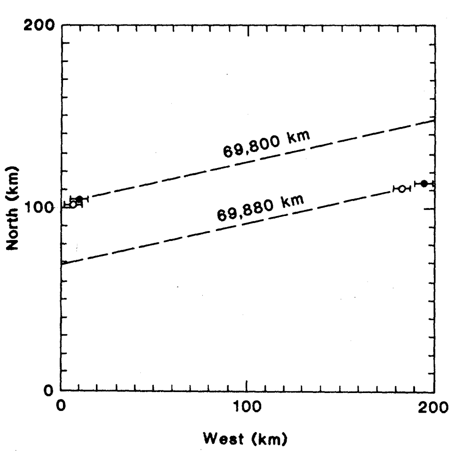

Fig. 2. Locations of 1981 occultation points in the plane of the sky at Neptune [(●) Mt. Lemmon timings, (○) Catalina Station timings; immersion points are on the right, and emersion points on the left; see figure 2 of (*1*)]. The error bars correspond to the reported timing uncertainties (±0.2 second) and are approximately 2σ errors. Dashed curves are projected equatorial rings at distances of 69,800 km and 69,880 km (the absolute distance from Neptune is only approximately determined, but the relative separation of the two rings is accurately known).

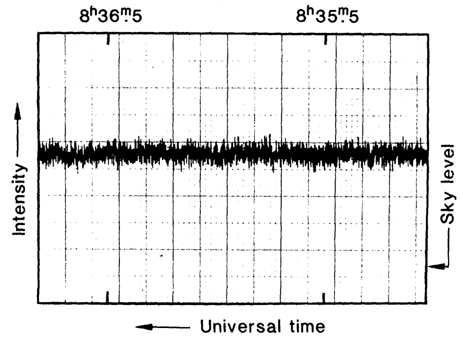

Fig. 3. Lightcurve of the 1981 appulse observed at Flagstaff.

Interpretation of the 1981 events as being caused by an arc is also not without difficulties. Figure 3 shows an observation of the same appulse obtained at the 72-inch Perkins telescope at Lowell Observatory, Flagstaff, Arizona, with a photomultiplier (RCA model C31034B) and a long-pass filter transmitting redward of 860 nm (*4*). The data are thus closely comparable to the red channel data shown in Fig. 2, but they show no event at the level of those seen at Tucson. There is some uncertainty about the depth of the expected event. The original prediction (*5*) included data on the relative brightnesses of star and planet with the same filter as was used for the observations at Lowell. These data predicted a 9 percent brightness change for total occultation. However, data obtained on the night of the occultation by Reitsema and colleagues (*1*) indicated that the star contributed 4 percent to the total signal at the 1.54-m telescope at Catalina Station. In any case, the Flagstaff data show no evidence of a single drop comparable to 4 percent or greater.

Figure 4 exhibits the sky plane shown in Fig. 2, expanded to include the points traversed by the Flagstaff observations. If the occulting object was an arc, its nondetection at Flagstaff sets an upper limit of about 600 km on its azimuthal extent in the direction north and west of the Tucson points. The limit is 600 km and not 900 km because prograde orbital motion would carry an arc to the south and east on the sky plane, and the projected distance traversed by an arc during the time interval from the last potential Flagstaff detection to the first Tucson detection is about 300 km.

There is strong evidence that Neptune has a belt of small satellites at radial distances of 65,000 to 70,000 km from its center. However, the geometry of this belt is still not easily fitted into a comprehensive picture. The observational evidence is summarized as follows. (i) Most occultation observations reveal no material in the satellite belt; it is therefore azimuthally patchy. (ii) If the 1981 feature was an arc, its nondetection at Flagstaff indicates that there is strong azimuthal patchiness on scales of only a few hundred kilometers. This result may argue against the Lagrangian point confinement model for arcs proposed by Lissauer (*6*), unless the 1981 occultation track happened to traverse a region with a very steep azimuthal density gradient. If the 1981 feature was an arc, it is (or was) both wider and denser than the 1984 arc. The differences between the 1981 and 1984 arcs are reminiscent of the differences between the ϵ and α rings of Uranus (*7*). (iii) The 1981 feature could have been a satellite with a diameter on the order of 100 km, which would be consistent with its nondetection at Flagstaff. In this case the Lissauer model would still be viable (the model in fact calls for such a satellite). However, this interpretation ignores the suggestive sky-plane profile of the occulting object.

Data from Neptune occultations are now being carefully examined for evidence of arcs (*8*). Further detections are likely; to be believable, observations should ideally be supported by coincidence detections from nearby sites or by multichannel data that give independent evidence that signal interruptions were caused by real celestial objects (or both). Observers are urged to report any unpublished occultation events that in their judgment may have been caused by a Neptu-

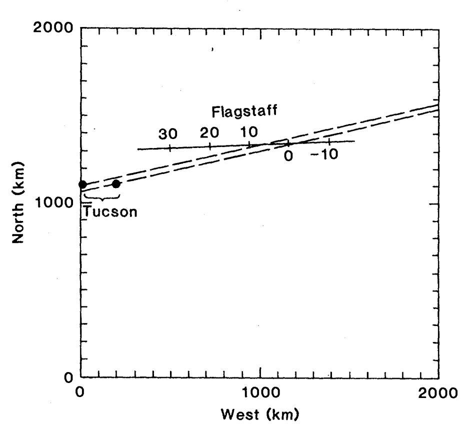

Fig. 4. Path of the 1981 star behind Neptune ring loci as seen from Flagstaff. Times are seconds after 18:36 U.T. (●) The Mt. Lemmon–Catalina immersion and emersion points of Fig. 2.

nian satellite or satellite belt and to continue monitoring Neptune appulses and occultations.

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Myrmecia pilosula, an Ant with Only One Pair of Chromosomes

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A new sibling species of the primitive Australian ant *Myrmecia pilosula* has a chromosome number of $n = 1$. C-banding techniques confirm that the two chromosomes of workers are homologous. Males are haploid, as in other Hymenoptera, and their somatic cells contain only a single chromosome. This new species is potentially of great importance in both laboratory and field studies on gene organization.

A MINIMAL CHROMOSOME NUMBER provides a simple and ideal system for genetic study. Until now, a chromosome number of $n = 1$ has been found in only one eukaryote, the nematode *Parascaris equorum univalens* (*1*). This nematode has a highly aberrant genetic system with a single pair of holocentric or polycentric chromosomes only in the germ cell line (*2*). Somatic cells contain numerous small chromosomes produced by fragmentation of the large pair of chromosomes during zygotic cleavage (*2*).

Standard insect chromosome preparation techniques were used (*3*). Chromosome spreads were made from the diploid somatic tissues of worker ovary follicle cells and worker pupal and prepupal cerebral ganglia. Spreads were also made from the haploid male pupal and prepupal cerebral ganglia. C-banding was achieved with routine staining with Stains-all (Serva, Heidelberg). Consistent and convincing G-banding was not achieved, however (*4*).

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All 20 worker chromosome preparations revealed large numbers of chromosome spreads containing only two large chromosomes. The chromosomes are of identical size and are both submetacentric with identical arm ratios. C-banding confirmed that the two chromosomes are homologous (Fig. 1A). All 15 male chromosome preparations showed numerous cells containing only a single chromosome. The chromosome was clearly identical in banding and morphology to the worker chromosomes (Fig. 1B).

Myrmecia pilosula (F. Smith) is of particular interest in studies on karyotype evolution. Originally described as one species, it is now known to consist of several karyotypically distinct sibling species. Other sibling species of *M. pilosula* have diploid chromosome numbers of 9, 10, 16, 24, 30, 31, and 32 (*3*).

The new sibling species discussed here was collected from Tidbinbilla Nature Reserve near Canberra, Australia, on 24 February 1985. The colony collected contained winged males and females plus a mated queen together with pupae and more than 100 workers. The colony has successfully reared workers and males in the laboratory.

Unfortunately, attempts to find further $n = 1$ colonies at Tidbinbilla and nearby locations have so far been unsuccessful. The search is hampered by the presence of other *M. pilosula* siblings currently indistinguishable morphologically from the $n = 1$ sibling. A taxonomic study of the *M. pilosula* group is therefore a high priority.

Eusocial insects tend to have higher chromosome numbers than their phylogenetic relatives (*5*), although the reason for this trend is in dispute (*5, 6*). The discovery of this highly eusocial insect with the lowest known insect chromosome number was therefore particularly unexpected.

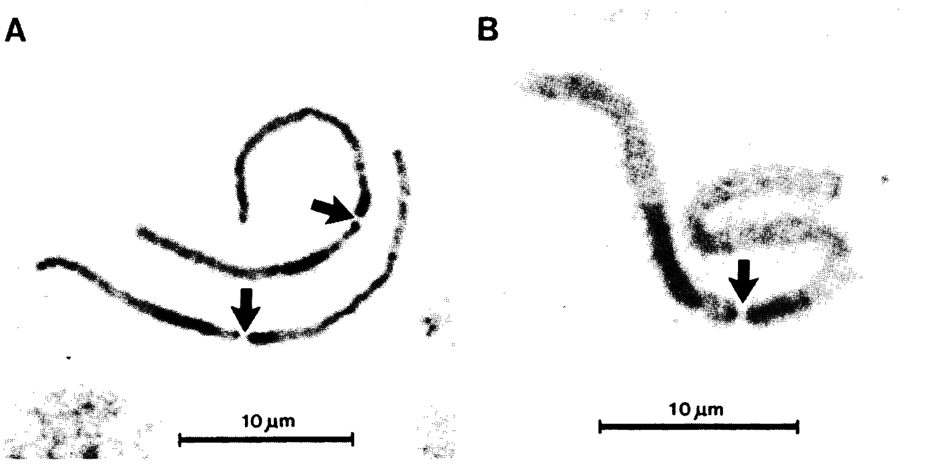

Fig. 1. Chromosomes from prepupal cerebral ganglia. (A) Worker prometaphase chromosomes. Identical C-banding provides evidence for homology of the two chromosomes. (B) Male prometaphase chromosome. Chromosomes consistently display a large centromeric C-band on the short arm and a smaller centromeric C-band on the long arm. Most of the short-arm C-band is not immediately adjacent to the centromere, though a very small portion of the short-arm C-band is centromeric. Arrows indicate position of centromere.

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