Minor Bodies in the Solar System

Abstracts

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Abstract no. 1 (O)

Beta-Pictoris systems and their relevance to the Solar system

P. ARTYMOWICZ

Abstract not yet received.

Abstract no. 2 (O)

MBOSS-98 Workshop Summary

M.E. BAILEY

Abstract not yet received.

Abstract no. 3 (O)

Spectrophotometric observations of Edgeworth-Kuiper Belt (EKB) objects

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The Edgeworth-Kuiper Belt (EKB) objects are fossil remnants of the formation of the solar system and they represent an important reservoir of primordial material.

The EKB objects deserve an intensive observational effort both to increase the number of known members and, mainly, to determine their physical-chemical characters. For this reason we started a spectrophotometric campaign at the European Southern Observatory (La Silla, Chile) with the 3.5 m New Technology Telescope (NTT). The aim of our observations is to obtain U, B, V, R, I colors for a large sample of EKB objects, to determine their precise magnitudes and their variation, if any. The first results concern six objects (1994 TB, 1994 JR1, 1995 QY9, 1996 TL66, 1996 TP66 and 1996 TO66). Two of them (1996 TL66 and 1996 TO66) have a spectrum similar to those of dark D-type asteroids, while the other have redder spectra. This difference in the spectra imply a diversity in the surface composition of this population. We analysed the B,V,R, I color data available in literature (about 20 EKB objects) and we found that the population nature seems very complex. Presently, the EKB objects level of understanding is the same as the asteroids one at the beginning of the 70's: the few known asteroids were divided into two groups on the basis of their UBV colors. The refinement of the observational techniques and the quantitative and qualitative increase of the data allowed researchers to draw a quite complete scenario of the asteroid population. For this reason there is a strong need of high quality observational data on this new population. The faintness of these objects represent a formidable challenge for the astronomers and only the use of 8/10 m class telescopes will allow to obtain a more precise picture of the EKB population.

Abstract no. 4 (O)

MBOSS 2000 and Beyond:
Research Possibilities with New Generation Telescopes and Spacecraft Missions

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European Southern Observatory, Santiago de Chile

At the beginning of the third millennium more than 700 m^2 of mirror collecting power at 6-10m class telescopes combined with more than 20 sophisticated instruments will be available for astronomical research, and last but not least also for the investigation of MBOSS objects from the ground. The detector and computer technology will support wide field applications at large to medium size telescopes. Telescopes operated in Earth orbit open access to almost all wavelength regions from the high energy to the coolest regimes in space. Large radio telescope arrays are in the planning phase. A spacecraft mission to Pluto/Charon and possibly to another TNO appears over the horizon for future research.

The talk will address the research possibilities with such an equipment for various kind of projects like: the search for new objects, the follow-up orbit assessment and the characterization of the physical and chemical properties of MBOSSs.

Abstract no. 5 (O)

Pencil-Beam Search for Distant TNOs

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We used the image data set obtained during our Oct. 97 NTT/EMMI observing campaign of the TNO 1996 TO66 at ESO La Silla (see our paper presented during this workshop) to start a pencil-beam search for very distant TNOs. During our 5 observing nights, the exposures of the foreground TNO were centered at the same target position on the sky (apart from a dithering of small amplitude for super-flatfielding). For the sampling of the lightcurve of 1996 TO66, a long series of R filter exposures was taken during 4 of the 5 nights. While the individual R filter exposures of 15 min each reach a limiting brightness of about 24.5 mag, the aligned (using the background stars) and co-added R images of a single night go down to 26 mag (about 8 frames per night). By blinking individual and co-added images a pencil-beam segment of 8×9 arcmin could be search for solar system objects (several main belt asteroids were easily recognized). The blinking of the individual frames should have allowed us to identify TNOs with a typical diameter of 100 km at about 50 AU solar distance, the same procedure applied to the co-added images should allow to find objects of the same size at about 80 AU or 400km bodies at 150 AU distance. This simple pencil-beam search in our narrow EMMI field of view was not successful, i.e. no distant TNO was found. According to Jewitt and Luu, AJ 112, 1996, model assumption, one would expect about 0.2 TNOs in such a field, so our negative detection is not a surprise. However, refined search techniques are under development and furthermore the use of the 0.5 deg Wide Field Imager at the 2.2m telescope in La Silla will greatly improve the statistical significance of such deep search programmes.

Abstract no. 6 (P)

Surveys from Siding Spring for Bright Kuiper Belt Objects

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We present a summary of a recent survey for bright ($R < 21$) Kuiper Belt objects with the Mount Stromlo and Siding Spring Observatories' 40-inch telescope. We also discuss planned surveys of $\sim 100\Box^\circ$ to $R > 21$ with the 40-inch telescope equipped with an $8\mathrm{k} \times 8\mathrm{k}$ CCD and $\sim 1000\Box^\circ$ to $V \sim 19$ with the University of New South Wales' Automated Patrol Telescope. These surveys should determine the bright end of the Kuiper Belt luminosity function and determine if a break exists in the luminosity function between $R \sim 18.5$ and $R \sim 21$.

Abstract no. 7 (O)

The PICOCAM project at Pic du Midi

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Detection of minor bodies in the outer solar system depends of course of telescope aperture but also of the field of view. Our idea was to use a small 55 centimeter telescope at Pic du Midi observatory that was initially designed for photometry. The took advantage of the small size of modern CCD cameras to use the prime focus of the F/3 mirror. We designed a three lens corrector to obtain a one degree square field. In fact the main problem is due to the short focal length (1.65 m), the pixel size is only of 1.1 arcsec with a CCD containing 9 microns pixels. In this configuration we hope to reach m = 21.5 with 15 minutes exposures. This limit seams too low to find TNO, but the telescope will be fully automatic and will observe 365 days per year. At Pic du Midi observatory we hope to observe about 3000 square degrees per year. The telescope will be also use to make photometric studies of comets and asteroids.

Abstract no. 8 (P)

The light curves of the Trans-Neptunian Objects 1996 TP66 and 1994 VK8

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We have obtained a number of R-band CCD images of two Trans-Neptunian Objects, 1996 TP66 and 1994 VK8, over two nights in October 1997. We discuss the resulting magnitude variations and the search for periodicity within these limits. In the case of 1996 TP66, we find no evidence of any periodic variations to an accuracy of 0.03 magnitudes. This implies that apparent elongation of this body along the line of sight was $< 3\%$ at this epoch for rotation periods less than a few days. 1994 VK8 appeared to show variability of $\simeq 0.6$ magnitudes. However no significant periodicity could be found within this limited dataset.

Abstract no. 9 (O)

Physical Characteristics of Trans Neptunian Objects and Centaurs

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The available knowledge of the sizes, rotation rates, lightcurve amplitudes, spectra and colours of the Centaurs and Trans Neptunian Objects will be summarised and compared with those of other outer solar system objects. There is a wide range of reflectances within the Centaur population with no obvious correlations with heliocentric distance, but spectroscopic evidence points to the Centaurs being comet-like with the detection of water ice on several of them. Published photometry of the Trans Neptunian Objects is not very consistent but some conclusions will be presented on the issues of spectral diversity within the Kuiper belt and on the relationship between Centaurs and the Trans Neptunian Objects.

Abstract no. 10 (O)

A Portrait of 1996 TO66

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The Transneptunian Object (TNO) 1996 TO66 (Sun distance about 45 AU) was observed with the ESO New Technology Telescope NTT during 5 nights in October 1997. The programme comprised BVRI imaging and low resolution spectrophotometry in the red (600-950 nm) wavelength range using the EMMI focal reducer at the Nasmyth focus of the telescope. ¿From the imaging photometry the radius of 1996 TO66 was estimated to be 340 ± 10km assuming a surface albedo of 4 percent. The R brightness of the object varied with a typical peak-to-peak magnitude of about 0.1 over around 3 hours. The variation amplitude would either imply an axis ratio (large-to-small body axis) of 1.1 or the presence of larger areas of different surface brightness. The spectroscopy of the object revealed a reflected sunlight spectrum, no emission and additional absorption lines were detected. The spectral gradient was estimated to be about 10 percent bluish with reference to solar-type stars. The object image appeared star-like and no signature of a weak gas or dust coma around it could be identified down to a magnitude limit of 29 mag/arcsec^2. The V-R versus B-V colour diagram sees 1996 TO66 clearly under the grey to slightly bluish TNOs with a closer neighbourhood to objects like 95P/Chiron rather than to 1993 SC or 5145 Pholus.

Abstract no. 11 (O)

The ices on Pluto

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In May 1995, we recorded, with the CGS4 spectrometer at the UKIRT Telescope, spectra of Pluto at a resolution around 700 that cover the 1.4-2.55 microns spectral range. This set of data is of higher quality (S/N and resolution) than the one in which Owen et al. (Owen et al., 1993) first detected absorptions of solid N_2 and CO. Furthermore, laboratory data on ice mixtures better adapted to the study of Pluto have since been recorded (Quirico and Schmitt, 1997 a,b). In addition, models that allow us to take into account stratification at the surface of a solid body have now been developed (Douté and Schmitt, 1998). These three factors lead to better constraints on the Pluto surface ices from near-infrared spectroscopy than in the earlier work of Owen et al.

Only the data of May 15 have been analyzed so far. They correspond to the time when Pluto's visible light is maximum. The main new results are that:

1- pure methane must exist in the superficial icy layers of Pluto, in addition to the methane diluted in nitrogen found by Owen et al. (1993),
2- part of the surface must be covered by an ice with very fine grains that is spectrally neutral,
3- at least three different icy surface units must be present.

Based on our spectroscopic analysis and on thermodynamic considerations, our best model for the icy surface of Pluto at the longitudes corresponding to the maximum of the visible light curve consists of:

- a first unit which is a thin layer of pure CH_4 covering a granular substrate of N_2, CH_4, and CO in molecular mixture and which constitutes about 70 per cent of the surface,
- a second unit, covering roughly 20 per cent of the surface, which is either (a) similar to the first unit but with the two components inverted (i.e. with the thin layer of pure CH_4 below the N_2-CH_4-CO mixture), or (b) a single thick layer of pure methane,
- a third unit made of N_2 with very fine grains that covers the remaining of the surface (about 10 per cent).

The icy surface of Pluto appears to be much more complex than that of Triton (see Quirico et al., submitted to *Icarus*). A possible scenario for the various sublimation and recondensation processes occurring on Pluto is presented.

References:

Douté S. and Schmitt B. , *J. Geophys. Res.*, in press, 1998; Owen T.C. et al., *Science*, vol. 261, p.745, 1993; Quirico E. and Schmitt B., *Icarus*, vol. 127, p. 354, 1997 a; Quirico E. and Schmitt B., *Icarus*, vol. 128, p. 181, 1997 b.

Abstract no. 12 (O)

Dynamics of the Outer Solar System

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In this talk I will review our understanding of the dynamical evolution of minor bodies in the outer solar system. Topics to be covered include: the stability of small bodies in this region, the evolution of gravitationally scattered bodies, and the delivery of objects from the Kuiper belt to short-period comets and the Centaurs. I will describe how the interplay between theoretical and observational studies of the trans-Neptunian region may be used to constrain theories of the late stages of outer planet formation.

Abstract no. 13 (O)

Collisional and cratering rates in the Kuiper belt: Applications to surface activation and modification

D. D. DURDA & S. A. STERN

Our previous work (Stern 1995; *Astron. J.* **110**, 856–868), as well as work by other contributors (e.g., Davis and Farinella 1997; *Icarus* **125**, 50–60) showed that collisional evolution is likely the dominant evolutionary process for Kuiper belt bodies, concluding that the small body population in the 30–50 AU region of the belt has probably evolved into a collision cascade, implying that short period, Jupiter Family comets (which are derived from the belt) may not all be primordial. Since that time, however, several important observational selection effects have been identified (Jewitt *et al.* 1998; *Astron. J.* **115**, 2125–2135) which suggest that the population of 50 km radius and larger objects is ~ 3 times larger than had been thought ca. 1995; furthermore, various new estimates of the number of smaller objects in the 30–50 AU zone have been made (cf., Weissman and Levison 1997; in *Pluto and Charon*, Gladman *et al.*; 1998). We will examine the implications of this revised disk population for the collision rates in the present belt, focusing on impact rates, cratering fractions, and the resultant degree of surface activation and modification that both small and large Kuiper belt objects experience.

Abstract no. 14 (O)

Previous Surveys of the Distant Solar System

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As with the cataloging of the asteroid-belt, the discovery of minor bodies beyond Jupiter has seen an explosive growth in the last decade. Dominated by wide-field photographic surveys before 1990, the increasing efficiency and size of CCDs since then have meant that the first significant forays into the distant minor body population have now occurred. This invited talk will review the successful and unsuccessful surveys for distant Solar-system minor bodies that have been made to date. In doing so I will attempt to define what physical and dynamical constraints have been made on these distant populations, and what we might hope to achieve in the next 3-4 years. It is hoped that some of these constraints will have been superseded by the end of the workshop.

Abstract no. 15 (O)

HST observations of the Kuiper-belt

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The study of the Kuiper Belt has been motivated by the belief that the objects therein are chemically and physically primitive and therefore may preserve information from primordial times. However, since observations of comae around distant objects (Chiron, P/Halley, P/Hale-Bopp) have shown that comets may exhibit outgassing to at least 13 - 19 AU, the assumption that Kuiper Belt Objects are inert is questionable.

Collisions in the Kuiper Belt can lead to a substantial number of freshly exposed surfaces which, on exposure to solar insolation may exhibit outgassing. It can be shown that CO is viable as a volatile source of outgassing at large heliocentric distances. This outgassing would result in an optically visible coma (23 mag/arcsec^2 at 0.1 arcsec from the centre of the nucleus) that can be detected with HST.

The WFPC2 has been used to image 4 of the brightest known KBOs, preliminary results will be reported.

Abstract no. 16 (P)

Numerical Modeling of Kuiper Belt Objects' Dynamics - Limitations.

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The investigation of KBOs' dynamics is based on numerical orbital integrations on extremely long time scales due to orbital evolution of particles. The evolution of KBOs to JFCs needs a time-span of order of 10^9 years. Such a long time of integration affects errors. So the question arises what is the boundary of an integration time to distinguish the physical solution from numerical noise and what it depends on.

The following paper presents numerical integrations less than 150 massless test particles in the model of the Solar System which consists of 4 giant planets and the central mass. For each test particle computations were repeated at least twice on different computers. The results show that an increase of errors in a solution depends on the eccentricity and the inclination of an orbit. The estimated maximum time-span of integration is of the order of 10 million years for highly elliptic orbits ($e \sim 0.6$) and up to 125 million years for quasi-circular orbits (for particular model of the Solar System with orbits of massless objects outside Neptune's orbit). Concluding, the integration of equations of motions in a typical KBOs many body problem, on a time scale longer than 120 - 130 million years, is useless. After such a long time of integration the solution is likely to be a numerical noise (assuming double precision in computations). So a different way of studying KBOs' and SP comets' dynamical evolution is needed. The integration of equations of motion between particular phases of objects which are considered as comets in different phases of their lives (KBOs - Centaurs - Comets - possibly extinct Comets) could be the new way of studying the dynamical evolution of SP comets.

Abstract no. 17 (O)

Pencil-Beam Surveys for Faint Trans-Neptunian Objects

BRETT GLADMAN

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Motivated by a desire to understand the size distribution of objects in the Edgeworth-Kuiper belt, an observing program has been conducted at the Palomar 5-m and Canada-France-Hawaii 3.6-m telescopes. We have conducted pencil-beam searches for outer solar system objects to a limiting magnitude of $R \sim 26$. The fields were searched using software recombinations of many short exposures shifted at different angular rates in order to detect objects at differing heliocentric distances. Five new trans-neptunian objects were detected in these searches. Our combined data set provides an estimate of ~ 90 trans-neptunian objects per square degree brighter than $\simeq 25.9$. This estimate is a factor of 3 above the expected number of objects based on an extrapolation of previous surveys with brighter limits, and appears consistent with the hypothesis of a single power-law luminosity function for the entire trans-neptunian region. Maximum likelihood fits to all self-consistent published surveys with published efficiency functions predicts a cumulative sky density $\Sigma(< R)$ obeying $\log \Sigma$ = 0.76(R-23.4) objects per square degree brighter than a given magnitude R.

Abstract no. 18 (O)

Dust measurements in the outer solar system

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Pioneers 10 and 11 and Voyager dust measurements in the outer solar system are reviewed. Identical dust detectors on board the Galileo and Ulysses spacecraft provided measurements of interstellar and planetary dust in the outer solar system and near Jupiter. Three distinctly different populations of dust particles have been inferred: (1) micron sized and bigger solar system dust on high eccentric and high inclination orbits, (2) interstellar grains of about 10^{-13} g in mass dominate in the dust flux in the outer solar system, (3) streams of tennanometer sized dust particles originating from within the Jovian system have been observed within a distance of about 2 AU from Jupiter.

Abstract no. 19 (O)

TNO colour survey: First results of the VLT

O. HAINAUT

Abstract not yet received.

Abstract no. 20 (O)

Possible meachnisms of cometary outbursts.

S. IBADOV

Abstract not yet received.

Abstract no. 21 (O)

Migration of Edgeworth–Kuiper belt objects to the Earth

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Basing on the results obtained by M. Duncan *et al.* (1995, Astron. J., v. 110, 3073–3081) and considering that the mean time interval, during which an object crosses the Jupiter's orbit during its lifetime, equals to 0.2 Myr, we obtained the number of the Jupiter–crossers with diameter $d > 1$ km, which came from the Edgeworth–Kuiper belt (EKB), to be equal to 30000. Our computer runs showed that the portion of Jupiter–crossing objects that reach the orbit of the Earth during their life–times is equal to 0.2 and the mean time, during which a Jupiter–crossing object crosses the orbit of the Earth, is about 5000 yr. We estimated that about 170 Earth–crossers with diameter $d \geq 1$ km (i.e., about 20 % of all such Earth–crossers) have come from the EKB. The above estimates are very approximate, but they show that the number of the EKB objects (EKBOs) hitting the Earth is not small. We showed that due to the mutual gravitational influence of EKBOs during the age T_{ss} of the Solar System the variation in a semimajor axis a of the object located in the middle of the EKB usually does not exceed 0.1 AU, a could decrease by more than 1 AU for many objects at the inner part of the belt, and several percents of EKBOs could take part in such very close encounters, when a changed by several AU. During T_{ss} about 0.5 % of EKBOs with $d \geq 100$ km collided with the same objects. On average, an EKBO changed its a by ~ 0.1 AU due to several close encounters with Pluto. Mutual gravitational influence of present EKBOs could not cause the growth of their mean eccentricity and inclination up to the present values. Planetesimals, which entered the trans–Neptunian region from the feeding zone of the giant planets during their accumulation, could increase the eccentricities of 'local' EKBOs and swept most of these objects. A small part of such planetesimals could left beyond the orbit of Neptune in eccentric orbits (such as that of 1996TL_{66}). Probably, most of large ($d \geq 100$ km) local EKBOs were formed mainly by compression of rarified condensations but not by accumulation of smaller planetesimals. This work was supported by the Russian Foundation for Basic Research and the Russian Federal Program "Astronomy".

Abstract no. 22 (O)

THE OUTER SOLAR SYSTEM

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Six years of intensive study have shown the Outer Solar System to be a richly populated region, in which the dynamical and physical imprints of the earliest epochs of planetary accretion may be preserved. The Outer Solar System has emerged as the prime intellectual focus of modern planetary science.

Kuiper Belt Objects (KBOs) fall into at least 3 distinct dynamical classes. The Classical KBOs avoid Neptune by having small eccentricities and semi-major axes larger than about 42 AU. The Plutinos avoid Neptune by virtue of mean-motion (and probably other) resonances that ensure a large separation even at perihelion. The Scattered KBOs possess eccentric, inclined orbits with perihelia (near 35 AU) that render them susceptible to weak Neptune perturbations on billion year timescales. The observational sample includes about 70 KBOs, of which 2/3rds are Plutinos, 1/3rd are Classical and there is one compelling example of a Scattered KBO (1996 TL66).

Extrapolated around the sky, we estimate that 100,000 KBOs with diameters > 100 km exist in the 30 to 50 AU region. The differential index of the size distribution power law is near -4, meaning that small objects should be very numerous (perhaps 10^9 larger than 5 km in diameter) and may contain a significant fraction of the current total mass (which is of order 0.1 $M_\oplus$). Too little mass exists for the KBOs to have grown in the available time, leading to the inference that the Kuiper Belt has lost most of its original mass, by processes unknown.

This review will be divided into two parts. First, I will describe the observational parameters of the Kuiper Belt as known from current observations, highlighting areas where there is particular observational uncertainty and room for improvement. Second, I will discuss the most important science questions raised by the observations.

Abstract no. 23 (P)

Kiso EKBOs & Centaurs Survey and the Design and Implementation of the Yet Another Moving Object Detection Software

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We are now carrying out Edgeworth-Kuiper Belt Objects (EKBOs) & Centaurs survey using 1.05-m Schmidt telescope with 2K CCD (2048×2048 pixels) at Kiso Observatory, Japan. We call this project as "Kiso EKBOs & Centaurs Survey". The field of view is $48' \times 48'$ and the R-band limited magnitude is $m_R = 21$ for this system. The aim of this survey is to decide the bright end of luminosity distribution of EKBOs which provide the time scale of planetesimal growth and to detect EKBOs and Centaurs that are bright enough for physical observations. Thanks to its large field of view, we have already surveyed more than 5.1 square degrees and still continue this project. In order to search objects in the obtained images, a detection programme for distant minor bodies was developed. We report the overview of Kiso Survey and the design and implementation of our "Yet Another Moving Object Detection Software" including its application to our data.

Abstract no. 24 (P)

Kuiper-Belt Objects: Distribution of Orbital Elements and Observational Selection Effects

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The influence of the observational selection effects in the set of the known (end of July 1998) Edgeworth-Kuiper belt objects is investigated. It seems that significant observational selection effects do not exist at present, and, thus, any kind of statistical conclusions should be of physical nature. However, marginal significance of observational selection effects may exist - e.g., the preferred direction of perihelia of the known objects corresponds to the direction known from the observational selection effects which were manifested in asteroids.

Concentration of perihelia of the known Edgeworth-Kuiper belt objects is not uniform. The decrease of the concentration for $q > 43$ AU can be explained by observational selection effects (however, greater part of objects with higher absolute magnitude seems to be of physical nature). The concentration of the objects with $q \in (40,42)$ AU is ≈ 3 times higher than the mean value of the concentration for the whole belt, while the concentration of the objects with $q \in (36,40)$ AU and $q > 43$ AU is ≈ 0.5 times the mean value of concentration.

The investigation of the problem continues, with increasing set of data, as new Edgeworth-Kuiper belt objects are discovered.

Abstract no. 25 (P)

Colours of Distant Solar System Bodies

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The NTT at la Silla, Chile and NOT on La Palma were used for VRI photometry of 9 Edgeworth-Kuiper objects and 3 Centaurs. The colours are compared to those of other Solar System objects.

Abstract no. 26 (O)

The Uppsala-DLR Trojan Survey of the Preceding Lagrangian Cloud

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The Trojan population is considered to be very numerous but a reliable estimate of the total number of objects librating around the Jupiter Lagrangian points is still missing. Furthermore, the true size distribution of the smaller Trojans is largely unexplored. The ESO Schmidt telescope was used during the apparitions in 1996 and 1997 to cover a large region of the sky centered on the preceding Lagrangian point, L4. Additional positions were secured with observations with the Bochum telescope. During the survey, which is nearly complete down to a limiting magnitude of about 20, we detected during 1996 almost 400 suspected Trojans, of which the large majority are new discoveries. Preliminary results regarding the size distribution will be given.

Abstract no. 27 (P)

The Centaurs

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The Centaurs are a peculiar class of objects with chaotic orbits which semimajor axes fall between those of Jupiter and Neptune. It is now believed that they could represent a link between trans neptunian objects and short-period comets. To investigate the nature of these particular objects, we have performed optical spectroscopic observations of 5 Centaurs in the region $0.37 < \lambda < 0.75$ μm.
The spectral slopes vary from neutral or slightly blue for 2060 Chiron to very red for objects as 7066 Nessus. We have not found any kind of cometary activity.

The obtained spectra show a wide types range which implies different surface compositions probably due to evolutionary mechanisms like long-term exposures to cosmic rays and/or solar ultraviolet radiation. These differences are very similar to those obtained also among the Kuiper belt objects. This compositional similarity could confirm that Centaurs are trans-neptunian objects injected into giant-planet orbits. Even if only Chiron has shown cometary activity until now, the Centaurs are probably transition objects between the trans neptunians, asteroids and cometary nuclei.

Abstract no. 28 (O)

Coagulation and Fragmentation in the Kuiper Belt

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Now that the Kuiper Belt has been firmly established as a significant and important part of the solar system, one of the new hurdles we face is how to explain its origin. We have been performing simulations of coagulation and fragmentation in the Kuiper Belt in order to deduce the conditions in the trans-Neptunian region needed to create the present Kuiper Belt: the total mass, the planetesimal size distribution, the planetesimals' tensile strength, etc. The latest results will be presented in the talk.

Abstract no. 29 (P)

Annual fluctuations of fern - snow cover in meteorite moraine implications for meteorite recovery

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During the 1986-1987 US Antarctic Meteorite Recovery Expedition to the Lewis Cliff Meteorite Placer Complex the concentrated deposit known as 'Meteorite Moraine' was discovered. Meteorites occurred in a density on the ice such that in several cases the field workers went along the ice on their knees shoulder to shoulder finding meteorites in several spots nearly every square meter. This level of concentration had not been seen before in the Lewis Cliff complex. Due to the weather and the fact that this location was discovered close to the end of the season several hundred meteorites were left in the file at that time hopefully to be recovered the next season.

When field teams returned the next year they found that the area of Meteorite Moraine was covered with snow that was still there at the end of the season. A metal detector was used unsuccessfully in the area to attempt to detect the meteorites through the snow cover (Huss. 1988).

The problem of the variability of the snow cover means that areas that have been covered by the systematic search system developed for the American teams might have to be gone back over in successive years in hope that the snow cover disappears and leaves the meteorites exposed rather than buried in seasonal snow cover.

Areas of the Lewis Cliff Ice Tongue that had been traversed several times and subjected to subsequent searches have resulted in meteorites being discovered in them (Cassidy 1987). This means that meteorite recovery areas that have been previously covered might merit teams to return to the standing surfaces to recover those meteorites that have potentially not been recovered.

This local movement of snow patches was previously noted by Cassidy and reiterated by Faure (Faure, 1990). These local movements of snow patches have distinct effects on the recovery capabilities of field teams.

References: Faure, G. Origin of Stranding Surfaces In Workshop on Antarctic Meteorite Standing Surfaces (W A Cassidy and I M Whillans, eds) pp11-12. LPI Tech Rpt 90-03. Lunar and Planetary Institute, Houston. Huss, G Personal Communication, Houston, 1988 Cassidy, W Personal Communication, Lewis Cliff, Antartica, 1987

Abstract no. 30 (P)

Means of cooperation between japanese antarctic meteorite recovery program and potential russian antarctic meteorite recovery program

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Recent geopolitical changes within the former Soviet Union make it possible for the Japanese Antarctic Meteorite Recovery program to consider the possibility of creating a joint Antarctic meteorite recovery expedition with Russia. The Russia logistical capability in the Antarctic combined with the long standing leadership of Japan in the area of meteorite recovery in the Antarctic could accelerate the recovery rates of meteorites and open up new meteorite recovery locales that are outside of Japanese logistical capabilities and within Russian logistical locales.

During informal conversations with Russian scientists the author was of the opinion that the Russian scientists were extremely interested in the concept of a Russian Antarctic Meteorite recovery program and had great admiration for the Japanese and American program. If eventually the Russians set up an independent program they could boost the annual recovery rate of meteorites substantially. Japanese researchers could have the chance of annually recovering meteorites as they have previously done with the American program. The Japanese presence was an important catalyst at the beginning in the American Antarctic Recovery Program. So it could be with the proposed Russian Antarctic Meteorite Recovery Program.

A beginning point could be the selection of potential meteorite recovery sites within reach of some of the major Russian bases in Antarctica. The Russian logistical capability includes heavy lift aircraft capability as well as extensive experience in long range traverses.

Meteorite recovery sites that have already been discovered but not completely searched by the Japanese program could be the first sites that the Russians could cover with the Japanese. The long range capability of the Russian Antarctic aircraft could reduce the time necessary to be in the Antarctic for Japanese to recover meteorites.

This could be the moment in history for Japan to have a joint program with Russia to recover meteorites in Antarctica!

Abstract no. 31 (O)

Recognition of irregular satellites of Uranus and other giant planets

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It is just 100 years since the discovery of Phoebe, the first "irregular" planetary satellite to be recognized. Eighty years later, following the discovery of Chiron, the first centaur, some similarities between the two were noted, and there was the first hint of a possible evolutionary connection, also perhaps involving comets like 29P/Schwassmann-Wachmann 1. Such a connection became more plausible as further research, both theoretical and—beginning in 1992—observational, began to reveal in the Kuiper Belt a possible source for that evolution. It was also really no surprise when, in 1997, Uranus was found to share the trait of the other three giant planets of possessing outer satellites that had presumably been captured from unstable heliocentric orbits in the vicinity. We describe here the sequential improvement in our knowledge of the orbits of the two new Uranian satellites, including the confusing role of the prediscovery images in 1984 and, finally, the clarity afforded by the observations in 1998. Implications for the recognition of other irregular satellites, notably the lost possible Jovian satellite of 1975, are discussed.

Abstract no. 32 (P)

TBD

N. MCBRIDE

Abstract not yet received.

Abstract no. 33 (O)

Size Distributions and Activity in Distant Comets

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The earliest stages of collapse of our solar nebula are not subject to direct observational constraints. However, comet nucleus size distributions are of great interest because they preserve a record of the outer nebula mass distributions in the late stages of planetary formation, as well as a record of collisional evolution. The rate of proto-planetary growth and scattering as a function of heliocentric distance depended on the size and mass distribution of the km-size planetesimals that have survived as today's comets, their surface density in the nebula and their velocity distributions. The estimated sizes of the Kuiper Belt objects are large compared to known short-period (SP) comet nuclei, although the statistics are still small for both populations. The SP comets are likely to be collisional fragments from the Kuiper Belt population, where bodies larger than 50 km probably retain the primordial size distributions. The larger Kuiper disk bodies may reflect the scale of instabilities in the outer solar nebula, whereas the long-period comets (LP) that have been stored in the Oort cloud may not have been subjected to collisions, so that their size distributions may be primordial.

We will present the results of observations of 21 distant, inactive comet nuclei observed with LRIS on the Keck II telescope during December 1997. Our sample included 17 SP Jupiter-family comets, 3 Halley-family comets, and limits for 1 dynamically new comet. The nucleus radii ranged between 0.9 and 9.8 km (assuming a 4% albedo), the average near $R_N \sim 2.5$ km showing that, in general, the comet nuclei are relatively small. This doubles the known sample of size estimates for the comet population, and these data will be compared to the size distributions for the Centaurs and the Kuiper Belt objects.

Abstract no. 34 (P)

The follow-up observations of the TNOs by Saji Observatory

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The distant minor-planet-like objects, TNOs(Trans Neputunian Objects), are very faint such that their magnitude are almost more than 20 mag. Saji Observatory started the follow-up observations of the TNOs from June, 1997, with using 1.03-m reflector, as one of the original observatory's programs. We wish to contribute the more accurate revision of the orbital elements of the TNOs by this program. We also hope to show that such activities for the public observatories have great possibilities to contribute to the modern astronomy. I will introduce our observations.

Abstract no. 35 (O)

Physical characteristics of distant comets

D. PRIALNIK

Abstract not yet received.

Abstract no. 36 (P)

Search for Trans-Neptunian Objects: a new MIDAS context confronted with some results obtained with the UH 8k CCD Mosaic Camera

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We present the results obtained with a new program dedicated to the automatic detection of trans-Neptunian objects (TNOs) with standard sets of images obtained in the same field of view. This program has the key advantage, when compared to other similar softwares, of being designed to be used with one of the main astronomical data processing package; the Munich Image Data Analysis System (MIDAS) developped by ESO. It is available freely from the World Wide Web server of the Observatory of Besançon (http://www.obs-besancon/www/publi/philippe/tno.html).

This program has been tested with observational data collected with the UH 8k CCD mosaic Camera, used during two nights, on October 25 and 26, 1997, at the prime focus of the CFH telescope (Mauna Kea, Hawaii). The purpose of these observational data was to detect new TNOs and a previous analysis conducted by the classical method of blinking, had lead to a first detection of a new TNO. This object appears close to the detection limit of the images (i.e. to the 24^{th} magnitude) and presents an unsual orbital inclination (i$\simeq$33°). It has allowed the efficient and successful testing of the program to detect faint moving objects, demonstrating its ability to detect the objects close to the sky background noise with a very limited number of false detections.

Abstract no. 37 (O)

The detection of small Kuiper-belt objects with the COROT mission

F. ROQUES

Abstract not yet received.

Abstract no. 38 (P)

Millimetric Observation of CO(J=1–0) in (2060) P/Chiron at the NRO 45m Radio Telescope

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Radio observation of Chiron at the NRAO 12-m telescope reported a detection of CO, but the other observations at the IRAM 30-m telescope did not detect CO although at almost the same time in June, 1995. On February 14, 1996, Chiron reached perihelion inside the orbit of Saturn. We carried out millimetric observations of Chiron to investigate the nature of the activity in this enigmatic object detecting the evident CO line with the 45-m telescope at Nobeyama Radio Observatory(NRO) in March, 1998. In spite of its large efficiency of gathering rays of light, the CO line (J=1–0, 115GHz) was not detected and three-sigma upper limit on the column density was derived, N(CO) $\leq 4 \times 10^{13} \mathrm{cm}^{-2}$. This upper limit is higher than the results of other previous observations due to poor weather conditions and a low efficiency of frozen antenna owing to the unusual much snow.

Using the 45-m telescope at NRO, new observations are planned this winter to obtain conclusive evidence of CO and to estimate the distribution of CO in the coma of (2060) P/Chiron.

Abstract no. 39 (O)

Pluto

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Pluto is a fascinating world, perched on the ragged edge of the planetary system. In recent years, Pluto has been the subject of intense observational scrutiny, which has revealed its major atmospheric components, its surface-ice composition, important first-order information on the planet's size, density, and internal structure, and the first direct images showing surface details. Further, studies of Pluto's single, large satellite, Charon, reveal the pair to represent the first known planetary binary. Most fascinatingly, however, whereas for several decades Pluto had been regarded as a rather inexplicable, tiny-ice world orbiting alone beyond the outer gas giant planets, in the mid-1990s, Pluto has instead been revealed to be the largest member of the outer solar system debris disk around the Sun, commonly called the Kuiper Belt. With that realization, it is becoming clear that Pluto is providing a key link to the formation of the outer solar system. These and other factors have made Pluto a prime target for future NASA reconnaissance mission.

Abstract no. 40 (O)

Ion irradiation of minor bodies in the outer Solar System

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Ion irradiation of carbon containing ices produces several effects among which the formation of complex molecules and even refractory organic materials whose spectral color and molecular complexity depends on the amount of deposited energy. Here results from laboratory experiments are summarized. Their relevance for the formation and evolution of complex organics on comets and other small bodies in the external Solar System is outlined.

Abstract no. 41 (O)

Preliminary results of TNO visual and IR photometry by the Galileo italian national telescope.

P. TANGA, A. CELLINO, M. DI MARTINO, G. P. TOZZI

The physical properties of the TNO are of difficult determination and known only at first approximation for a small sample of objects. The visual and IR photometry by Luu and Jewitt (1997) has shown the wide variety of colour indexes V-J, J-H and H-K, to which a variety in surface properties should correspond.
The multiband photometry performed by Tegler and Romanishin (1998) over a sample of 11 KBO has shown a bimodal distribution of the colour indexes. It appears to be totally uncorrelated from the orbital parameters, and its origin is unknown.
During the test period of the Galileo Italian national telescope at La Palma (Canary Islands) photometry in B,V,R,J,H,K bands will be performed, with the aim of increasing the statistics of the spectral properties. Preliminary results of the analisys will be presented.

Abstract no. 42 (O)

Thermal Infrared Observations of 1993 SC and 1996 TL66 using the Infrared Space Observatory

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Thermal infrared observations of an object with a known visual magnitude allow one to separate the albedo from the radius. Objects in the Kuiper-Edgeworth belt (KBOs) are usually assumed to be dark with geometric albedoes comparable to the nuclei of comets (typically 0.05 as in the case of comet P/Halley). This leads to the conclusion that KBOs must be very large with diameters up to 400 km. The recent detection of the Centaur, 1997 CU26, in the thermal IR (Jewitt and Kalas, Ap. J. Lett., 499, L103-106) provides further support for this assumption.

Pre-launch calculations indicated that KBOs would be detectable with the ISOPHOT experiment on the European Space Agency's Infrared Space Observatory and several attempts were made to observe the brightest KBOs including 1993 SC, 1992 QB1, 1994 TB, and 1996 TL66. The initial analysis of these data indicated that the signal to noise ratio was inferior to pre-launch estimates and our assessment is that the signal level is now close to the detection threshold of the instrument. Consequently, an extremely detailed data reduction has had to be performed. At the time of writing, our reduction is indicating a detection of 1993 SC at the 2.5 sigma level giving a flux of 12.7 (+- 5.1) mJy which leads to a radius of 158 (+27 - 35) km and an albedo of 0.020 (+0.013 -0.006) using a standard thermal model. There is an additional absolute calibration uncertainty of 20inconsistencies in other data sets which continue to concern us and lead us to question our results. We are continuing to work on these issues.

In the presentation, we will describe the observing strategy that was used, the latest status of the data reduction, and the models we are using to evaluate the results.

Abstract no. 43 (P)

Astrometry of Outer Solar System Bodies – Experience with Small Telescope and Future Plans

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Astrometry of faint and slowly moving objects in the outer solar system is considered to be the target for large telescopes, but in special cases observations using small telescopes were obtained. We have measured precise positions of several Centaur-type asteroids (including recovery of 1997 CU_{26}) and also of Transneptunian object 1996 TL_{66} using 0.57-m f/5.2 reflector equipped with CCD at the Kleť Observatory.

This work will be extended to fainter objects with new 1.02-m reflector at Kleť, whose start of operation is planned at the end of 1998.

Abstract no. 44 (O)

Simulations of the Bias Effects in Kuiper Belt Surveys

CHADWICK TRUJILLO

It has been suggested that the KBO population in the 30–50 AU region may be depleted compared the > 50 AU region due to Neptune's influence and, possibly, collisional erosion (Stern and Colwell, ApJ, 490, 879–882, 1997). This hypothesis is tested observationally with a Monte Carlo simulation. Equations of apparent motion and position for an arbitrary body in orbit (Sykes and Moynihan, Icarus, 124, 399–406, 1996) are used to create a Monte Carlo model of the classical Kuiper Belt, including a "wall" of enhanced density at large heliocentric distance. Given a Monte Carlo model of the KBOs and the sky coverage data from prior KBO surveys, the expected number of model KBOs "discovered" is determined. Maximum likelihood methods are then used to place limits on the allowed parameters of the Kuiper Belt wall, should one exist.

Abstract no. 45 (P)

The SUBARU survey project with Suprime-Cam

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We propose Kuiper Belt Survey as one of the long-term projects for the SUBARU telescope. The SUBARU is the most appropriate telescope among large telescope projects because of the ability of wide field imaging at the prime-focus with using the Mosaic CCD camera, called Suprime-Cam. We introduce this system in this poster paper, and the expected discovery rate of new objects in the outer region based on the recent results.