mutual eclipse events observed in 1985 and 1986 and gives a system mass density of 1.6 ± 0.2 g/cm^3. Using this model, which assumes that both objects have uniform albedo distributions, and the known absolute magnitude of the Pluto-Charon system, we estimate the geometric albedos of Pluto and Charon to be 0.6 and 0.3 (± 0.1), repectively, suggesting that limb darkening plays only a minor role in the mutual event lightcurves. These model parameters, together with the absolute orbit radius given by Tholen (1985, *Astron. J.* **90**, 2353.), yield eclipse-lightcurve-derived estimates of 2300 ± 100 km and 1500 ± 100 km for the diameters of Pluto and Charon, respectively. This model predicts that the current mutual eclipse event series will end in 1990. The table below gives our predictions for selected mutual events during 1987.

Event Date	UT of Min-sep.	Type Event	Depth (mag)	Uncert. (mag)	Contact First (Hrs)	Contact Last (Hrs)	Length (Hrs)
2/15/87	11:50	Inf	0.64	0.04	-2.3	2.5	4.8
2/18/87	16:30	Sup	0.18	0.04	-2.3	2.5	4.8
4/26/87	18:20	Inf	0.49	0.03	-2.5	2.5	5.0
4/29/87	23:00	Sup	0.24	0.04	-2.2	2.5	4.7
7/25/87	04:35	Inf	0.50	0.02	-2.6	2.0	4.6
7/28/87	09:10	Sup	0.22	0.02	-1.9	2.6	4.5

34.02

Pluto Eclipses of and by Charon Must be Unequal

J.D.Mulholland (U. Nice & U. Florida), B.A.S.Gustafson (U. Florida)

Application of Fraunhofer diffraction of electromagnetic radiation predicts that reduction in total magnitude of the Pluto-Charon system due to an eclipse of Pluto by its satellite Charon will, under some circumstances, be nearly double the reduction due to an eclipse of Charon by Pluto, even if their albedos are identical and uniform. Such a difference has been detected in the observations, but ascribed to other causes. Important inferences on the dynamics and physics of Pluto-Charon hinge on the proper explanation of this asymmetry. The proposed scattering effect is both wavelength and aperture dependent, and therefore it is easily testable.

34.03

Improved Physical Parameters for the Pluto-Charon System

D. J. Tholen, M. W. Buie, A. D. Storrs (Inst. for Astron., Univ. of Hawaii), and N. Lark (Dept. of Physics, Univ. of the Pacific)

Through the end of July, we have observed portions of Pluto-Charon mutual events on thirteen different nights during the 1986 opposition. Modeling of these data have led to a major improvement in the determination of several orbital and physical parameters for the system. The model parameters are still being refined as more observational data are accumulated, reduced, and incorporated into the database, but at the time of this writing, the values of some of the more interesting model parameters are:

orbital period	=	6.38720	days
Pluto radius (assumes a=19130)	=	1145	km
Charon radius	=	640	km
mean density of the system	=	1.84	gm/cc
blue geometric albedo of the occulted material on Pluto	=	0.61	
blue geometric albedo of the occulted material on Charon	=	0.42	

In addition to having a lower albedo than Pluto, we have also found Charon to be more neutrally colored than Pluto in the wavelength region from about 0.4 to 0.9 microns. Perhaps Charon formed with or retained less of the volatile material that makes Pluto's surface so bright, thereby allowing the darker rocky material to have a greater influence on Charon's reflectance spectrum.

The derived density implies that rock is the largest fraction, by mass, of the system's composition. If water ice comprised as much as half of the mass, the rock component would be forced to have a density of 11.5 gm/cc to bring the density up to 1.84 gm/cc, which is untenable.

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34.04

The Surface Albedo Distribution of the Pluto-Charon System

M. W. Buie and D. J. Tholen (Inst. for Astron., Univ. of Hawaii)

Complete understanding of the wealth of data provided by the mutual eclipses of Pluto and Charon depends upon a good description of the system out of eclipse. We have developed a model which fits the known photoelectric photometry of the system spanning 1953 to 1986. The albedo patterns on the surface of Pluto are assumed to be circular while the contribution from Charon is considered to be constant. A similar model based on two circular spots (Marcialis, 1984, BAAS, **16**, 651) failed to account for the secular dimming since 1953.

The new model differs from the earlier work in two important ways. The reflected light from the system is computed using the scattering models of B. Hapke, and we have added two more circular spots. The new spots are simply bright polar caps which are solely responsible for fitting the secular dimming. The other two spots are only slightly different from the old model. The spot model parameters are:

	R(km)	ssa	P(0)
Pluto	1145	0.62	2.0
Charon	641	0.926	1.0

Pluto Spots	Lat	Long	Radius	ssa	P(0)
	-16	99	25	0.07	0.1
	- 8	217	16	0.999	2.0
	North Cap		81	0.956	2.0
	South Cap		48	0.994	2.0

The spot locations are listed as latitude and east longitude, minimum light occuring at ~90° east longitude. The column labeled "ssa" refers to the single scattering albedo of the surface material and P(0) is the value of the average particle phase function for back-scattering. This set of parameters yields a reasonable fit to the data, even though the very large differences in the albedos may not be physically reasonable.

34.05

Photometry of Pluto-Charon Mutual Events in 1986

R.L. Marcialis (LPL/U. of Arizona)

Three mutual events between Pluto and its large satellite Charon were monitored from Steward Observatory in the spring of 1986 (see Table below). Final reductions of the photometry will be presented at the meeting.

It is immediately apparent, at least for those areas occulted this year, that the albedo of Charon is roughly half that of Pluto. Implications as to the surface compositions and/or albedo distributions will be discussed.

The "first-order" theory developed by Dunbar and Tedesco (Astronomical Journal, in press) or some similar theory will be applied to extract best-fittting sizes, albedos and orbital elements for the system. These results will be compared to parameters obtained independently by

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other observers over the same time period. This procedure will serve as a consistency check, allowing better estimates of the error limits for each parameter obtained from inversion of the light curves.

UT Date	Instrument	Station	Telescope	Satellite
4 March 86	LPL Occ. Phot.	Kitt Peak	2.28m	Superior
20 March 86	LPL CCD	Mt. Bigelow	1.55m	Inferior
5 April 86	LPL Occ. Phot.	Kitt Peak	2.28m	Superior

34.06
Time Resolved Spectrophotometry of Pluto

W. D. Cochran and S. R. Sawyer (McDonald Obs., U. Texas)

We obtained time resolved spectrophotometry of Pluto in the 0.74 - 1.02 μ region at 13Å resolution during the dates 13-18 May 1983 and 24-28 and 30 April 1984. The strength of the methane absorption bands did not discernibly vary with rotational phase during either run. We constructed a model to investigate whether the absorption features arise from CH_4 frost or CH_4 gas. The 30% brightness variation of Pluto with rotational phase was modeled by the two spot model of Marcialis (1983). It assumes two dark circular spots of radii 46° and 28°, both at latitude $-23°$, separated by 134° in longitude. The surface frost was modeled using the bidirectional reflectance spectroscopy theory of Hapke (1981). Solid methane absorption coefficients were unavailable, so liquid methane absorption coefficients from Ramaprasad *et al.* (1978) were used. The gas was modeled using the Goody random band model. The gaseous methane absorption coefficients of Giver (1978) were used. Pure frost models which limited the CH_4 frost to the bright (unspotted) surface areas did not produce good fits to the observed data. They were unable to simultaneously fit the strong and weak bands, and unrealistically large frost particle diameters (greater than 1 cm) were required. They also showed a high degree of phase variation. The phase variation could be removed by allowing CH_4 frost to be present on both the bright and dark areas of the surface, and assuming nearly identical particle sizes for the two regions. However, particles sizes greater than 5 mm were required, and the strong and weak bands still could not be fit simultaneously. Pure gas models were able to fit simultaneously all of the observed bands and did not exhibit phase variation. Column abundances of 15-20 m-am of CH_4 gas were required. The best fit assumed a CH_4 frost with particle diameter of 1.0 mm and CH_4 gas with a column abundance of 15 m-am. The column abundance of CH_4 gas on Pluto is estimated to be 15 ± 5 m-am.

34.07-T

Tests of a Large Impact Origin for the Pluto-Charon System

A.R. Hildebrand (U. Arizona)

The Pluto-Charon system has the most anomalous specific angular momentum of all the known planets and a highly inclined retrograde sense of rotation, indicating the possibility of a large impact origin for Charon.

Assuming a differentiated proto-Pluto and impactor, a large impact scenario would produce a water ice-rich Charon depleted in silicates and volatiles. If one or both impacting bodies were not differentiated, a significant silicate depletion might not occur, but the resulting moon would still be depleted in volatiles such as methane. (A silicate enhancement could result if both bodies were undifferentiated). Hubble Space Telescope observations of the system and ground-based observations of Pluto and Charon's mutual eclipses will allow determination of the system's orbit, barycenter, and individual radii and albedos. Calculated masses can provide densities accurate to 1% for Pluto and 10% for Charon. Observations of stellar occultations could provide independent and more accurate radii determinations. If we understand the composition of outer solar system material, the rock-ice mixtures of Pluto and Charon may have detectably different densities, Charon being less dense if differentiated precursors collided.

Methane gas and ice have been detected in the system and the presence of volatiles, such as methane, may be the easiest test of a large impact origin for Charon. Pluto's albedo is roughly twice that of Charon and is consistent with a partial coating of methane frost; darker Charon may lack any very reflective ices. Calculations, following the method of Hunten and Watson (1982, Icarus 51:665-667), indicate that a reasonable cosmochemical allotment of methane could not have escaped from Charon in 4.5 Ga; an impact origin can explain the apparent depletion. Spectral searches for methane on Charon may be performed by the HST and, during the current eclipse series, by ground-based observers. Observation of stellar occultations by Charon would allow detection of any Charonian atmospheric volatiles, methane included.

34.08
Faint Star Catalogue for Accurate Positions of Pluto

G.De Sanctis and G.Massone(Astr.Obs.Torino)

The importance of obtaining highly accurate positions of the planet Pluto has been evidenced during the last years by a series of papers which analysed in detail the fit of the observed coordinates with those computed by using different ephemerides. Systematic differences were generally found, strengthening the need to continue in this astrometric program. The Observatory of Torino participates in this research since 1973. In order to improve the accuracy of the obtained positions, we decided to prepare an "ad hoc" Catalogue containing about 1600 stars ranging from 11 to 12.5 mag,very close to the path of Pluto in the period 1980-90. The primary reference stars were taken from AGK3RN Catalogue. 21 plates Kodak IIa-O, partially overlapping, were performed at the 40/200 cm Double Astrograph of the Observatory of Nice, using an objective grating. The field of each plate was 4°x4°, ensuring about 15 reference stars per plate. A preliminary reduction is in progress using second order plate constant method. A detailed study of the expected accuracy as well as a definitive reduction by more sophisticated methods are planned. After that, we intend to extend this Catalogue in order to cover a much longer period.

Session 35
Circumstellar Disks
(A. Coradini and R. Greenberg, Moderators)
15:30–16:00, Room 65
(in parallel with Sessions 33 and 34)

35.01
Photometric Images (BVI) of the β Pictoris Circumstellar Disk

J.N. Hayashi, J.C. Gradie, R. Howell (U. Hawaii), B. Zuckerman, H. Epps (UCLA)

Images of the β Pictoris circumstellar disk have been obtained through Johnson B (0.45 μm) , V (0.55 μm) and I (0.9 μm) filters using a stellar coronagraph (Lyot type) and a 500 x 500 CCD at the University of Hawaii 2.2 meter telescope at the Mauna Kea Observatory. The B and I images were taken on 7 October 1985 UT and the V images were taken on 4 February 1986 UT. The light from the star and that scattered from the optical elements was removed by a series of techniques. The light from β Pictoris was removed by an occulting spot; the majority of the scattered light was removed by a Lyot mask. Residual scattered light was removed by subtracting an equivalent exposure of γ Lepus from the β Pictoris images and by subtracting smoothed β Pictoris intensity profiles taken perpendicular to the disk from intensity profiles taken through the disk. At 0.9 μm an asymmetric belt is seen out to 40 arcseconds in the northeast direction and out to 35 arcseconds in the