of the total rotation, then the extension between this and the American plate would have amounted to about 400 km. The Southern Basin and Range may be traced in a NW–SE direction over a distance of about 1,200 km so here again considerable dilation is predicted. If there is sufficient evidence to show that this is too high then we may be led to assume that the motion of the Sierra Nevada with the Pacific plate occupied a smaller proportion of the total rotation between the Pacific and American plates.

The validity of the proposed mechanism will ultimately depend on how well it can explain all the large scale Tertiary tectonic phenomena in the Western Cordillera of North America. The mechanism should also be tested in other areas, particularly where palaeomagnetic data suggest that large rotations have occurred during relatively brief periods of geological time. In some instances oroclines may not be observed as they require the existence of an orogenic belt in the vicinity of the hinging poles. While linkage may perhaps be favoured in tectonic regimes where the crust has a strong grain, there does not seem to be any reason why it should not also be found to occur elsewhere.

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letters to nature

Uranus rings: an optical search

THE discovery of rings surrounding Uranus[1–4] has prompted a careful re-examination of telescopic observations made nearly a year ago with a new type of solid-state area detector called a charge-coupled device or CCD. The extreme narrowness of the individual Uranus rings explains why they had not previously been detected either by visual or conventional photographic methods, for even if they were composed of highly reflecting, ice-coated particles, the rings would likely be hidden in the glare of reflected light from Uranus itself. The average reflectivity (averaged over the disk) of Uranus in the blue and green regions of the spectrum is very high, ~ 0.55–0.60. At longer wavelengths, however, methane in the planet's atmosphere begins to absorb much of the incident solar radiation, hence the bluish-green appearance of Uranus in the telescope. In the deep methane absorption band at 886 nm the reflectivity of the planet drops to only 0.012, and Uranus would thus appear very dark to any detector which was sensitive to this near-infrared region of the spectrum. It is of particular significance to the ring detection problem that such imaging would suppress the light reflected from the planet relative to that reflected from any nearby solid bodies, such as satellites or ring particles, by a factor of nearly 50. Unfortunately, most detectors have lost nearly all of their detectability at wavelengths longer than 800 nm.

The CCD is an exception. Low noise and quantum efficiencies of 0.5 and higher permit telescopic imaging of Uranus in the 886 nm methane band with acceptably short exposure times. In May 1976 we obtained several dozen images of Uranus in this band using a CCD camera at the f/13 cassegrain focus of the University of Arizona's 154 cm (Mt Lemmon) telescope. Exposure times ranged between 1 and 5 min. These images, recorded digitally on magnetic tape, have recently been re-examined to see if they contain any hint of the Uranus rings. Because the widths of the individual rings[1] lie way below the resolving power of any groundbased telescope, we can evaluate only an average reflectivity based on the simplifying assumption that all of the ring material is spread uniformly between the innermost and outermost rings—a region of space extending from 44,000 to 51,000 km from the centre of Uranus. Evidence of the rings has not been found in any of the CCD images. But it is possible to set an upper limit of approximately 0.0001 for the average reflectivity as defined above.

A preliminary examination of the reported occultation events implies that these narrow rings occupy ~ 2% of the space between the innermost and outermost events, and an analysis by Hubbard indicates that the individual rings themselves are only partially (approximately one-half) filled with solid particles[5]. If these numbers are accepted as being essentially correct, we find that the average reflectivity of the individual particles must be at most a few per cent, much closer to that of carbonaceous chondritic material than to the ice-coated particles in the rings surrounding Saturn[6–8]. Considering the extremely low temperatures characteristic of this remote part of the solar system (<90 K), this preliminary conclusion on the nature of the Uranus ring particles comes as somewhat of a surprise.

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