The Voyager 2 Encounter with Uranus

E. C. Stone

California Institute of Technology
Pasadena, CA 91125

Submitted to

NATURE, News and Views Section
January 2, 1986

SRL 86-1

The Voyager 2 Encounter With Uranus

E. C. Stone
California Institute of Technology

Propelled outward by swings past Jupiter and Saturn, Voyager 2 will encounter Uranus on January 24, 1986. Approaching within 81,500 km of Uranus' cloud tops, Voyager 2 will provide the first detailed investigation of a planetary system that was first seen by Herschel just over 200 years ago. Since then, much has been learned about Uranus, although it is almost 3,000 million kilometers from Earth (see,e.g., Uranus and the Outer Planets, G. E. Hunt, ed., Cambridge,1982, and Uranus and Neptune, J. T . Bergstrahl, ed., NASA SP-2330,1984). Even so, much less is known about Uranus than was known about either Jupiter or Saturn before the first spacecraft flybys, providing an even greater opportunity for discovery. Using many of the techniques employed in studying Jupiter and Saturn, eleven scientific teams will study the planet, the rings, the satellites, and the magnetosphere.

The Planet

Although Uranus is a giant gaseous planet like Jupiter and Saturn, it differs in several important ways. Since Uranus is much colder, the ammonia clouds form deeper in the atmosphere and may not be easily visible, though there may be higher, more visible methane ice clouds and haze layers.

The weather system and cloud patterns may also differ significantly from those on Jupiter and Saturn because Uranus is tipped over, with its south pole currently facing the sun. The resulting eddy flow carrying heat toward the equator depends on the balance between absorbed solar energy and the outward convection of any internal energy, both of which will be accurately determined. Cloud motions may also provide the first direct indication of the rotational period of the planet for comparison with the dynamically derived period of ~16 hours.

Uranus' composition is also different, having formed in a region of the solar nebula with an abundance of various ices. The relative abundance of methane can be determined by measurements of the atmospheric temperature profile, as can the helium abundance, which Orton (Science, submitted for publication) has suggested may be 40±15%, much greater than for the Sun, Jupiter, or Saturn.

The Rings

Uranus' nine narrow rings, like Saturn's F-ring, are probably prevented from diffusing radially by pairs of adjacent shepherding satellites. The size and location of these and other small satellites are critical to an understanding of the dynamics of this unique ring system, as is the detailed structure of the individual rings which will be determined by stellar occultations and by precise measurements of the dual-frequency radio transmissions through the rings. Other dynamical effects,such as the kinks observed in Saturn's F-ring, may also be present.

The radio occultation observations will also provide information on the sizes of the ring particles. Their composition is unknown, but those in the outermost ring have a reflectivity of only ~5%. The colors of the different rings may indicate whether the surfaces are coated with the residue of irradiated methane or with carbonaceous chondritic material.

Although only nine dense rings have been observed from Earth, there may be diffuse rings of micron-sized particles, such as the Jovian ring system, which will be most apparent when backlighted.

The Satellites

The five known satellites have surface water ice and are similar in size to the intermediate-sized Saturn satellites. They are, however, much darker, as might result either from a uniform contamination of the ice by a dark material or from very dark surfaces with white patches. Images should resolve such features as small as 600 m on Miranda and 13 km on Oberon, as well as impact craters and any extensive resurfacing or ridges and grooves such as observed on Enceladus at Saturn.

The bulk composition of the satellites is unknown and could range from a mixture of water and methane ice to mostly rock (Dermott and Nicholson, preprint, Cornell Univ., 1985). The satellites' perturbations of the spacecraft trajectory will yield considerably improved mass estimates, as will an analysis of the more accurate orbital parameters provided by Voyager 2 observations of the satellites.

As at Saturn, other smaller orbiting objects are likely to be discovered in addition to numerous shepherding satellites.

The Magnetosphere

Voyager 2 will determine the nature of any planetary magnetic field and associated magnetospheric phenomena, including the planetary distribution of ultraviolet emissions. If the intense UV emissions observed by the International Ultraviolet Explorer satellite are auroral, then a large magnetosphere and extended magnetotail are expected. The magnetic dipole would likely be tipped like the planet, resulting in a unique pole-on interaction with the solar wind. The presence of a large magnetic field is not assured, however, since by late 1985 Voyager 2 had not yet detected auroral kilometric radiation, possibly because ionospheric effects suppress auroral radio emissions from the sunlit pole (Curtis, Nature, 318, 47, 1985).

Alternatively, the UV emissions may be primarily airglow similar to that observed at midlatitudes on Jupiter and Saturn (Shemansky and Smith, Geophys. Res. Letters, in press). If so,there will also be an escaping flux of neutral hydrogen which may, as it is ionized, load the solar wind, resulting in a comet-like interaction as was observed at Giacobini-Zinner by the International Cometary Explorer spacecraft. If there is a magnetic field, the neutral hydrogen would be a major source of magnetospheric plasma.

There should be answers to these and many other questions as Voyager 2 encounters the most remote object yet visited by a spacecraft.