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DISTANT EKOs
The Kuiper Belt Electronic Newsletter



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NEWS & ANNOUNCEMENTS

I meant to send this link out in the previous issue, so if you can bear one more comment about the definition of a “planet”, perhaps this can be a good place to start:

http://en.wikipedia.org/wiki/Star_Trek_planet_classifications

And for some historical perspective, Here’s an interesting, thorough historical review of asteroids’ paths through nomenclature space (“When Did the Asteroids Become Minor Planets?”):

<http://aa.usno.navy.mil/hilton/AsteroidHistory/minorplanets.html>

and see:

<http://spaceweather.com/swpod2006/13sep06/Pollock1.jpg>

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In IAUC 8745, 8746, and 8751, Keith Noll and collaborators announced the discovery of satellites around three more TNOs. The first is 2003 QW111, with the satellite at a separation of 0.325 arcsec. This object appears to be in the 4:7 resonance with Neptune, the first binary found in that resonance. The second is 2000 QL251, with the satellite at a separation of 0.261 arcsec. This object is in the 1:2 resonance, and is the first binary to be found in that resonance. The third is (120347) 2004 SB60, with the satellite at a separation of 0.110 arcsec and a brightness difference of 2.3 mag.

IAUCs: <http://cfa-www.harvard.edu/iauc/08700/08745.html>,

<http://cfa-www.harvard.edu/iauc/08700/08746.html>,

<http://cfa-www.harvard.edu/iauc/08700/08751.html>

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2003 FX128 also is determined to be a binary. See paper by Grundy et al. in this issue of the newsletter.

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2006 RJ103, discovered by the SDSS Collaboration (MPEC 2006-V65), is identified as a Neptunian trojan, making it the fifth confirmed object of that type.

MPEC: <http://cfa-www.harvard.edu/cfa/ps/mpec/K06/K06V65.html>

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IAUC 8747 announced the official names of 2003 UB313 and its satellite. “Xena” has officially been named “Eris”, who is the goddess of Strife (Latin: Discordia). Similarly, its satellite has been named “Dysnomia”, the goddess of Lawlessness. Perhaps appropriate names considering the strife that ensued in the planet nomenclature debate, and an oblique reference to the actress, Lucy Lawless, who played the part of Xena. Also of note: Dysnomia is a memory disorder. According to Wikipedia: “Dysnomia is a marked difficulty in remembering names or recalling words needed for oral or written language [...] They have trouble remembering names, numbers, facts and even what they did a few minutes ago. These memory difficulties present significant problems in academic study.”

IAUC: <http://cfa-www.harvard.edu/iauc/08700/08747.html>

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An announcement in MPEC 2006-U62 discusses the problems in publishing discovery announcements of TNOs with short arcs, which have large orbital uncertainties. It is proposed that although provisional designations will still be supplied, MPECs will not be issued for newly discovered TNOs with observed arcs of less than one month. A new web page will be constructed to list these candidate TNOs.

MPEC: <http://cfa-www.harvard.edu/cfa/ps/mpec/K06/K06U62.html>

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There were 4 new TNO discoveries announced since the previous issue of *Distant EKO*s:

2006 RC103, 2006 QQ180, 2006 SG369, 2006 SL371

4 new Centaur/SDO discoveries:

2006 SX368, 2006 QP180, 2006 SF369, 2003 OS33

and 1 new Neptunian trojan discovery:

2006 RJ103

Reclassified objects:

2005 TN74 (SDO → TNO)

2006 HV122 (TNO → SDO)

2006 HX122 (TNO → SDO)

Objects recently assigned numbers:

Pluto = (134340)

1999 RH215 = (134568)

2000 OJ67 = (134860)

2001 KO76 = (135024)

2001 QT322 = (135182)

2002 GG32 = (135571)

2002 PB171 = (135742)

2003 EL61 = (136108)

2003 LG7 = (136120)

2003 UB313 = (136199)

2003 WL7 = (136204)

2005 FY9 = (136472)

Objects recently assigned names:

2003 UB313 = Eris

2002 CR46 = Typhon

2003 FX128 = Ceto

Deleted/Re-identified objects:

2003 QZ113 = 2002 PX170

Current number of TNOs: 1017 (including Pluto)

Current number of Centaurs/SDOs: 187

Current number of Neptune Trojans: 5

Current number of satellites: 24 around 20 objects

Out of a total of 1209 objects:

507 have measurements from only one opposition

465 of those have had no measurements for more than a year

248 of those have arcs shorter than 10 days

(for more details, see: http://www.boulder.swri.edu/ekonews/objects/recov_stats.gif)

Discovery and Characteristics of the Kuiper Belt Binary 2003 QY90

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We present photometric and astrometric results from four epochs of ground-based observations at the Magellan telescopes of the Kuiper belt binary, 2003 QY90. Resolved observations show both components to be highly variable and often of nearly equal brightness, causing difficulty in distinguishing between the primary and secondary components for observations spaced widely in time. Resolved lightcurve observations on one night show one component to have a single-peaked rotation period of 3.4 ± 1.1 hours and a peak-to-peak amplitude of 0.34 ± 0.12 magnitudes. The other component exhibits a less constrained lightcurve, with a single-peaked rotation period of 7.1 ± 2.9 hours and a peak-to-peak amplitude of 0.90 ± 0.36 mag. Under the assumption of equal albedos, the diameter ratio is 1.25 ± 0.11 in the Sloan i' filter. While we cannot determine an orbit from our four distinct epochs of observation (due to ambiguity in component identification), we place limits on the orbital period of the system of 300–600 days, we find a minimum semi-major axis of 13,092 km for a circular orbit and a system mass range of $(2.3\text{--}18.0) \times 10^{17}$ kg depending on the identification of components in our observations.

Published in: *Icarus*, 183,179 (2006 July)

Available on the web at: <http://web.mit.edu/~susank/www/>

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The Frequency of Binary Kuiper Belt Objects

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We estimate the frequency of widely spaced (separations >0.5 arcseconds) Kuiper Belt binaries (KBBs) from surveys for new Kuiper Belt objects (KBOs) with the Deep Ecliptic Survey (DES; Elliot *et al.* 2005) and through recovery observations for newly discovered KBOs at the Magellan telescopes. We find the frequency of KBBs versus discovery separation to be related by an inverse power law when combining our results with those for the fraction of close binaries (separations < 0.5 arcseconds) found in the literature. For wide separations, our data and the resulting model agrees with that proposed by Goldreich *et al.* (2002). However, including the frequency at the smallest separation rules out the semi-major axis dependence of the Goldreich *et al.* (2002) model at the 99% confidence level, indicating that there is likely a turnover in the distribution at very close separations, or that the number of close binaries has been underestimated. In either case, the binary frequency distribution favors binary-formation models invoking gravitational rather than physical interactions—such as those proposed by Goldreich *et al.* (2002) and Astakhov *et al.* (2005).

Published in: *The Astrophysical Journal Letters*, 643, 57 (2006 May 20)

Available on the web at: <http://web.mit.edu/~susank/www/>

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Charon's Radius and Density from the Combined Data Sets of the 2005 July 11 Occultation

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The 2005 July 11 C313.2 stellar occultation by Charon was observed by three separate research groups, including our own, at observatories throughout South America. Here, the published timings from the three data sets have been combined to more accurately determine the mean radius of Charon: 606.0 ± 1.5 km. Our analysis indicates that a slight oblateness in the body (0.006 ± 0.003) best matches the data, with a confidence level of 86%. The oblateness has a pole position angle of 71.4 ± 10.4 deg and is consistent with Charon's pole position angle of 67 deg. Charon's mean radius corresponds to a bulk density of 1.63 ± 0.07 g cm⁻³, which is significantly less than Pluto's (1.92 ± 0.12 g cm⁻³). This density differential favors an impact formation scenario for the system in which at least one of the impactors was differentiated. Finally, unexplained differences between chord timings measured at Cerro Pachón and the rest of the data set could be indicative of a depression as deep as 7 km on Charon's limb.

Published in: The *Astronomical Journal*, **132**, 1575 (2006 October)

Preprints available on the web at <http://arxiv.org/abs/astro-ph/0602082>

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What is A Planet?

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A planet is an end product of disk accretion around a primary star or substar. I quantify this definition by the degree to which a body dominates the other masses that share its orbital zone. Theoretical and observational measures of dynamical dominance reveal gaps of 4–5 orders of magnitude separating the eight planets of our solar system from the populations of asteroids and comets. The proposed definition dispenses with upper and lower mass limits for a planet. It reflects the tendency of disk evolution in a mature system to produce a small number of relatively large bodies (planets) in nonintersecting or resonant orbits, which prevents collisions between them.

Published in: The *Astronomical Journal*, **132**, 2513 (2006 December)

For preprints, contact soter@amnh.org

or on the web at <http://arxiv.org/abs/astro-ph/0608359>

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The Surface of 2003 EL₆₁ in the Near Infrared

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We report the detection of crystalline water ice on the surface of 2003 EL₆₁. Reflectance spectra were collected from Gemini North telescope from 1.0 to 2.4 micron wavelength range, and from the Keck telescope across the 1.4 to 2.4 micron wavelength range. The signature of crystalline water ice is obvious in all data collected. Like the surfaces of many outer solar system bodies, the surface of 2003 EL₆₁ is rich in crystalline water ice, which is energetically less favored than amorphous water ice at low temperatures, suggesting that resurfacing processes may be taking place. The near infrared color of the object is much bluer than a pure water ice model. Adding a near infrared blue component such as hydrogen cyanide or phyllosilicate clays improves the fit considerably, with hydrogen cyanide providing the greatest improvement. The addition of hydrated tholins and bitumens also improves the fit but is inconsistent with the neutral $V - J$ reflectance of 2003 EL₆₁. A small decrease in reflectance beyond 2.3 micron may be attributable to cyanide salts. Overall, the reflected light from 2003 EL₆₁ is best fit by a model of 2/3 to 4/5 pure crystalline water ice and 1/3 to 1/5 near infrared blue component such as hydrogen cyanide or kaolinite. The surface of 2003 EL₆₁ is unlikely to be covered by significant amounts of dark material such as carbon black, as our pure ice models reproduce published albedo estimates derived from the spin state of 2003 EL₆₁.

To appear in: The Astrophysical Journal, vol. 655 (2007 January 20)

For preprints, contact trujillo@gemini.edu

or on the web at <http://arxiv.org/abs/astro-ph/0601618>

Optical Spectroscopy of the Large Kuiper Belt Objects 136472 (2005 FY9) and 136108 (2003 EL61)

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We present high signal precision optical reflectance spectra of the large Kuiper belt objects 2005 FY9 and 2003 EL61. The spectrum of 2005 FY9 exhibits strong CH₄-ice bands. A comparison between the spectrum and a Hapke model indicates the CH₄ bands are shifted 3.25 ± 2.25 Å relative to pure CH₄-ice, suggesting the presence of another ice component on the surface of 2005 FY9, possibly N₂-ice, CO-ice, or Ar. The spectrum of 2003 EL61 is remarkably featureless. There is a hint of an O₂-ice band at 5773 Å; however, this feature needs to be confirmed by future spectroscopic observations of 2003 EL61 with a higher continuum signal precision, sufficient to detect a second weaker O₂-ice band at 6275 Å.

To appear in: The Astronomical Journal (2007 February)

For preprints, contact Stephen.Tegler@nau.edu

or on the web at <http://arxiv.org/abs/astro-ph/0611135>

Trans-Neptunian Object (55636) 2002 TX₃₀₀ : A Fresh Icy Surface in the Outer Solar System

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Context: The knowledge of the physical properties of the population of known large trans-Neptunian objects (TNOs) is a key issue in understanding the origin and evolution of the Solar System. In particular, the knowledge of their surface composition helps to understand the original composition of the TNOs and the processes that affect their surfaces during their life.

Aims: We studied the surface composition of bright TNO 2002 TX₃₀₀, an object with a few hundred kilometer diameter (900–400 km if visual albedo is $0.08 < p_V < 0.4$).

Methods: We report visible and near infrared spectra covering the 0.5–2.2 μm spectral range, obtained with the Italian 3.58 m Telescopio Nazionale Galileo at “El Roque de los Muchachos” Observatory (La Palma, Spain), and derive mineralogical information using multiple scattering models.

Results: The spectrum of this large TNO is dominated by strong water ice absorption bands in the near-infrared and also presents a neutral to blue slope in the whole observed range. Models suggest that the surface of 2002 TX₃₀₀ is fresh, composed of a large fraction of large water ice particles and dark materials (may be carbon and/or silicates) and a very low fraction of highly processed organic materials (tholins). The spectrum of 2002 TX₃₀₀ is very similar to that of Pluto’s satellite Charon. This can indicate that there is an ubiquitous mechanism that keeps water ice as the principal component of the outer layer of the surface of some large TNOs.

Published in: *Astronomy & Astrophysics*, **457**, 329 (2006 October)

For preprints, contact licandro@ing.iac.es

Subsurface Oceans and Deep Interiors of Medium-sized Outer Planet Satellites and Large Trans-Neptunian Objects

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The detection of induced magnetic fields in the vicinity of the jovian satellites Europa, Ganymede, and Callisto is one of the most surprising findings of the Galileo mission to Jupiter. The observed magnetic signature cannot be generated in solid ice or in silicate rock. It rather suggests the existence of electrically conducting reservoirs of liquid water beneath the satellites’ outermost icy shells that may contain even more water than all terrestrial oceans combined. The maintenance of liquid water layers is closely related to the internal structure, composition, and thermal state of the corresponding satellite interior. In this study we investigate the possibility of subsurface oceans in the medium-sized icy satellites and the largest trans-neptunian objects (TNO’s). Controlling parameters for subsurface ocean formation are the radiogenic heating rate of the silicate component and the effectiveness of the heat transfer to the surface. Furthermore, the melting temperature of ice will be significantly reduced by small amounts of salts and/or incorporated volatiles such as methane and ammonia that are highly abundant in the outer Solar System. Based on the assumption that the satellites are differentiated and using an equilibrium condition between the heat production rate in the rocky cores

and the heat loss through the ice shell, we find that subsurface oceans are possible on Rhea, Titania, Oberon, Triton, and Pluto and on the largest TNO's 2003 UB313, Sedna, and 2004 DW. Subsurface oceans can even exist if only small amounts of ammonia are available. The liquid subsurface reservoirs are located deeply underneath an ice-I shell of more than 100 km thickness. However, they may be indirectly detectable by their interaction with the surrounding magnetic fields and charged particles and by the magnitude of a satellite's response to tides exerted by the primary. The latter is strongly dependent on the occurrence of a subsurface ocean which provides greater flexibility to a satellite's rigid outer ice shell.

Published in: Icarus, 185, 258 (2005 November)

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Origin of Scattered Disk Resonant TNOs: Evidence for an Ancient Excited Kuiper Belt of 50 AU Radius

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Resonance occupation of trans-Neptunian objects (TNOs) in the scattered disk (> 48 AU) was investigated by integrating the orbits of 85 observed members for 4 Gyr. Twenty seven TNOs were locked in the 9:4, 16:7, 7:3, 12:5, 5:2, 8:3, 3:1, 4:1, 11:2, and 27:4 resonances. We then explored mechanisms for the origin of the resonant structure in the scattered disk, in particular the long-term 9:4, 5:2, and 8:3 resonant TNOs (median 4 Gyr), by performing large scale simulations involving Neptune scattering and planetary migration over an initially excited planetesimals disk (wide range of eccentricities and inclinations). To explain the formation of Gyr-resident populations in such distant resonances, our results suggest the existence of a primordial planetesimal disk of at least 45–50 AU radius that suffered a dynamical perturbation leading to 0.1–0.3 or greater eccentricities and a range of inclinations up to ~ 20 degrees during early stages of the solar system history, before planetary migration.

To appear in: Icarus

For preprints, contact patryk@kobe-u.ac.jp

or on the web at <http://harbor.scitec.kobe-u.ac.jp/~patryk/index-en.html>

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Coupling Dynamical and Collisional Evolution of Small Bodies II: Forming the Kuiper Belt, the Scattered Disk and the Oort Cloud

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The Oort Cloud, the Kuiper Belt and the Scattered Disk are dynamically distinct populations of small bodies evolving in the outer regions of the Solar System. Whereas their collisional activity is now quiet, gravitational interactions with giant planets may have shaped these populations both dynamically and collisionally during their formation. Using a hybrid approach (Charnoz & Morbidelli 2003), the present paper tries to couple the primordial collisional and dynamical evolution of these three populations in a self-consistent way. A critical parameter is the primordial size-distribution. We show that the initial planetesimal size distribution that allows an effective mass depletion of the

Kuiper belt by collisional grinding, would decimate also the population of comet-size bodies that end in the Oort Cloud and, in particular, in the Scattered Disk. As a consequence, the Scattered Disk and the Oort Cloud would be too anemic, by a factor 20 to 100, relative to the estimates achieved from the observation of the fluxes of long period and Jupiter family comets, respectively. For these two reservoirs to have a sufficient number of comets, the initial size distribution in the planetesimal disk had to be such that the mass depletion by collisional erosion of in the Kuiper belt was negligible. Consequently, the current mass deficit of the Kuiper belt, needs to be explained by dynamical mechanisms.

To appear in: Icarus

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Dynamical Determination of the Kuiper Belt's Mass from Motions of the Inner Planets of the Solar System

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In this paper we dynamically determine the mass of the Kuiper Belt Objects by exploiting the latest observational determinations of the orbital motions of the inner planets of the Solar System. Our result, in units of terrestrial masses, is 0.033 ± 0.115 by modelling the Classical Kuiper Belt Objects as an ecliptic ring of finite thickness. A two-rings model yields for the Resonant Kuiper Belt Objects a value of 0.018 ± 0.063 . Such figures are consistent with recent determinations obtained with ground and space-based optical techniques. Some implications for precise tests of Einsteinian and post-Einsteinian gravity are briefly discussed.

To appear in: Monthly Notices of the Royal Astronomical Society

For preprints, contact `lorenzo.iorio@libero.it`

or on the web at <http://arxiv.org/abs/gr-qc/0609023>

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Photometry of Cometary Nuclei: Rotation Rates, Colours and a Comparison with Kuiper Belt Objects

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We present time-series data on Jupiter Family Comets (JFCs) 17P/Holmes, 47P/Ashbrook-Jackson and 137P/Shoemaker-Levy 2. In addition we also present results from ‘snap-shot’ observations of comets 43P/Wolf-Harrington, 44P/Reinmuth 2, 103P/Hartley 2 and 104P/Kowal 2 taken during the same run. The comets were at heliocentric distances of between 3 and 7 AU at this time. We present measurements of size and activity levels for the snap-shot targets. The time-series data allow us to constrain rotation periods and shapes, and thus bulk densities. We also measure colour indices ($V - R$) and ($R - I$) and reliable radii for these comets. We compare all of our findings to date with similar results for other comets and Kuiper Belt Objects (KBOs). We find that the rotational properties of nuclei and KBOs are very similar, that there is evidence for a cut-off in bulk densities at

$\sim 0.6 \text{ g cm}^{-3}$ in both populations, and the colours of the two populations show similar correlations. For JFCs there is no observational evidence for the optical colours being dependent on either position in the orbit or on orbital parameters.

To appear in: Monthly Notices of the Royal Astronomical Society

For preprints, contact csnodgra@eso.org

or on the web at <http://arxiv.org/abs/astro-ph/0610301>

PAPERS RECENTLY SUBMITTED TO JOURNALS

The Orbit, Mass, Size, Albedo, and Density of (65489) Ceto-Phorcys: A Tidally-evolved Binary Centaur

**W.M. Grundy¹, J.A. Stansberry², K.S. Noll³, D.C. Stephens⁴, D.E. Trilling², S.D. Kern³,
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⁶ NASA Ames Research Center, MS 2456, Moffett Field CA 94035, USA

Submitted to: *Icarus*

For preprints, visit <http://www.lowell.edu/~grundy/abstracts/2006.FX128.html>

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Surface Composition of the Largest Dwarf Planet 136199 Eris (2003 UB313)

**C. Dumas¹, O. Hainaut¹, F. Merlin², M. A. Barucci², C. deBergh², A. Guilbert²,
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¹ ESO, Casilla 19001, Santiago 19, Chile

² LESIA, Obs. Paris-Meudon, 5 Place Jules Janssen, 92195 Meudon, France

Submitted to: *Astronomy and Astrophysics*

OTHER PAPERS OF INTEREST

Laboratory Simulation Experiments on the Solid-state Greenhouse Effect in Planetary Ices

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Icarus, 185, 274 (2006 November)

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THESES

A Study of Binary Kuiper Belt Objects

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About 10^5 bodies larger than 100 km in diameter (Jewitt 1998) reside in the Kuiper Belt, beyond the orbit of Neptune. Since 1992 observational surveys have discovered over one thousand of these objects, believed to be fossil remnants of events that occurred nearly 4.5 billion years ago. Sixteen of these objects are currently known to be binaries, and many more are expected to be discovered.

As part of the Deep Ecliptic Survey (DES) I have helped catalog nearly one third of the known Kuiper Belt object (KBO) population, and used that database for further physical studies. Recovery observations for dynamical studies of newly discovered objects with the Magellan telescopes and a high resolution imager, MagIC, revealed three binaries, 88611 (2001 QT297), 2003 QY90, and 2005 EO304. One binary was found in the discovery observations, 2003 UN284.

Lightcurve measurements of these, and other non-binary KBOs, were obtained to look for unique rotational characteristics. Eleven of thirty-three objects, excluding the binaries, were found to have measurable variability. One of these objects, 2002 GW32 has a particularly large amplitude (>1 magnitude) of variability, and 2002 GP32 has a relatively short (~ 3.3 hours, single-peaked) lightcurve. Among the binary population all the observed objects showed some level of variation. The secondary of 88611 was fit with a single-peaked period of 5.50 ± 0.02 hours while the primary component appears to be non-variable above the measurement errors (0.05 magnitudes). Neither component appears to be color variable. The components of 2003 QY90 are both highly variable yielding single-peaked rotation periods of 3.4 ± 1.1 and 7.1 ± 2.9 hours with amplitudes of 0.34 ± 0.12 and 0.90 ± 0.36 magnitudes, respectively. The rotation periods are comparable to those of other non-binary KBOs although distinct from that of an identified contact binary.

Orbits and partial orbits for Kuiper belt binaries (KBBs) show a wide range of eccentricities, and an increasing number of binaries with decreasing binary semi-major axis. These characteristics exclude the formation models proposed by Funato *et al.* (2003) and Weidenschilling (2002), respectively. Conversely, the formation models of Astakhov *et al.* (2005) and Goldreich *et al.* (2002) appear to describe the observations, at least in part.

Dissertation directed by J. L. Elliot

Ph.D. awarded September, 2005 from MIT

Available on the web at: <http://web.mit.edu/~susank/www/>

CONFERENCE INFORMATION

**ESO Workshop: Observing Planetary Systems
to be held in Santiago de Chile, March 5-8, 2007**

Deadline to register: Dec. 15, 2006.

Workshop URL: <http://www.sc.eso.org/santiago/science/OPSWorkshop/>

The *Distant EKO*s Newsletter is dedicated to provide researchers with easy and rapid access to current work regarding the Kuiper belt (observational and theoretical studies), directly related objects (e.g., Pluto, Centaurs), and other areas of study when explicitly applied to the Kuiper belt.

We accept submissions for the following sections:

- ★ Abstracts of accepted papers
- ★ Titles of submitted (but not yet accepted) papers and conference articles
- ★ Thesis abstracts
- ★ Short articles, announcements, or editorials
- ★ Status reports of on-going programs
- ★ Requests for collaboration or observing coordination
- ★ Table of contents/outlines of books
- ★ Announcements for conferences
- ★ Job advertisements
- ★ General news items deemed of interest to the Kuiper belt community

A L^AT_EX template for submissions is appended to each issue of the newsletter, and is sent out regularly to the e-mail distribution list. Please use that template, and send your submission to:

`ekonews@boulder.swri.edu`

The *Distant EKO*s Newsletter is available on the World Wide Web at:

`http://www.boulder.swri.edu/ekonews`

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Moving ... ??

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