Issue No. 47 *July 2006*

DISTANT EKOs

The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

ekonews@boulder.swri.edu www.boulder.swri.edu/ekonews

CONTENTS

News & Announcements 2
Abstracts of 7 Accepted Papers 3
Title of 1 Submitted Paper 7
Title of 1 Conference Contribution 7
Abstract of 1 Thesis 8
Newsletter Information 9

NEWS & ANNOUNCEMENTS

IAU Circular #8723 announces the names for Pluto's two newly-discovered moons: Nix and Hydra. In keeping with the underworld theme, Nix (or Nyx, but that name was already taken) is the goddess of darkness and the mother of Charon, and Hydra is the nine-headed serpent that guarded the underworld. Not coincidentally, the initials "N" and "H" are also are the initials of the New Horizons mission.
IAUC: `http://cfa-www.harvard.edu/iauc/08700/08723.html`
Other links:
`http://www.swri.org/9what/releases/2006/NixHydra.htm`
`http://en.wikipedia.org/wiki/Nyx`
`http://en.wikipedia.org/wiki/Lernaean_Hydra`

. . . . . .

In the previous issue of the *Distant EKOs Newsletter*, I highlighted news items about Centaur 60558 Echeclus (= 2000 EC98 = comet 174P/Echeclus), and its intriguing activity. In CBET 563, Choi et al. report on observations showing that the source of activity appears to be a secondary body moving independently of the primary. The authors point out that the unusual motion of the secondary cannot be accounted for by a bound Keplerian orbit unless the mass of Echeclus is a factor of at least 200 greater than the current best estimate. They suggest that the secondary may be a fragment ejected from the primary.
CBET: `http://cfa-www.harvard.edu/iau/cbet/000500/CBET000563.txt`

. . . . . .

A database dedicated to photometric data of KBOs and Centaurs has been created on Besançon Observatory website. With just a few mouse clicks, users can download the photometric data obtained for an object in a standard format. Some basic preprocessing (light-travel time corrections, apparent/absolute magnitudes, phase angles) can be computed by this database. So far it contains 2493 different photometric data for 33 different objects. Observers are welcomed to improve these statistics.
URL: `www.obs-besancon.fr/bdp`
Contact: Philippe Rousselot (`rousselot@obs-besancon.fr`)

. . . . . .

There were 24 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2005 XU100, 2006 HA123, 2006 HB123, 2006 HC123, 2006 HD123, 2006 HE123, 2006 HN122, 2006 HO122, 2006 HP122, 2006 HQ122, 2006 HR122, 2006 HS122, 2006 HT122, 2006 HU122, 2006 HV122, 2006 HW122, 2006 HX122, 2006 HY122, 2006 HZ122, 2006 JU58, 2006 JV58, 2006 HF123, 2006 HG123, 2006 HJ123

and 1 new Centaur/SDO discovery:

2006 HH123

Reclassified objects:

2003 LA7 (TNO → SDO)
2005 EO297 (TNO → SDO)

Objects recently assigned names:

1997 CQ29 = Logos

Current number of TNOs: 1012
Current number of Centaurs/SDOs: 169
Current number of Neptune Trojans: 4
Current number of satellites: 21 around 17 objects

Out of a total of 1185 objects:
513 have measurements from only one opposition
459 of those have had no measurements for more than a year
238 of those have arcs shorter than 10 days
(for more details, see: `http://www.boulder.swri.edu/ekonews/objects/recov_stats.gif`)

PAPERS ACCEPTED TO JOURNALS

A Distant Planetary-Mass Solar Companion May Have Produced Distant Detached Objects

Rodney S. Gomes[1], John J. Matese[2], and Jack J. Lissauer[3]

[1] Observatório Nacional, Rua General José Cristino, 77, 20921-400, Rio de Janeiro, RJ, Brazil

[2] Department of Physics, University of Louisiana at Lafayette, Lafayette, LA, 70504-4210, USA

[3] Space Science and Astrobiology Division, MS 245-3, NASA Ames Research Center, Moffett Field, CA, 94035, USA

Most known trans-Neptunian objects (TNO's) are either on low eccentricity orbits or could have been perturbed to their current trajectories via gravitational interactions with known bodies. However, one or two recently-discovered TNO's are distant detached objects (DDO's) (perihelion, q, $>$ 40 AU and semimajor axis, a, $>$ 50 AU) whose origins are not as easily understood. We investigate the parameter space of a hypothetical distant planetary-mass solar companion which could detach the perihelion of a Neptune-dominated TNO into a DDO orbit. Perturbations of the giant planets are also included. The problem is analyzed using two models. In the first model, we start with a distribution of undetached, low-inclination TNO's having a wide range of semimajor axes. The planetary perturbations and the companion perturbation are treated in the adiabatic, secularly averaged tidal approximation. This provides a starting point for a more detailed analysis by providing insights as to the companion parameter space likely to create DDO's. The second model includes the companion and the planets and numerically integrates perturbations on a sampling that is based on the real population of scattered disk objects (SDO's). A single calculation is performed including the mutual interactions and migration of the planets. By comparing these models, we distinguish the distant detached population that can be attributable to the secular interaction from those that require additional planetary perturbations. We find that a DDO can be produced by a hypothetical Neptune-mass companion having semiminor axis, b_c, $\leq$ 2000 AU or a Jupiter-mass companion with $b_c \leq$ 5000 AU. DDO's produced by such a companion are likely to have small inclinations to the ecliptic only if the companion's orbit is significantly inclined. We also discuss the possibility that the tilt of the planets' invariable plane relative to the solar equatorial plane has been produced by such a hypothetical distant planetary-mass companion. Perturbations of a companion on Oort cloud comets are also considered.

To appear in: Icarus

For preprints, contact `rodney@on.br`
or on the web at `http://staff.on.br/rodneyg/companion/solar_companion.pdf`

. . . . . .

The Color of the Kuiper Belt Core

A.A.S. Gulbis[1], J.L. Elliot[1], and J.F. Kane[1]

[1] Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139, USA

Recent dynamical analyses of the Kuiper belt have introduced a rigorous classification scheme, determined the mean orbital plane, and identified "Core" and "Halo" populations as a function of inclination with respect to this plane (Elliot, *et al.* 2005. AJ, 129, 1117–1162). Here, we use new observations and existing data to investigate the colors of Kuiper belt objects (KBOs) within this framework. With respect to the bulk KBO color distribution (all objects for which we have $B-V$ and $V-R$ colors; median $B-R=1.56$), we find that the population of objects classified following Elliot, *et al.* as Classical tends to be red ($B-R>1.56$) while the Scattered Near population is mostly neutral ($B-R<1.56$). Colors of Scattered Extended and Resonant objects are consistent with the bulk distribution. Separating objects into specific resonances demonstrates that the color of the Resonant sample is dominated by KBOs in the 3:2 resonance, which is consistent with previous findings. Unlike the objects in the 3:2 resonance, however, the majority of objects in the 5:2 resonance are neutral and all but one of the objects in the 4:3, 5:3, 7:4, 2:1, and 7:3 resonances are red. In particular, the objects in the 7:4 resonance are remarkably red. We find that the colors of KBOs in the Core (low-inclination) and Halo (high-inclination) are statistically different, with Core objects being primarily red and Halo objects having a slight tendency to be neutral. Notably, virtually all of the non-Resonant Core objects are red. This combination of low inclination, unperturbed orbits and red colors in the Core may be indicative of a relic grouping of objects.

Published in: Icarus, 183, 168–178 (July 2006)
For preprints, contact `gulbis@mit.edu`

. . . . . .

A Thick Cloud of Neptune Trojans and Their Colors

A. Scott S. Sheppard[1] and B. Chadwick Trujillo[2]

[1] Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Rd. NW, 20015, USA

[2] Gemini Observatory, 670 North A'ohoku Place, Hilo, Hi 96720, USA

The dynamical and physical properties of asteroids offer one of the few constraints on the formation, evolution and migration of the giant planets. Trojan asteroids share a planet's semi-major axis but lead or follow it by about 60 degrees near the two triangular Lagrangian points of gravitational equilibrium. Here we report the discovery of a high inclination Neptune Trojan, 2005 TN_{53}. This demonstrates that the Neptune Trojan population occupies a thick disk which is indicative of "freeze-in" capture instead of in-situ or collisional formation. The Neptune Trojans appear to have a population several times larger than the Jupiter Trojans. Our color measurements show that Neptune Trojans have statistically indistinguishable slightly red colors suggesting they had a common formation and evolutionary history and are distinct from the classical Kuiper Belt objects.

To appear in: Science; published in Science Express (2006 June 15)
For preprints, contact `sheppard@dtm.ciw.edu`
or on the web at `http://www.dtm.ciw.edu/sheppard/trojans/`

. . . . . .

Discovery of a Binary Centaur

Keith S. Noll[1], Harold F. Levison[2], Will M. Grundy[3], and Denise C. Stephens[4]

[1] Space Telescope Science Institute, 3700 San Martin Dr., Baltimore, MD 21218, USA

[2] Dept. of Space Studies, Southwest Research Institute, Ste. 400, 1050 Walnut St., Boulder, CO 80302, USA

[3] Lowell Observatory, 1400 W. Mars Hill Rd., Flagstaff, AZ 86001, USA

[4] Johns Hopkins University, Dept. Physics and Astronomy, Baltimore, MD 21218, USA

We have identified a binary companion to (42355) 2002 CR_{46} in our ongoing deep survey using the Hubble Space Telescope's High Resolution Camera. It is the first companion to be found around an object in a non-resonant orbit that crosses the orbits of giant planets. Objects in orbits of this kind, the Centaurs, have experienced repeated strong scattering with one or more giant planets and therefore the survival of binaries in this transient population has been in question. Monte Carlo simulations suggest, however, that binaries in (42355) 2002 CR_{46}-like heliocentric orbits have a high probability of survival for reasonable estimates of the binary's still-unknown system mass and separation. Because Centaurs are thought to be precursors to short period comets, the question of the existence of binary comets naturally arises; none has yet been definitively identified. The discovery of one binary in a sample of eight observed by HST suggests that binaries in this population may not be uncommon.

To appear in: Icarus

Preprints on the web at `http://arxiv.org/abs/astro-ph/0605606`

. . . . . .

Ion Irradiation of Frozen Methanol, Methane, and Benzene: Linking to the Colors of Centaurs and Trans-Neptunian Objects

R. Brunetto[1,2], M.A. Barucci[3], E. Dotto[4], and G. Strazzulla[2]

[1] Dipartimento di Fisica, Universit di Lecce, via Arnesano 73100, Lecce, Italy

[2] INAF-Osservatorio Astrofisico di Catania, Via S. Sofia 78, 95123, Catania, Italy

[3] LESIA, Observatoire de Paris, 92195, Meudon Principal Cedex, France

[3] INAF-Osservatorio Astronomico di Roma, Via Frascati 33, 00040, Monteporzio Catone (Roma), Italy

We present visible and near-infrared (0.65–2.7 μm) diffuse reflectance spectra of frozen (16–80 K) methanol (CH_3OH), methane (CH_4), and benzene (C_6H_6), collected before and after irradiation with 200 keV H^+ and Ar^+ ions, and 400 keV Ar^{++} ions, up to a dose released to target molecule of about 350 eV per 16 amu. The results evidence a strong reddening and darkening of the spectra, due to the formation of an organic (C-rich) refractory residue. The spectral behavior is compared with some Centaurs and trans-Neptunian objects; we find that many icy objects in the outer solar system may have grown an irradiation mantle, produced by cosmic ion irradiation of simple hydrocarbons and/or alcohols.

Published in: The Astrophysical Journal, 644, 646 (2006 June 10)

. . . . . .

Exploration of the Kuiper Belt by High Precision Photometric Stellar Occultations: First Results

F. Roques[1], A. Doressoundiram[1],V. Dhillon[2], T. Marsh[3], S. Bickerton[4,10], JJ Kavelaars[4], M. Moncuquet[1], M. Auvergne[1], I. Belskaya[8], M. Chevreton[1], F. Colas[1], A. Fernandez[1], A. Fitzsimmons[5], J. Lecacheux[1], O. Mousis[9], S. Pau[1], N. Peixinho[1,6], and G.P. Tozzi[7]

[1] LESIA, Observatoire de Paris, F-92195 Meudon Principal Cedex, France

[3] Department of Physics, University of Warwick, Coventry CV4 7AL, UK

[4] National Research Council of Canada, Victoria, British Columbia, V9E 2E9, Canada

[5] Queens University Belfast, Northern Ireland

[6] Centro GAUC / Observatório de Coimbra, Largo D. Dinis, 3001-454 Coimbra, Portugal

[7] INAF, Osservatorio astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy

[8] Astronomical Observatory of Kharkiv National University, 61022 Kharkiv, Ukraine

[9] Observatoire de Besançon, B.P. 1615, 25010 Besançon Cedex, France

[10] Department of Physics and Astronomy, McMaster University, Hamilton, Ontario, L8S 4M1, Canada

We report here the first detection of hectometre-size objects by the method of serendipitous stellar occultation. This method consists of recording the diffractions shadow created when an object cross the observers line of sight and occults the disk of a background star. One of our detections is most consistent with an object between Saturn and Uranus. The two other diffractions patterns detected are caused by KBOs beyond 100 AU from the Sun and hence are the farthest objects heretofore detected in the solar system. These detections show that the Kuiper Belt is much more extended than previously known and that the outer part of the disk could be composed of smaller objects than in the inner region. This gives critical clues to understanding the problem of the formation of the outer planets of the solar system.

To appear in: Astronomical Journal (2006 August)
For preprints, contact `francoise.roques@obspm.fr`

. . . . . .

Constraints on the Formation Regions of Comets from their D:H Ratios

Jonathan Horner[1], Olivier Mousis[2], and Franck Hersant[3]

[1] Physikalisches Institut, University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland

[2] Observatoire de Besançon, CNRS-UMR 6091, BP 1615, 25010, Besançon Cedex, France

[3] LESIA, Observatoire de Meudon, CNRS-UMR 8109, 5 Place Jules Janssen, 92195 Meudon Cedex, France

Studies of the D:H ratio in H_2O within the Solar nebula provide a relationship between the degree of enrichment of deuterium and the distance from the young Sun. In the context of cometary formation, such models suggest that comets which formed in different regions of the Solar nebula should have measurably different D:H ratios. We aim to illustrate how the observed comets can give information about the formation regions of the reservoirs in which they originated. After a discussion of the current understanding of the regions in which comets formed, simple models of plausible formation regions for two different cometary reservoirs (the Edgeworth-Kuiper belt and the Oort Cloud) are convolved with a deuterium-enrichment profile for the pre-solar nebula. This allows us to illustrate how different formation regions for these objects can lead to great variations in the deuterium enrichment distributions that we would observe in comets today. We also provide an illustrative example of how variations in the population within a source region can modify the

resulting observational profile. The convolution of a deuterium-enrichment profile with examples of proto-cometary populations gives a feel for how observations could be used to draw conclusions on the formation region of comets which are currently fed into the inner Solar system from at least two reservoirs. Such observations have, to date, been carried out on only three comets, but future work with instruments such as ALMA and Herschel should vastly improve the dataset, leading to a clearer consensus on the formation of the Oort cloud and Edgeworth-Kuiper belt.

To appear in: Earth, Moon and Planets
For preprints, contact jonathan.horner@space.unibe.ch
or on the web at http://www.phim.unibe.ch/~horner/

PAPERS RECENTLY SUBMITTED TO JOURNALS

Methane and Ethane on the Bright Kuiper Belt Object 2005 FY9

M.E. Brown[1], K.M. Barkume[1], G.A. Blake[1], E.L. Schaller[1], D.L. Rabinowitz[2], H.G. Roe[1], and C.A. Trujillo[3]

[1] Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125, USA

[2] Department of Physics, Yale University, New Haven, CT 06520, USA

[3] Gemini Observatory, 670 North A'ohoku Place, Hilo, HI 96720, USA

Submitted to: The Astronomical Journal
Preprints on the web at www.gps.caltech.edu/~mbrown/papers

CONFERENCE CONTRIBUTIONS

Outer Irregular Satellites of the Planets and Their Relationship with Asteroids, Comets and Kuiper Belt Objects

Scott S. Sheppard[1]

[1] Carnegie Institution of Washington, Department of Terrestrial Magnetism, Washington, DC, USA

To appear in: Asteroids, Comets and Meteors 2005; Proceedings of IAU Symposium 229
For preprints, contact sheppard@dtm.ciw.edu
or on the web at http://www.arxiv.org/abs/astro-ph/0605041

THESES

A Survey for TNOs Using the APS POSS I Database

Edward Rhoads[1]

[1] Department of Astronomy, University of Minnesota, 116 Church St. S.E., Minneapolis, MN 55455, USA

The digitized first epoch Palomar Observatory Sky Survey (POSS I) is an ideal and unused archive for the purpose of data mining Trans-Neptunian Objects (TNOs). The POSS I survey has positions accurate to 0.3″, and covers over three quarters of the sky within 15 degrees of the ecliptic. Overall, there are 232 plates within 15 degrees of the ecliptic which have been scanned by the Automated Plate Scanner (APS) project (Pennington et al. 1993) from which we can potentially discover TNOs with diameters of 500 km or larger. Out of the 232 plates within 15 degrees of the ecliptic, 165 plates were analyzed. 148 of these plates were found to be useful for a reliable TNO search. Each plate covers 38.4 square degrees of sky, and the raw sky coverage on the 165 plates was 6343 square degrees. When accounting for overlap in TNO phase space and the area of the plates covered by stars and galaxies, the effective sky coverage area for this search was 4931 square degrees for Plutinos, and 4992 square degrees for classical TNOs; making this survey one of the most extensive to date. To refine the search we first determined the expected TNO parameters on these plates such as motion between the red and blue plates, the O-E color, and ellipticity using known TNOs. During the time between exposures on the POSS I O and E fields (30–40 minutes), the motion in Right Ascension (RA) for a TNO or Centaur is expected to be between 1″ to 5″. Also, the direction of movement, within the errors, was expected to be within 20 degrees of parallel to the ecliptic. Using Varuna, Quaoar, and Pluto the expected O-E color is between 1.0 (0.2 magnitudes bluer than the color of Pluto) and 4.0 (a very red limit). The ellipticity on the O plate and the E plate are found to lie within 0.2 of each other. Finally, real objects are expected to have diameters consistent with the seeing of the plate, and solar system objects are expected to have diameters consistent with their movement during the plate exposure. Using these constraints, computer codes were used to separate TNO candidates from the millions of objects on each plate, and lists of possible TNO, Centaur, and asteroid candidates were created. Every candidate that remains after the various criteria had been applied were visually inspected in order to determine if it was a potential solar system object. The results of this massive survey yielded 17 reliable TNOs and TNO candidates, including Pluto, Quaoar, and Varuna. In addition to the TNOs, 28 Centaur and 31 Asteroid candidates were found. Also, Quaoar was pre-covered, and the Main Belt Asteroid (395) Delia was also recovered.

Dissertation directed by Roberta Humphreys and Chick Woodward
Ph.D. awarded in 2005 from the University of Minnesota

The *Distant EKOs* 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 LaTeX 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 EKOs* Newsletter is available on the World Wide Web at:

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

Recent and back issues of the newsletter are archived there in various formats. The web pages also contain other related information and links.

Distant EKOs is not a refereed publication, but is a tool for furthering communication among people interested in Kuiper belt research. Publication or listing of an article in the newsletter or the web page does not constitute an endorsement of the article's results or imply validity of its contents. When referencing an article, please reference the original source; *Distant EKOs* is not a substitute for peer-reviewed journals.

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the newsletter bounces back from an address for three consecutive issues, the address will be deleted from the mailing list. All address changes, submissions, and other correspondence should be sent to:

`ekonews@boulder.swri.edu`