lar system carbon budget include: 1) the aforementioned solid-body densities, and parameters derivable from these densities such as ice and silicate mass fractions; 2) the abundance ratios and isotopic compositions of H,C,N, and O in the atmospheres of the giant planets; and 3) models of the formation mechanisms of the giant planets and their satellite systems–for example, the importance of planetesimal dissolution in the envelopes of the forming giant planets, and the possibility that the satellite systems are formed from the outer portions of these envelopes rather than a solar nebula source. In order to include organic materials in the carbon budget, as a first step we have compiled information on the densities, chemical abundance ratios, isotopic compositions, etc. of organic materials found in carbonaceous chondrites, Comet Halley, stratospheric particles, interstellar materials, and laboratory-produced tholins. Using this information as a background, detailed investigation of the outer solar system carbon budget, starting with derivation of ice/silicate fractions for the Pluto/Charon system, is in progress.

02.02

Radio Science with Voyager 2 at Uranus: Results on Masses and Densities of the Planet and Principal Satellites

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We have analyzed radio Doppler data and star-satellite imaging data from Voyager 2 at Uranus, along with eight years of ground-based astrometric data, and have obtained improved masses and densities for the satellites of Uranus as well as a new ratio of the mass of the Sun to the mass of the Uranian system of 22902.94 ± 0.04. The mean density of Uranus is 1.285 ± 0.001 gm cm^{-3}. The satellite densities for Miranda, Ariel, Umbriel, Titania, and Oberon are based on improved masses and radii over those published previously in Voyager team reports (Science, 233; Tyler et al., pp. 79-84 for the Radio Science Team and Smith et al., pp. 43-64 for the Imaging Science Team). The mean observed uncompressed density for all five satellites is 1.48 ± 0.06 g cm^{-3}. This is 0.10 g cm^{-3} higher than the value expected for a homogeneous solar mix consisting of 34% anhydrous rock, 51% water ice, 7% ammonia ice and 8% methane, present as clathrate hydrate. In order to reconcile this difference, we have considered possible deviations from a normal solar mix of rock and ices, but always consistent with solar system abundances compiled by Anders and Ebihara (Geochim. et Cosmochim. Acta, 46, 2363, 1982). Both homogeneous and fully differentiated satellite models have been computed, and in considering evolutionary effects from the decay of radioactive nuclides, conductive heat flow has been taken into account by numerical integration. We conclude that a cometary origin for the satellites is ruled out by the Voyager 2 data.

02.03-T

Spectrophotometry of Oberon

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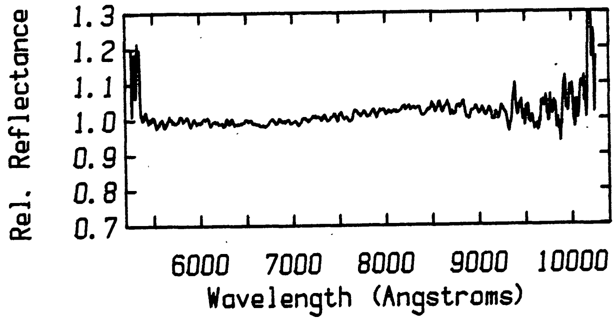
The LPL CCD/Spectrometer combination was used at the UAO Catalina Station 1.54m to observe Oberon on the nights of 1987 May 31 and June 03. Ninety minutes of integration has resulted in a continuous spectrum from 5000-10200 Å, at approximately 7 Å/pixel dispersion. The spectrum is reproduced in the Figure below at 35 Å resolution, normalized to unity at 5500 Å.

Oberon's spectrum appears featureless throughout this wavelength region (all structure longaward of 9000 Å may be attributed to telluric features.) The overall slope is approximately 17 percent/micron toward the red. This slope is less than one-third that found by P. Johnson *et al.* (*Icarus* 36, 75), but greater than the essentially flat continuum reported by Bell *et al.* (*BAAS* 11, 570)

We feel confident in our value for the slope on two accounts. First, the sky was measured simultaneously with our spectrometer, with spatial information radial to Uranus permitting proper background subtraction. Second, our results are in excellent agreement with Voyager *in situ* measurements at the short-wavelength end of the spectrum (Green and Orange filters.)



02.04

Depth/diameter measurements of craters on Uranian and Saturnian satellites: Preliminary results

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Crater depth/diameter values for the intermediate-sized Uranian and Saturnian satellites Ariel, Umbriel, Titania, Oberon, Mimas and Rhea have been measured using both photoclinometry and shadow measurements. Photoclinometric depths of simple craters on Ariel, Mimas and Rhea are 25 to 50% shallower (at 9 km diameter) than simple lunar craters. Shadow measurements of simple crater depths on Mimas and Rhea indicate that a large portion of this difference may be real and not due to the photoclinometric technique. Planned photoclinometric measurements of Mercurian craters using Mariner 10 images will provide an estimate of the magnitude of any technique-dependent depth reduction. Least-squares fits to the depth/diameter data for complex craters on the six satellites examined to date have slopes ranging from 0.56 to 0.70 (except Umbriel where the data is particularly noisy), substantially higher than for any of the terrestrial planets (Pike, 1980). Shadow measurements on Mimas and Rhea again indicate that much of this difference may be real. Simple-to-complex transition diameters for Titania, Oberon and Umbriel, for which only complex craters are distinguishable, were calculated assuming the least-squares fit to simple craters on Ariel. Within the approximate margin of error due to scatter in the data, transition diameters for Umbriel, Ariel, Titania and Rhea approximately follow an inverse gravity trend, although slightly below that determined from central peak statistics. Mimas, and perhaps Oberon,

	Mimas	Umbriel	Ariel	Rhea	Oberon	Titania
Transition diam. (km)	12.2	10.5	8.7	8.6	4.4	5.2
Surface gravity (cgs)	7.8	23.7	26.8	28.0	33.4	36.6
Number of craters	42	28	51	105	14	40

may be somewhat below this trend. Crater collapse on the icy satellites begins at smaller diameters than would be expected from simple extrapolation of the terrestrial transition diameter trend (Pike, 1980), supporting conclusions based on central peak studies (Chapman and McKinnon, 1986). Collapse, as a function of crater diameter, does not appear to take place to the same degree as in terrestrial craters, however, consistent with the poor development of terraces on these satellites. This suggests there may be a fundamental difference in the crater modification process relative to the terrestrial planets, a question that requires further investigation. Photoclinometric and shadow measurements of craters on Miranda, Tethys, Dione and Ganymede, as well as completion of measurements on Mimas and Rhea, are in progress.

02.05

Topography on Ariel: Evidence for Solid-State Resurfacing

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Voyager images of Ariel show many apparent flow features. The flows have relatively low crater densities, and in many cases have markedly convex topographic profiles. We interpret these observations as evidence of extrusion of material to the surface of Ariel in the solid state. Although suggested for other icy satellites like Ganymede, this is the first clear observational evidence for solid state resurfacing in the outer solar system. The flows commonly fill tectonic depressions that appear to be large grabens, suggesting formation by extrusion in an extensional environment. Medial grooves of uncertain origin are observed in some flows. Simple geologic relationships indicate that flow distances have been very limited in some cases, placing constraints on the rheology of the flows.