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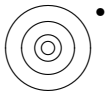
DISTANT EKOs



The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

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

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NEWS & ANNOUNCEMENTS

There were 2 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2010 VK201, 2010 VL201

and 1 new Centaur/SDO discovery:

2011 AC72

Reclassified objects:

2010 VZ98 (TNO → SDO)

Deleted objects:

2010 VS11

Current number of TNOs: 1164 (including Pluto)
Current number of Centaurs/SDOs: 291
Current number of Neptune Trojans: 7

Out of a total of 1427 objects:

635 have measurements from only one opposition
577 of those have had no measurements for more than a year
323 of those have arcs shorter than 10 days

(for more details, see: `http://www.boulder.swri.edu/ekonews/objects/recov_stats.jpg`)
Another measure of the astrometric "secure vs. lost" status for TNOs is from Marc Buie's web page `http://www.boulder.swri.edu/~buie/kbo/kbofollowup.html` Out of 1427 objects:

159 have secure positions
376 have decent positions
382 are at risk (uncertainty < 0.5 deg and "need ratio" > 1)
510 are lost (uncertainty > 0.5 deg)

PAPERS ACCEPTED TO JOURNALS

Thermal Evolution Model of Centaur 10199 Chariklo

A. Guilbert-Lepoutre[1]

[1] Department of Earth and Space Sciences, UCLA, 595 Charles E. Young Drive East, Los Angeles CA 90095, USA

Centaur 10199 Chariklo appears to have a varying spectral behavior. While three different spectral studies detect the presence of water ice at the surface, two more recent studies do not detect any absorption bands. In this article we consider the possibility that Chariklo undergoes cometary activity that could be responsible for the observed spectral variations. We simulate its thermal evolution, finding that crystalline water ice should be present in the object core, and amorphous water ice should be found at the surface. Upon entering the inner solar system, Chariklo might experience some cometary activity due to water ice crystallization if the obliquity is high, due to the adjustment of the internal structure to a new thermal equilibrium. No other activity is expected from this source, unless an external source like an impact provides the heat needed. In the case of such an event, we find that dust emitted in a coma is unlikely to be responsible for the observed spectral variations. On the contrary, water ice grains in the coma would reproduce this pattern, meaning that the water ice detected after Chariklo's discovery was present in these grains and not on the object surface. Nonetheless, any activity would require an external additional heat source to be triggered, through an outburst, which might favor the spatial variations hypothesis.

To appear in: The Astronomical Journal

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On a Giant Impact Origin of Charon, Nix and Hydra

Robin M. Canup[1]

[1] Planetary Science Directorate, Southwest Research Institute, 1050 Walnut Street, #300, Boulder, CO 80302, USA

It is generally believed that Charon formed as a result of a large, grazing collision with Pluto that supplied the Pluto-Charon system with its high angular momentum. It has also been proposed that Pluto's small outer moons, Nix and Hydra, formed from debris from the Charon-forming impact (Stern et al. 2006; Ward & Canup 2006), although the viability of this scenario remains unclear. Here I use SPH impact simulations to show that it is possible to simultaneously form an intact Charon and an accompanying debris disk from a single impact. The successful cases involve colliding objects that are partially differentiated prior to impact, having thin outer ice mantles overlying a uniform composition rock-ice core. The composition of the resulting debris disks varies from a mixture of rock and ice (similar to the bulk composition of Pluto and Charon) to a pure ice disk. If Nix and Hydra formed from such an impact-generated disk, their densities should be less than or similar to that of Charon and Pluto, and the small moons could be composed entirely of ice. If they were instead formed from captured material (e.g., Lithwick & Wu 2008), a mixed rock-ice composition and densities similar to that of Charon and Pluto would be expected. Improved constraints on the properties of Nix and Hydra through occultations and/or the New Horizons encounter may thus help to distinguish between these two modes of origin, particularly if the small moons are found to have ice-like densities.

Published in: The Astronomical Journal, 141, 35 (2011 February)

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Using Kuiper Belt Binaries to Constrain Neptune's Migration History

R.A. Murray-Clay[1] and H.E. Schlichting[2]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS-51, Cambridge, MA 02138, USA

[2] UCLA, Department of Earth and Space Science, 595 Charles E. Young Drive East, Los Angeles, CA 90095, USA

Approximately 10–20% of all Kuiper belt objects (KBOs) occupy mean-motion resonances with Neptune. This dynamical configuration likely resulted from resonance capture as Neptune migrated outward during the late stages of planet formation. The details of Neptune's planetesimal-driven migration, including its radial extent and the concurrent eccentricity evolution of the planet, are the subject of considerable debate. Two qualitatively different proposals for resonance capture have been proposed—migration-induced capture driven by smooth outward evolution of Neptune's orbit and chaotic capture driven by damping of the planet's eccentricity near its current semi-major axis. We demonstrate that the distribution of comparable-mass, wide-separation binaries occupying resonant orbits can differentiate between these two scenarios. If migration-induced capture occurred, this fraction records information about the formation locations of different populations of KBOs. Chaotic capture, in contrast, randomizes the orbits of bodies as they are placed in resonance. In particular, if KBO binaries formed by dynamical capture in a protoplanetary disk with a surface mass density typical of observed extrasolar disks, then migration-induced capture produces the following signatures. The 2:1 resonance should contain a dynamically cold component, with inclinations less than 5–10°, having a binary fraction comparable to that among cold classical KBOs. If the 3:2 resonance also hosts a cold component, its binary fraction should be 20–30% lower than in the cold classical belt. Among cold 2:1 (and if present 3:2) KBOs, objects with eccentricities $e < 0.2$ should have a binary fraction $\sim$20% larger than those with $e > 0.2$. Other binary formation scenarios and disk surface density profiles can generate analogous signatures but produce quantitatively different results. Searches for cold components in the binary fractions of resonant KBOs are currently practical. The additional migration-generated trends described here may be distinguished with objects discovered by LSST.

To appear in: The Astrophysical Journal

For preprints, contact `rmurray-clay@cfa.harvard.edu`

or on the web at `http://arxiv.org/abs/1102.1430`

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Measuring the Sizes, Shapes, Surface Features and Rotations of Solar System Objects with Interferometry

Jian-Yang Li[1], Marc J. Kuchner[2], Ronald J. Allen[3], and Scott S. Sheppard[4]

[1] Department of Astronomy, University of Maryland, College Park MD, 20742, USA

[2] Goddard Space Flight Center, Greenbelt, MD, USA

[3] Space Telescope Science Institute, Baltimore, MD, USA

[4] Carnegie Institute of Washington, Department of Terrestrial Magnetism, Washington, DC, USA

We consider the application of interferometry to measuring the sizes and shapes of small bodies in the solar system that cannot be spatially resolved by today's single-dish telescopes. Assuming ellipsoidal shapes, we provide a formalism to derive the shape parameters from visibility measurements along three different baseline orientations. Our results indicate that interferometers can measure the size of an object to better than 15% uncertainty if the limb-darkening is unknown. Assuming a Minnaert scattering model, one can theoretically derive the limb-darkening parameters from simultaneous measurements of visibilities at several different projected baseline lengths to improve the size and shape determination to an accuracy of a few percent. The best size measurement can be reached when one axis of the object's projected disk is aligned with one baseline orientation, and the measurement of cross-sectional area is independent of

baseline orientation. We construct a 3-D shape model for the dwarf planet Haumea and use it to synthesize interferometric data sets. Using the Haumea model, we demonstrate that when photometric light curve, visibility light curve, and visibility phase center displacement are combined, the rotational period and sense of rotation can all be derived, and the rotational pole can be estimated. Because of its elongated shape and the dark red spot, the rotation of Haumea causes its optical photocenter to move in a loop on the sky. Our simulations show that this loop has an extend of about 80 μas without the dark red spot, and about 200 μas with it. Such movements are easily detectable by space-based astrometric interferometer designed e.g. for planet detection. As an example, we consider the possible contributions to the study of small bodies in the solar system by the Space Interferometry Mission. We show that such a mission could make substantial contributions in characterizing the fundamental physical properties of the brightest Kuiper Belt Objects and Centaurs as well as a large number of main belt asteroids. We compile a list of Kuiper Belt Objects and Centaurs that are potentially scientifically interesting and observable by such missions.

Published in: Icarus 211, 1007 (2011 February)
For preprints, contact jyli@astro.umd.edu

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A Photometric System for Detection of Water and Methane Ices on Kuiper Belt Objects

C. Trujillo[1], S. Sheppard[2], and E. Schaller[3]

[1] Gemini Observatory, Northern Operations Center, 670 N. A'ohoku Place, Hilo, Hawaii 96720, USA

[2] Carnegie Institution of Washington, 5241 Broad Branch Rd. NW, Washington, DC 20015, USA

[3] Lunar and Planetary Laboratory, University of Arizona, USA

We present a new near-infrared photometric system for detection of water ice and methane ice in the solar system. The system consists of two medium-band filters in the K-band region of the near-infrared, which are sensitive to water ice and methane ice, plus continuum observations in the J-band and Y-band. The primary purpose of this system is to distinguish between three basic types of Kuiper Belt Objects (KBOs) — those rich in water ice, those rich in methane ice, and those with little absorbance. In this work, we present proof-of-concept observations of 51 KBOs using our filter system, 21 of which have never been observed in the near-IR spectroscopically. We show that our custom photometric system is consistent with previous spectroscopic observations while reducing telescope observing time by a factor of ~ 3. We use our filters to identify Haumea collisional family members, which are thought to be collisional remnants of a much larger body and are characterized by large fractions of water ice on their surfaces. We add 2009 YE_7 to the Haumea collisional family based on our water ice band observations ($J - H_2O = -1.03 \pm 0.27$) which indicate a high amount of water ice absorption, our calculated proper orbital elements, and the neutral optical colors we measured, $V - R = 0.38 \pm 0.04$, which are all consistent with the rest of the Haumea family. We identify several objects dynamically similar to Haumea as being distinct from the Haumea family as they do not have water ice on their surfaces. In addition, we find that only the largest KBOs have methane ice, and we find that Haumea itself has significantly less water ice absorption than the smaller Haumea family members. We find no evidence for other families in the Kuiper Belt.

To appear in: Astrophysical Journal, vol. 730 (2011 March 20)
For preprints, contact trujillo@gemini.edu
or on the web at http://arxiv.org/abs/1102.1971

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Remote Sensing D/H Ratios in Methane Ice: Temperature-Dependent Absorption Coefficients of CH_3D in Methane Ice and in Nitrogen Ice

W.M. Grundy[1], S.J. Morrison[2], M.J. Bovyn[3], S.C. Tegler[3], and D.M. Cornelison[4]

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

[2] Cornell University, Dept. of Astronomy, Ithaca NY 14853, USA; 2010 summer REU student at Northern Arizona University

[3] Northern Arizona University, Dept. of Physics and Astronomy, Box 6010 Flagstaff AZ 86011, USA

[4] Missouri State University, Dept. of Physics, Astronomy, and Materials Science, 901 S. National Ave., Springfield MO 65897, USA; formerly at Northern Arizona University Dept. of Physics and Astronomy

The existence of strong absorption bands of singly deuterated methane (CH_3D) at wavelengths where normal methane (CH_4) absorbs comparatively weakly could enable remote measurement of D/H ratios in methane ice on outer solar system bodies. We performed laboratory transmission spectroscopy experiments, recording spectra at wavelengths from 1 to 6 μm to study CH_3D bands at 2.47, 2.87, and 4.56 μm, wavelengths where ordinary methane absorption is weak. We report temperature-dependent absorption coefficients of these bands when the CH_3D is diluted in CH_4 ice and also when it is dissolved in N_2 ice, and describe how these absorption coefficients can be combined with data from the literature to simulate arbitrary D/H ratio absorption coefficients for CH_4 ice and for CH_4 in N_2 ice. We anticipate these results motivating new telescopic observations to measure D/H ratios in CH_4 ice on Triton, Pluto, Eris, and Makemake.

To appear in: Icarus

Preprint available on the web at `http://www.lowell.edu/~grundy/abstracts/2011.CH3D.html`

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Photometry of Triton 1992-2004: Surface Volatile Transport and Discovery of a Remarkable Opposition Surge

B. Buratti[1], J. Bauer[1], M. Hicks[1], J. Hillier[2], A. Verbiscer[3], H. Hammel[4], B. Schmidt[1], B. Cobb[1], B. Herbert[1], M. Garsky[1], J. Ward[1], and J. Foust[1]

[1] Jet Propulsion Laboratory, California Inst. of Technology, 4800 Oak Grove Dr. 183-501, Pasadena, CA 91109, USA

[2] Grays Harbor College, 1620 Edward P Smith Drive, Aberdeen, WA 98520-7599, USA

[3] University of Virginia, Department of Astronomy, P.O. Box 400325, Charlottesville, VA 22904, USA

[4] Space Sciences Institute, 4750 Walnut St. Suite 205, Boulder, CO 80301, USA

Triton, the large satellite of Neptune, was imaged by the Voyager 2 spacecraft in 1989 with dark plumes originating in its volatile-rich south polar region. Southern summer solstice, a time when seasonal volatile transport should be at a maximum, occurred in 2001. Ground-based observations of Triton's rotational light curve obtained from Table Mountain Observatory in 2000-2004 reveal volatile transport on its surface. When compared with a static frost model constructed from Voyager images, the light curve shows an increase in total amplitude. An earlier light curve obtained in 1992 from Mauna Kea Observatory is consistent with the static frost model. This movement of volatiles on the surface agrees with recent imaging results from the Hubble Space Telescope (Bauer et al. 2010). The changes in the light curve can be explained by the transport of nitrogen frost on the surface or by the uncovering of bedrock of less volatile methane. We also find that Triton exhibits a large opposition surge at solar phase angles less than 0.1°. This surge cannot be entirely explained by the effects of coherent backscatter.

To appear in: Icarus

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Millisecond Dips in the 2007-V09 RXTE/PCA Light Curve of Sco X-1 and One Possible Occultation Event

Hsiang-Kuang Chang[1,2], Chih-Yuan Liu[2], and Kuan-Ting Chen[2]

[1] Institute of Astronomy, National Tsing Hua University, Hsinchu, Taiwan

[2] Department of Physics, National Tsing Hua University, Hsinchu, Taiwan

Serendipitous stellar occultation search is so far the only way to detect the existence of very small, very dim, remote objects in the Solar system. To date, however, there are only very few reported detections for trans-Neptunian objects (TNOs) in optical bands. In the X-ray band, with the RXTE/PCA data of Sco X-1 taken from 2007 June to 2009 October, we found one possible X-ray occultation event. We discuss the veracity and properties of this event, and suggest upper limits to the size distribution of TNOs at hectometre size and of main-belt asteroids at decametre size.

Published in: Monthly Notices of the Royal Astronomical Society, 411, 427 (2011 Feb.)
Preprints available on the web at `http://arxiv.org/abs/1009.2547`

OTHER PAPERS OF INTEREST

Mid-IR, Far-IR, Raman Micro-spectroscopy, and FESEM-EDX study of IDP L2021C5: Clues to its Origin

R. Brunetto[1,2], J. Borg[1], E. Dartois[1], F.J.M. Rietmeijer[3], F. Grossemy[1], C. Sandt[4], L. Le Sergeant d'Hendecourt[1], A. Rotundi [2], P. Dumas[4], Z. Djouadi[1], and F. Jamme[4]

[1] Institut d'Astrophysique Spatiale, CNRS, UMR-8617, Université Paris-Sud, bâtiment 121, F-91405 Orsay Cedex, France

[2] Dip. Scienze Applicate, Università degli Studi di Napoli "Parthenope", Centro Direzionale, I-80143 Napoli, Italy

[3] Dept. of Earth and Planetary Sciences, MSC 03-2040, 1-University of New Mexico, Albuquerque, NM 87131-0001, USA

[4] Synchrotron SOLEIL, L'Orme des Merisiers, Saint-Aubin - BP 48, F-91192 Gif-sur-Yvette Cedex, France

Interplanetary Dust Particles (IDPs) are potentially of cometary origin. They may therefore provide important clues to a better understanding of the early Solar System physical and chemical conditions. A chondritic porous aggregate IDP (named L2021C5) was analyzed using mid to far FTIR (2-60 μm) micro-spectroscopy, Raman micro-spectroscopy, field-emission scanning electron microscopy (FESEM) and energy dispersive X-ray (EDX) analyses. The IDP was pressed between diamond windows to increase the quality of the spectral data by overcoming the diffraction limitation and minimizing light scattering effects from particles of a global size similar to the wavelength of the observation. This combination of techniques has enabled a mineralogical, organic and compositional description of the compressed particle. The IR spectra show that in L2021C5 amorphous silicates are more abundant than crystalline ones, and that the crystalline component is richer in olivine than in pyroxene. The composition and distribution of these inorganic components match very well the small silicate grains emission observed for comet Hale-Bopp from ISO-SWS spectra. Raman spectroscopy has allowed the detection of carbonaceous structures displaying different degrees of order, covering almost the whole range observed so far for IDPs. The combination of the three analytical techniques indicates that L2021C5 is a low-Ca, chondritic porous aggregate that experienced only mild flash heating on atmospheric entry, as indicated by the disordered carbon properties, the Fe/S atomic ratio of sulfides, the absence of Na depletion, and the small depletion of S. Based on a plausible cometary origin and on the estimated low entry velocity, we suggest that this IDP came from the Zodiacal cloud that is dominated by dust from Jupiter-Family comets.

To appear in: Icarus
For preprints, contact `rosario.brunetto@ias.u-psud.fr`

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 ... ??

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`ekonews@boulder.swri.edu`