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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

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CONTENTS

NEWS & ANNOUNCEMENTS

There was 1 new TNO discovery announced since the previous issue of *Distant EKOs*:

2011 HE103

and 11 new Centaur/SDO discoveries:

2011 JA32, 2013 AS105, 2013 AZ60, 2013 BK76, 2013 BL78, 2013 BN45, 2013 CA134, 2013 CE88, 2013 CJ118, 2013 CV82, 2013 CY133

Reclassified objects:
2000 WW12 (TNO → SDO)

Objects recently assigned numbers:
2009 YD7 = (353222)

Objects recently assigned names:
2009 HW77 = Orius

Current number of TNOs: 1258 (including Pluto)
Current number of Centaurs/SDOs: 371
Current number of Neptune Trojans: 9

Out of a total of 1638 objects:
649 have measurements from only one opposition
630 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

2011 HM_{102}: Discovery of a High-Inclination L5 Neptune Trojan in the Search for a post-Pluto *New Horizons* Target

Alex H. Parker[1], Marc W. Buie[2], David J. Osip[3], Stephen D.J. Gwyn[4], Matthew J. Holman[1], David M. Borncamp[2], John R. Spencer[2], Susan D. Benecchi[5], Richard P. Binzel[6], Francesca E. DeMeo[6], Sébastian Fabbro[4], Cesar I. Fuentes[7], Pamela L. Gay[8], JJ Kavelaars[4], Brian A. McLeod[1], Jean-Marc Petit[9], Scott S. Sheppard[5], S. Alan Stern[2], David J. Tholen[10], David E. Trilling[7], Darin A. Ragozzine[11,1], Lawrence H. Wasserman[12], and the Ice Hunters

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We present the discovery of a long-term stable L5 (trailing) Neptune Trojan in data acquired to search for candidate Trans-Neptunian objects for the New Horizons spacecraft to fly by during an extended post-Pluto mission. This Neptune Trojan, 2011 HM_{102}, has the highest inclination (29.4°) of any known member of this population. It is intrinsically brighter than any single L5 Jupiter Trojan at $H_V \sim 8.18$. We have determined its *gri* colors (a first for any L5 Neptune Trojan), which we find to be similar to the moderately red colors of the L4 Neptune Trojans, suggesting similar surface properties for members of both Trojan clouds. We also present colors derived from archival data for two L4 Neptune Trojans (2006 RJ_{103} and 2007 VL_{305}), better refining the overall color distribution of the population. In this document we describe the discovery circumstances, our physical characterization of 2011 HM_{102}, and this object's implications for the Neptune Trojan population overall. Finally, we discuss the prospects for detecting 2011 HM_{102} from the New Horizons spacecraft during their close approach in mid- to late-2013.

Published in: The Astronomical Journal, 145, 96 (2013 April)
For preprints, contact aparker@cfa.harvard.edu
or on the web at http://arxiv.org/abs/1210.4549

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Crantor, a Short-lived Horseshoe Companion to Uranus

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Context. Stable co-orbital motion with Uranus is vulnerable to planetary migration, but temporary co-orbitals may exist today. So far, only two candidates have been suggested, both moving on horseshoe orbits: 83982 Crantor (2002 GO_9) and 2000 SN_{331}.

Aims. (83982) Crantor is currently classified in the group of the Centaurs by the MPC although the value of its orbital period is close to that of Uranus. Here we revisit the topic of the possible 1:1 commensurability of (83982) Crantor with Uranus, explore its dynamical past, and look into its medium-term stability and future orbital evolution.

Methods. Our analysis is based on the results of N-body calculations that use the most updated ephemerides and include perturbations by the eight major planets, the Moon, the barycenter of the Pluto-Charon system, and the three largest asteroids.

Results. (83982) Crantor currently moves inside Uranus' co-orbital region on a complex horseshoe orbit. The motion of this object is primarily driven by the influence of the Sun and Uranus, although Saturn plays a significant role in destabilizing its orbit. The precession of the nodes of (83982) Crantor, which is accelerated by Saturn, controls its evolution and short-term stability. Although this object follows a temporary horseshoe orbit, more stable trajectories are possible and we present 2010 EU_{65} as a long-term horseshoe librator candidate in urgent need of follow-up observations. Available data indicate that the candidate 2000 SN_{331} is not a Uranus co-orbital.

Conclusions. Our calculations confirm that (83982) Crantor is currently trapped in the 1:1 commensurability with Uranus but it is unlikely to be a primordial 1:1 librator. Although this object follows a chaotic, short-lived horseshoe orbit, longer term horseshoe stability appears to be possible. We also confirm that high-order resonances with Saturn play a major role in destabilizing the orbits of Uranus co-orbitals.

Published in: Astronomy and Astrophysics, 551, A114 (2013 March)
For preprints, contact `nbplanet@fis.ucm.es`
or on the web at `http://arxiv.org/abs/1301.0770`

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Stable Regions around Pluto

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In a previous work, Giuliatti Winter et al. found several stable regions for test particles in orbit around Pluto associated with families of periodic orbits obtained in the circular, restricted three-body problem. They have shown that a possible eccentricity of the Pluto-Charon binary slightly reduces but does not destroy any of these stable regions. In this work, we extended their results by analysing the cases with the orbital inclination (i) equal to zero and considering the argument of pericentre (ω) equal to 90°, 180° and 270°. We explore the influence of the orbital inclination of the particles in these stable regions. In this case, the initial inclination varies from 10° to 170° in steps of 10°. We also present a sample of results for the longitude of the ascending node $\Omega = 90°$, considering the cases $i = 20°$, 50°, 130° and 180°. Our results show that stable regions are present in all of the inclined cases, except when the initial inclination of the particles is equal to 110°. A sample of 3D trajectories of quasi-periodic orbits were found related to the periodic orbits obtained in the planar case by Giuliatti Winter et al.

To appear in: Monthly Notices of the Royal Astronomical Society
For preprints, contact `giuliattiwinter@pq.cnpq.br`

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Trans-Neptunian Objects as Natural Probes to the Unknown Solar System

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Trans-Neptunian objects (TNOs) are icy/rocky bodies that move beyond the orbit of Neptune in a region known as the trans-Neptunian belt (or Edgeworth-Kuiper belt). TNOs are believed to be the remnants of a collisionally, dynamically and chemically evolved protoplanetary disk composed of billions of planetesimals, the building blocks from which the planets formed during the early solar system. Consequently, the study of the physical and dynamical properties of TNOs can reveal important clues about the properties of that disk, planet formation, and other evolutionary processes that likely occurred over the last 4.5 Gyr.

In contrast to the predictions of accretion models that feature protoplanetary disk planetesimals evolving on dynamically cold orbits (with both very small eccentricities, e, and inclinations, i), in reality TNOs exhibit surprisingly wide ranges of orbital eccentricities and inclinations, from nearly circular to very eccentric orbits (putting some objects at aphelia beyond 1000 AU!) and ranging up to $\sim$50 deg of inclination with respect to the fundamental plane of the solar system.

We can group TNOs into several distinct dynamical classes: (1) Resonant: TNOs currently locked in external Neptunian mean motion resonances; (2) Classical: non-resonant TNOs concentrated with semimajor axes in the range $37 < a < 45$–50 AU on relatively stable orbits (which typically feature only minor orbital changes over time); (3) Scattered: TNOs on orbits that suffer(ed) notable gravitational perturbations by Neptune, yielding macroscopic orbital changes over time; (4) Detached: TNOs typically possessing perihelia, $q > 40$‘AU, $a > 45$–50 AU and orbits stable over the age of the solar system.

Several theoretical models have addressed the origin and orbital evolution of the main dynamical classes of TNOs, but none have successfully reproduced them all. In addition, none have explained several objects on peculiar orbits, or provided insightful predictions, without which a model cannot be tested properly against observations. Based on extensive simulations of planetesimal disks with the presence of the four giant planets and huge numbers of modeled planetesimals (reaching up to a million test particles or several thousand massive objects), I explore in detail the dynamics of the TNOs, in particular their (un)stable regions over timescales comparable to the age of the solar system, and the role of resonances across the entire trans-Neptunian region. I also propose that, along with the orbital history of the giant planets, the orbital evolution of primordial embryos (massive planetesimals comparable to Mars-Earth masses) can explain the fine orbital structure of the trans-Neptunian belt, the orbits of Jovian and Neptunian Trojans (objects moving about the L4/L5 Lagrange points of Jupiter and Neptune, respectively), and possibly the current orbits of the giant planets. Those primordial embryos were ultimately scattered by the giant planets, a process that stirred both the orbits of the giant planets and the primordial planetesimal disk to the levels observed at 40–50 AU. In particular, the main constraints provided by the trans-Neptunian belt are optimally satisfied if at least one such primordial embryo (planetoid) survived in the outskirts of the solar system. Therefore, a model with a hypothesized resident planetoid yields results that fit the identified main dynamical classes of TNOs, including those objects on unusual orbits within each class.

To appear in: Monographs on Environment, Earth and Planets

For preprints, contact `patryksan@gmail.com`

or on the web at `http://arxiv.org/abs/1212.6124`

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A Possible Divot in the Size Distribution of the Kuiper Belt's Scattering Objects

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Via joint analysis of a calibrated telescopic survey, which found scattering Kuiper Belt objects, and models of their expected orbital distribution, we explore the scattering-object (SO) size distribution. Although for $D > 100$ km the number of objects quickly rise as diameters decrease, we find a relative lack of smaller objects, ruling out a single power law at greater than 99% confidence. After studying traditional "knees" in the size distribution, we explore other formulations and find that, surprisingly, our analysis is consistent with a very sudden decrease (a divot) in the number distribution as diameters decrease below 100 km, which then rises again as a power law. Motivated by other dynamically hot populations and the Centaurs, we argue for a divot size distribution where the number of smaller objects rises again as expected via collisional equilibrium. Extrapolation yields enough kilometer-scale SOs to supply the nearby Jupiter-family comets. Our interpretation is that this divot feature is a preserved relic of the size distribution made by planetesimal formation, now "frozen in" to portions of the Kuiper Belt sharing a "hot" orbital inclination distribution, explaining several puzzles in Kuiper Belt science. Additionally, we show that to match today's SO inclination distribution, the supply source that was scattered outward must have already been vertically heated to the of order 10 degrees.

Published in: Astrophysical Journal Letters, 764, 2 (2013 February 10)

Preprints available on the web at `http://arxiv.org/abs/1210.4827`

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Lightcurves of 32 Large Transneptunian Objects

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We present observations of 32 primarily bright, newly discovered Transneptunian objects (TNOs) observable from the Southern Hemisphere during 39 nights of observation with the Irene du Pont 2.5-m telescope at Las Campañas Observatory. Our dataset includes objects in all dynamical classes, but is weighted towards Scattered objects. We find 15 objects for which we can fit periods and amplitudes to the data, and place lightcurve amplitude upper limits on the other 17 objects. Combining our sample with the larger lightcurve sample in the literature, we find a 3-sigma correlation between lightcurve amplitude and absolute magnitude with fainter objects having larger lightcurve amplitudes. We looked for correlations between lightcurve and individual orbital properties, but did not find any statistically significant results. However, if we consider lightcurve properties with respect to object dynamical classification, we find statistically different distributions between the Classical-Scattered and Classical-Resonant populations at the 95.60% and 94.64% level, respectively, with the Classical objects having larger amplitude lightcurves. The significance is 97.05% if the Scattered and Resonant populations are combined. The properties of binary lightcurves are largely consistent with the greater TNO population except in the case of tidally locked systems. All the Haumea family objects measured so far have lightcurve amplitudes $\leq$0.3 magnitudes and rotation periods $\leq$10 hours suggesting that they are not significantly different from the larger TNO population, although no large amplitudes have yet been measured among this group of objects. We expect multiple factors are influencing object rotations: object size dominates lightcurve properties except in the case of tidal, or proportionally large collisional interactions with other TNOs, the influence of the latter being different for each TNO sub-population. We also present phase curves and colors for some of our objects; our values are not significantly different from those presented in the literature for other samples.

To appear in: The Astronomical Journal
For preprints, contact sbenecchi@dtm.ciw.edu or susank@psi.edu
or on the web at http://arxiv.org/abs/1301.5791

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A 3D General Circulation Model for Pluto and Triton with Fixed Volatile Abundance and Simplified Surface Forcing

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We present a 3D general circulation model of Pluto and Triton's atmospheres, which uses radiative-conductive-convective forcing. In both the Pluto and Triton models, an easterly (prograde) jet is present at the equator with a maximum magnitude of 10–12 m s^{-1} and 4 m s^{-1}, respectively. Neither atmosphere shows any significant overturning circulation in the meridional and vertical directions. Rather, it is horizontal motions (mean circulation and transient waves) that transport heat meridionally at a magnitude of 1 and 3 $\times 10^7$ W at Pluto's autumn equinox and winter solstice, respectively (seasons referenced to the Northern Hemisphere). The meridional and dayside-nightside temperature contrast is small ($\leq$5 K). We find that the lack of vertical motion can be explained on Pluto by the strong temperature inversion in the lower atmosphere. The height of the Voyager 2 plumes on Triton can be explained by the dynamical properties of the lower atmosphere alone (i.e., strong wind shear) and does not require a thermally defined troposphere (i.e., temperature decreasing with height at the surface underlying a region of temperature increasing with height). The model results are compared with Pluto stellar occultation light curve data from 1988, 2002, 2006, and 2007 and Triton light curve data from 1997.

To appear in: Icarus
For preprints, contact azalucha@seti.org
or on the web at http://arxiv.org/abs/1211.0009

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Near-Infrared Spectral Monitoring of Pluto's Ices: Spatial Distribution and Secular Evolution

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We report results from monitoring Pluto's 0.8 to 2.4 μm reflectance spectrum with IRTF/SpeX on 65 nights over the dozen years from 2001 to 2012. The spectra show vibrational absorption features of simple molecules CH_4, CO, and N_2 condensed as ices on Pluto's surface. These absorptions are modulated by the planet's 6.39 day rotation period, enabling us to constrain the longitudinal distributions of the three ices. Absorptions of CO and N_2 are concentrated on Pluto's anti-Charon hemisphere, unlike absorptions of less volatile CH_4 ice that are offset by roughly 90° from the longitude of maximum CO and N_2 absorption. In addition to the diurnal variations, the spectra show longer term trends. On decadal timescales, Pluto's stronger CH_4 absorption bands have been getting deeper, while the amplitude of their diurnal variation is diminishing, consistent with additional CH_4 absorption at high northern latitudes rotating into view as the sub-Earth latitude moves north (as defined by the system's angular momentum vector). Unlike the CH_4 absorptions, Pluto's CO and N_2 absorptions appear to be declining over time, suggesting more equatorial or southerly distributions of those species. Comparisons of geometrically-matched pairs of observations favor geometric explanations for the observed secular changes in CO and N_2 absorption, although seasonal volatile transport could be at least partly responsible. The case for a volatile transport contribution to the secular evolution looks strongest for CH_4 ice, despite it being the least volatile of the three ices.

To appear in: Icarus

Preprints available at `http://www.lowell.edu/users/grundy/abstracts/2013.Pluto.html`

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A Model for the Common Origin of Jupiter Family and Halley Type Comets

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A numerical simulation of the Oort cloud is used to explain the observed orbital distributions and numbers of Jupiter-family and Halley-type short-period comets. Comets are given initial orbits with perihelion distances between 5 and 36 AU, and evolve under planetary, stellar and Galactic perturbations for 4.5 Gyr. This process leads to the formation of an Oort cloud (which we define as the region of semimajor axes $a > 1000$ AU), and to a flux of cometary bodies from the Oort cloud returning to the planetary region at the present epoch. The results are consistent with the dynamical characteristics of short-period comets and other observed cometary populations: the near-parabolic flux, Centaurs, and high-eccentricity trans-Neptunian objects. To achieve this consistency with observations, the model requires that the number of comets versus initial perihelion distance is concentrated towards the outer planetary region. Moreover, the mean physical lifetime of observable comets in the inner planetary region ($q < 2.5$ AU) at the present epoch should be an increasing function of the comets' initial perihelion distances. Virtually all observed Halley-type comets and

nearly half of observed Jupiter-family comets come from the Oort cloud, and initially (4.5 Gyr ago) from orbits concentrated near the outer planetary region. Comets that have been in the Oort cloud also return to the Centaur ($5<q<28$ AU, $a<1000$ AU) and near-Neptune high-eccentricity regions. Such objects with perihelia near Neptune are hard to discover, but Centaurs with characteristics predicted by the model (e.g. large semimajor axes, above 60 AU, or high inclinations, above 40°) are increasingly being found by observers. The model provides a unified picture for the origin of Jupiter-family and Halley-type comets. It predicts that the mean physical lifetime of all comets in the region $q<1.5$ AU is less than $\sim$200 revolutions.

Published in: Earth, Moon, and Planets, 110, 105 (2013 February)
Preprints on the web at `http://star.arm.ac.uk/preprints/2013`

OTHER PAPERS OF INTEREST

Perspectives on Effectively Constraining the Location of a Massive Trans-Plutonian Object with the New Horizons Spacecraft: A Sensitivity Analysis

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Preprints on the web at `http://arxiv.org/abs/1301.3831`

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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`ekonews@boulder.swri.edu`