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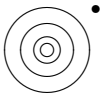
DISTANT EKOs



The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

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CONTENTS

NEWS & ANNOUNCEMENTS

There were 12 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2004 HA79, 2004 HB79, 2004 HX78, 2004 HY78, 2004 HZ78, 2004 KB19, 2004 KC19, 2004 MS8, 2004 VX130, 2004 VY130, 2004 VZ130, 2005 CD81

and 1 new Centaur/SDO discovery:

2011 FY9

Reclassified objects:

2009 MF10 (TNO → SDO)

Objects recently assigned names:

2004 SB60 = Salacia

Current number of TNOs: 1175 (including Pluto)
Current number of Centaurs/SDOs: 293
Current number of Neptune Trojans: 7

Out of a total of 1475 objects:

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

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

PAPERS ACCEPTED TO JOURNALS

Optical and Infrared Colors of Transneptunian Objects with HST

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We present optical colors of 72 transneptunian objects (TNOs), and infrared colors of 80 TNOs obtained with the WFPC2 and NICMOS instruments, respectively, on the Hubble Space Telescope (HST). Both optical and infrared colors are available for 32 objects that overlap between the datasets. This dataset adds an especially uniform, consistent and large contribution to the overall sample of colors, particularly in the infrared. The range of our measured colors is consistent with other colors reported in the literature at both optical and infrared wavelengths. We find generally good agreement for objects measured by both us and others; 88.1% have better than 2-sigma agreement. The median H_V magnitude of our optical sample is 7.2, modestly smaller ($\sim$0.5 mag) than for previous samples. The median absolute magnitude, H_V, in our infrared sample is 6.7. We find no new correlations between color and dynamical properties (semi-major axis, eccentricity, inclination and perihelion). We do find that colors of Classical objects with $i < 6^\circ$ come from a different distribution than either the Resonant or excited populations in the visible at the >99.99% level with a K-S test. The same conclusion is found in the infrared at a slightly lower significance level, 99.72%. Two Haumea collision fragments with strong near infrared ice bands are easily identified with broad HST infrared filters and point to an efficient search strategy for identifying more such objects. We find evidence for variability in (19255) 1999 VK_8, 1999 OE_4, 2000 CE_{105}, 1998 KG_{62} and 1998 WX_{31}.

To appear in: Icarus

For preprints, contact susank@psi.edu or sbenecchi@dtm.ciw.edu

or on the web at http://arxiv.org/abs/1103.2175

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Physical Studies of Centaurs and Trans-Neptunian Objects with the Atacama Large Millimeter Array

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Once completed, the Atacama Large Millimeter Array (ALMA) will be the most powerful (sub)-millimeter interferometer in terms of sensitivity, spatial resolution and imaging. This paper presents the capabilities of ALMA applied to the observation of Centaurs and Trans-Neptunian Objects, and their possible output in terms of physical properties. Realistic simulations were performed to explore the performances of the different frequency bands and array configurations, and several projects are detailed along with their feasibility, their limitations and their possible targets. Determination of diameters and albedos via the radiometric method appears to be possible on $\sim$500 objects, while sampling of the thermal lightcurve to derive the bodies' ellipticity could be performed at least 30 bodies that display

a significant optical lightcurve. On a limited number of objects, the spatial resolution allows for direct measurement of the size or even surface mapping with a resolution down to 13 milliarcsec. Finally, ALMA could separate members of multiple systems with a separation power comparable to that of the HST. The overall performance of ALMA will make it an invaluable instrument to explore the outer Solar System, complementary to space-based telescopes and spacecrafts.

To appear in: Icarus
Preprints available on the web at `http://arxiv.org/abs/1102.3872`

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First Results from the MIT Optical Rapid Imaging System (MORIS): A Stellar Occultation by Pluto and a Transit by Exoplanet XO-2b

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We present a high-speed, visible-wavelength imaging instrument: MORIS (the MIT Optical Rapid Imaging System). MORIS is mounted on the 3 m Infrared Telescope Facility (IRTF) on Mauna Kea, Hawaii. Its primary component is an Andor iXon camera, a nearly 60" square field of view with high quantum efficiency, low read noise, low dark current, and full-frame readout rates ranging from as slow as desired to a maximum of between 3.5 Hz and 35 Hz (depending on the mode; read noise of 6 e-/pixel and 49 e-/pixel with electron-multiplying gain = 1, respectively). User-selectable binning and subframing can increase the cadence to a few hundred hertz. An electron-multiplying mode can be employed for photon counting, effectively reducing the read noise to subelectron levels at the expense of dynamic range. Data cubes, or individual frames, can be triggered to several-nanosecond accuracy using the Global Positioning System. MORIS is mounted on the side-facing exit window of SpeX, allowing simultaneous near-infrared and visible observations. Here, we describe the components, setup, and measured characteristics of MORIS. We also report results from the first science observations: the 2008 June 24 stellar occultation by Pluto and an extrasolar planetary transit by XO-2b. The Pluto occultation of a 15.8 R magnitude star has a signal-to-noise ratio of 35 per atmospheric scale height and a midtime error of 0.32 s. The XO-2b transit reaches photometric precision of 0.5 mmag in 2 minutes and has a midtime timing precision of 23 s.

Published in: Publications of the Astronomical Society of the Pacific (2011 April)
For preprints, contact `amanda@saao.ac.za`
or on the web at `http://arxiv.org/abs/1102.5248`

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Five New and Three Improved Mutual Orbits of Transneptunian Binaries

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We present three improved and five new mutual orbits of transneptunian binary systems (58534) Logos-Zoe, (66652) Borasisi-Pabu, (88611) Teharonhiawako-Sawiskera, (123509) 2000 WK_{183}, (149780) Altjira, 2001 QY_{297}, 2003 QW_{111}, and 2003 QY_{90} based on Hubble Space Telescope and Keck II laser guide star adaptive optics observations. Combining the five new orbit solutions with 17 previously known orbits yields a sample of 22 mutual orbits for which the period P, semimajor axis a, and eccentricity e have been determined. These orbits have mutual periods ranging from 5 to over 800 days, semimajor axes ranging from 1,600 to 37,000 km, eccentricities ranging from 0 to 0.8, and system masses ranging from 2×10^{17} to 2×10^{22} kg. Based on the relative brightnesses of primaries and secondaries, most of these systems consist of near equal-sized pairs, although a few of the most massive systems are more lopsided. The observed distribution of orbital properties suggests that the most loosely-bound transneptunian binary systems are only found on dynamically cold heliocentric orbits. Of the 22 known binary mutual orbits, orientation ambiguities are now resolved for 9, of which 7 are prograde and 2 are retrograde, consistent with a random distribution of orbital orientations, but not with models predicting a strong preference for retrograde orbits. To the extent that other perturbations are not dominant, the binary systems undergo Kozai oscillations of their eccentricities and inclinations with periods of the order of tens of thousands to millions of years, some with strikingly high amplitudes.

To appear in: Icarus

Preprints available at: `http://www.lowell.edu/~grundy/abstracts/2011.5+3-orbits.html`

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High-contrast Observations of (136108) Haumea. A Crystalline Water-ice Multiple System.

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The trans-neptunian region of the Solar System is populated by a large variety of icy bodies showing great diversity in orbital behavior, size, surface color and composition. One can also note the presence of dynamical families and binary systems. One surprising feature detected in the spectra of some of the largest Trans-Neptunians is the presence of crystalline water-ice. This is the case for the large TNO (136 108) Haumea ($2003\,EL_{61}$).

We seek to constrain the state of the water ice of Haumea and its satellites, and investigate possible energy sources to maintain the water ice in its crystalline form.

Spectro-imaging observations in the near infrared have been performed with the integral field spectrograph SINFONI mounted on UT4 at the ESO Very Large Telescope. The spectra of both Haumea and its larger satellite Hi'iaka are analyzed. Relative astrometry of the components is also performed, providing a check of the orbital solutions and equinox seasons.

We describe the physical characteristics of the crystalline water-ice present on the surface of Haumea and its largest satellite Hi'iaka and analyze possible sources of heating to maintain water in crystalline state: tidal dissipation in the system components *vs.* radiogenic source. The surface of Hi'iaka appears to be covered by large grains of water ice, almost entirely in its crystalline form. Under some restricted conditions, both radiogenic heating and tidal forces between Haumea and Hi'iaka could provide the energy sufficient to maintain the ice in its crystalline state.

Published in: Astronomy & Astrophysics, 528, 105 (2011 April)
For preprints, contact cdumas@eso.org *or online at* http://arxiv.org/abs/1101.2102

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Observed Binary Fraction Sets Limits on the Extent of Collisional Grinding in the Kuiper Belt

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The size distribution in the cold classical Kuiper belt can be approximated by two idealized power laws: one with steep slope for radii $R > R^*$ and one with shallow slope for $R < R^*$, where R^* ∼25-50 km. Previous works suggested that the SFD roll-over at R^* can be the result of extensive collisional grinding in the Kuiper belt that led to the catastrophic disruption of most bodies with $R < R^*$. Here we use a new code to test the effect of collisions in the Kuiper belt. We find that the observed roll-over could indeed be explained by collisional grinding provided that the initial mass in large bodies was much larger than the one in the present Kuiper belt, and was dynamically depleted. In addition to the size distribution changes, our code also tracks the effects of collisions on binary systems. We find that it is generally easier to dissolve wide binary systems, such as the ones existing in the cold Kuiper belt today, than to catastrophically disrupt objects with $R \sim R^*$. Thus, the binary survival sets important limits on the extent of collisional grinding in the Kuiper belt. We find that the extensive collisional grinding required to produce the SFD roll-over at R^* would imply a strong gradient of the binary fraction with R and separation, because it is generally easier to dissolve binaries with small components and/or those with wide orbits. The expected binary fraction for $R \leq R^*$ is ≤0.1. The present observational data do not show such a gradient. Instead, they suggest a large binary fraction of ∼0.4 for R = 30-40 km. This may indicate that the roll-over was *not* produced by disruptive collisions, but is instead a fossil remnant of the KBO formation process.

Published in: The Astronomical Journal, 141, 159 (2011 May)
Preprints available on the web at http://arxiv.org/abs/1102.5706

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Discovery of Carbon Monoxide in the Upper Atmosphere of Pluto

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Pluto's icy surface has changed colour and its atmosphere has swelled since its last closest approach to the Sun in 1989. The thin atmosphere is produced by evaporating ices, and so can also change rapidly, and in particular carbon monoxide should be present as an active thermostat. Here we report the discovery of gaseous CO via the 1.3mm wavelength J=2-1 rotational transition, and find that the line-centre signal is more than twice as bright as a tentative result obtained by Bocké-Morvan et al. in 2000. Greater surface-ice evaporation over the last decade could explain this, or increased pressure could have caused the atmosphere to expand. The gas must be cold, with a narrow line-width consistent with temperatures around 50 K, as predicted for the very high atmosphere, and the line brightness implies that CO molecules extend up to ≈ 3 Pluto radii above the surface. The upper atmosphere must have changed markedly over only a decade since the prior search, and more alterations could occur by the arrival of the New Horizons mission in 2015.

To appear in: MNRAS

Preprints available on the web at `http://arxiv.org/abs/1104.3014`

OTHER PAPERS OF INTEREST

Binary Planetesimals and Their Role in Planet Formation

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One of the main evolutionary stages of planet formation is the dynamical evolution of planetesimal disks. These disks are thought to evolve through gravitational encounters and physical collisions between single planetesimals. In recent years, many binary planetesimals (BPs) have been observed in the solar system, indicating that the binarity of planetesimals is high. However, current studies of planetesimal disk formation and evolution do not account for the role of binaries. Here, we point out that gravitational encounters of BPs can have an important role in the evolution of planetesimal disks. BPs catalyze close encounters between planetesimals and can strongly enhance their collision rate. Binaries may also serve as an additional heating source of the planetesimal disk, through the exchange of the binaries gravitational potential energy into the kinetic energy of planetesimals in the disk.

Published in: The Astrophysical Journal, 727, L3 (2011 January 20)
Preprints available at `http://arxiv.org/abs/1012.0567`

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The Orbits of Neptune's Outer Satellites

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In 2009 we used the Subaru telescope to observe all the faint irregular satellites of Neptune for the first time since 2004. These observations extend the data arcs for Halimede, Psamathe, Sao, Laomedeia and Neso from a few years to nearly a decade. We also report on a search for unknown Neptune satellites in a half square degree of sky and a limiting magnitude of 26.2 in the R-band. No new satellites of Neptune were found.

We numerically integrated the orbits for the five irregulars and we summarize the results of the orbital fits in terms of the state vectors, post–fit residuals, and mean orbital elements. Sao and Neso are confirmed to be Kozai librators, while Psamathe is a "reverse circulator". Halimede and Laomedeia do not seem to experience any strong resonant effects.

Published in: The Astronomical Journal, 141, 135 (2011 April)
For preprints, contact `marina.brozovic@jpl.nasa.gov`
or on the web at `http://iopscience.iop.org/1538-3881/141/4/135`

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.

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Moving ... ??

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