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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

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NEWS & ANNOUNCEMENTS

LSST Solar System Science Collaboration

Over its 10 year lifespan, the Large Synoptic Sky Survey Telescope (LSST) will catalog over 5 million Main Belt asteroids, almost 300,000 Jupiter Trojans, over 100,000 NEOs, and over 40,000 KBOs. Many of these objects will receive 100s of observations in multiple bandpasses. The LSST Solar System Science Collaboration (SSSC) is preparing methods and tools to analyze this data, as well as understand optimum survey strategies for discovering moving objects throughout the Solar System.

The SSSC launched a new website. Check it out at `http://www.lsstsssc.org` , and please consider joining the collaboration if you're an eligible researcher. If you have any questions, please contact the SSSC Co-Chairs, Meg Schwamb (`mschwamb.astro@gmail.com`) and David Trilling (`David.Trilling@nau.edu`).

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There were no new TNO discoveries announced since the previous issue of *Distant EKOs*, but there were 10 new Centaur/SDO discoveries:

2013 RQ98, 2013 RR98, 2013 UT15, 2014 UN225, 2015 GT50, 2015 KG163, 2015 KH163, 2015 RX245, 2015 RY245, 2017 NM2

Reclassified objects:

2011 JA32 (SDO → TNO)

Objects recently assigned numbers:

2012 VS113 = (495190)
2013 TJ159 = (495297)
2015 AM281 = (495603)
2012 VR113 = (495189)
2015 FG345 = (495613)
2013 GP136 = (496315)

Current number of TNOs: 1816 (including Pluto)
Current number of Centaurs/SDOs: 715
Current number of Neptune Trojans: 17

Out of a total of 2548 objects:

706 have measurements from only one opposition
699 of those have had no measurements for more than a year
344 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

OSSOS VI. Striking Biases in the Detection of Large Semimajor Axis Trans-Neptunian Objects

Cory Shankman[1], J.J. Kavelaars[1,2], Michele T. Bannister[3], Brett J. Gladman[4], Samantha M. Lawler[2], Ying-Tung Chen[5], Marian Jakubik[6], Nathan Kaib[7], Mike Alexandersen[5], and Stephen D.J. Gwyn[2]

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The accumulating but small set of large semimajor axis trans-Neptunian objects (TNOs) shows an apparent clustering in the orientations of their orbits. This clustering must either be representative of the intrinsic distribution of these TNOs, or else have arisen as a result of observation biases and/or statistically expected variations for such a small set of detected objects. The clustered TNOs were detected across different and independent surveys, which has led to claims that the detections are therefore free of observational bias. This apparent clustering has led to the so-called "Planet 9" hypothesis that a super-Earth currently resides in the distant solar system and causes this clustering. The Outer Solar System Origins Survey (OSSOS) is a large program that ran on the Canada-France-Hawaii Telescope from 2013 to 2017, discovering more than 800 new TNOs. One of the primary design goals of OSSOS was the careful determination of observational biases that would manifest within the detected sample. We demonstrate the striking and non-intuitive biases that exist for the detection of TNOs with large semimajor axes. The eight large semimajor axis OSSOS detections are an independent data set, of comparable size to the conglomerate samples used in previous studies. We conclude that the orbital distribution of the OSSOS sample is consistent with being detected from a uniform underlying angular distribution.

Published in: The Astronomical Journal, 154, 50 (2017 August)
Preprints available on the web at `https://arxiv.org/abs/1706.05348`
and `https://doi.org/10.3847/1538-3881/aa7aed`

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Observational Bias and the Clustering of Distant Eccentric Kuiper Belt Objects

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The hypothesis that a massive Planet Nine exists in the outer solar system on a distant eccentric orbit was inspired by observations showing that the objects with the most distant eccentric orbits in the Kuiper Belt have orbits that are physically aligned, that is, they are clustered in longitude of perihelion and have similar orbital planes. Questions have remained, however, about the effects of observational bias on these observations, particularly on the longitudes of perihelion. Specifically, distant eccentric Kuiper Belt objects (KBOs) tend to be faint and only observable near their perihelia, suggesting that the longitudes of perihelion of the known distant objects could be strongly biased by the limited number of locations in the sky where deep surveys have been carried out. We have developed a method to rigorously estimate the bias in longitude of perihelion for Kuiper Belt observations. We find that the probability that the 10 known KBOs with semimajor axis beyond 230 au are drawn from a population with uniform longitude of perihelion is 1.2%. Combined with the observation that the orbital poles of these objects are also clustered, the overall probability of detecting these two independent clusterings in a randomly distributed sample is 0.025%. While observational bias is clearly present in these observations, it is unlikely to explain the observed alignment of the distant eccentric KBOs.

Published in: The Astronomical Journal, 154, 65 (2017 August)
Preprints available on the web at `https://arxiv.org/abs/1706.04175`
and `https://doi.org/10.3847/1538-3881/aa79f4`

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Evidence for a Possible Bimodal Distribution of the Nodal Distances of the Extreme Trans-Neptunian Objects: Avoiding a Trans-Plutonian Planet or just Plain Bias?

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It is a well-known fact that the presence of a massive perturber interacting with a population of minor bodies following very eccentric orbits can strongly affect the distribution of their nodal distances. The details of this process have been explored numerically and its outcome confirmed observationally in the case of Jupiter, where a bimodal distribution of nodal distances of comets has been found. Here, we show evidence for a possible bimodal distribution of the nodal distances of the extreme trans-Neptunian objects (ETNOs) in the form of a previously unnoticed correlation between nodal distance and orbital inclination. This proposed correlation is unlikely to be the result of observational bias as data for both large semimajor axis Centaurs and comets fit well into the pattern found for the ETNOs, and all these populations are subjected to similar background perturbations when moving well away from the influence of the giant planets. The correlation found is better understood if these objects tend to avoid a putative planet with semimajor axis in the range 300–400 au.

Published in: Monthly Notices of the Royal Astronomical Society, 471, L61
For preprints, contact `nbplanet@ucm.es`
or on the web at `https://arxiv.org/abs/1706.06981`
and `https://doi.org/10.1093/mnrasl/slx106`

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Non-resonant Secular Dynamics of Trans-Neptunian Objects Perturbed by a Distant Super-Earth

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We use a secular model to describe the non-resonant dynamics of trans-Neptunian objects in the presence of an external ten-earth-mass perturber. The secular dynamics is analogous to an "eccentric Kozai mechanism" but with both an inner component (the four giant planets) and an outer one (the eccentric distant perturber). By the means of Poincaré sections, the cases of a non-inclined or inclined outer planet are successively studied, making the connection with previous works. In the inclined case, the problem is reduced to two degrees of freedom by assuming a non-precessing argument of perihelion for the perturbing body.

The size of the perturbation is typically ruled by the semi-major axis of the small body: we show that the classic integrable picture is still valid below about 70 AU, but it is progressively destroyed when we get closer to the external perturber. In particular, for $a > 150$ AU, large-amplitude orbital flips become possible, and for $a > 200$ AU, the Kozai libration islands at $\omega = \pi/2$ and $3\pi/2$ are totally submerged by the chaotic sea. Numerous resonance relations are highlighted. The most large and persistent ones are associated to apsidal alignments or anti-alignments with the orbit of the distant perturber.

To appear in: Celestial Mechanics and Dynamical Astronomy

For preprints, contact `melaine.saillenfest@obspm.fr`

or on the web at `https://arxiv.org/abs/1707.01379`

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First Transneptunian Object in Polar Resonance with Neptune

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Capture in mean motion resonance has been observed in the Solar System for small objects with prograde as well as retrograde orbits of moderate inclinations. However, no example of an object with a nearly polar orbit was known to be in resonance with a planet. In this Letter, we report that the nearly-polar transneptunian object (471325), nicknamed Niku, is in a 7:9 resonance with Neptune, with a mean lifetime in resonance of 16 ± 11 million years. While entrance and exit in the 7:9 resonance is caused by close encounters with Neptune the resonant configuration provides a temporary protection mechanism against disruptive close encounters with this planet. The other nearly polar transneptunian objects do not seem to be in resonance with the planets with the possible exception of 2008 KV42, also known as Drac, that has a small chance of being in the 8:13 resonance with Neptune.

To appear in: Monthly Notices of the Royal Astronomical Society

Preprints available on the web at `https://arxiv.org/abs/1708.00346`

and `https://doi.org/10.1093/mnrasl/slx125`

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The Disturbing Function for Polar Centaurs and Transneptunian Objects

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The classical disturbing function of the three-body problem is based on an expansion of the gravitational interaction in the vicinity of nearly coplanar orbits. Consequently, it is not suitable for the identification and study of resonances of the Centaurs and transneptunian objects on nearly polar orbits with the Solar system planets. Here, we provide a series expansion algorithm of the gravitational interaction in the vicinity of polar orbits and produce explicitly the disturbing function to fourth order in eccentricity and inclination cosine. The properties of the polar series differ significantly from those of the classical disturbing function: the polar series can model any resonance, as the expansion order is not related to the resonance order. The powers of eccentricity and inclination of the force amplitude of a p:q resonance do not depend on the value of the resonance order $|p-q|$ but only on its parity. Thus, all even resonance order eccentricity amplitudes are $\propto e^2$ and odd ones $\propto e$ to lowest order in eccentricity e. With the new findings on the structure of the polar disturbing function and the possible resonant critical arguments, we illustrate the dynamics of the polar resonances 1:3, 3:1, 2:9 and 7:9 where transneptunian object 471325 could currently be locked.

Published in: Monthly Notices of the Royal Astronomical Society, 471, 2097
Preprints available on the web at `https://arxiv.org/abs/1707.02431`
and `https://doi.org/10.1093/mnras/stx1714`

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Study of the Plutino Object (208996) 2003 AZ_{84} from Stellar Occultations: Size, Shape, and Topographic Features

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We present results derived from four stellar occultations by the plutino object (208996) 2003 AZ_{84}, detected on 2011 January 8 (single-chord event), 2012 February 3 (multi-chord), 2013 December 2 (single-chord), and 2014 November 15 (multi-chord). Our observations rule out an oblate spheroid solution for 2003 AZ_{84}'s shape. Instead, assuming hydrostatic equilibrium, we find that a Jacobi triaxial solution with semiaxes $(470 \pm 20) \times (383 \pm 10) \times (245 \pm 8)$ km can better account for all our occultation observations. Combining these dimensions with the rotation period of the body (6.75 hr) and the amplitude of its rotation light curve, we derive a density $\rho = 0.87 \pm 0.01$ g cm-3, a geometric albedo $p_V = 0.097 \pm 0.009$. A grazing chord observed during the 2014 occultation reveals a topographic feature along 2003 AZ_{84}'s limb, which can be interpreted as an abrupt chasm of width $\sim$23 km and

depth >8 km, or a smooth depression of width ∼80 km and depth ∼13 km (or an intermediate feature between those two extremes).

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For preprints, contact bruno.sicardy@obspm.fr
or on the web at https://arxiv.org/abs/1705.10895
and http://iopscience.iop.org/article/10.3847/1538-3881/aa74e9

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2004 TT_{357}: A Potential Contact Binary in the Trans-Neptunian Belt

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We report photometric observations of the trans-Neptunian object 2004 TT_{357} obtained in 2015 and 2017 using the 4.3 m Lowell's Discovery Channel Telescope. We derive a rotational period of 7.79±0.01 h and a peak-to-peak lightcurve amplitude of 0.76±0.03 mag. 2004 TT_{357} displays a large variability that can be explained by a very elongated single object or can be due to a contact/close binary. The most likely scenario is that 2004 TT_{357} is a contact binary. If it is in hydrostatic equilibrium, we find that the lightcurve can be explained by a system with a mass ratio q_{min} = 0.45±0.05, and a density of ρ_{min} = 2 g cm^{-3}, or less likely a system with q_{max} = 0.8±0.05, and ρ_{max}=5 g cm^{-3}. Considering a single triaxial ellipsoid in hydrostatic equilibrium, we derive a lower limit to the density of 0.78 g cm^{-3}, and an elongation (a/b) of 2.01 assuming an equatorial view. From *Hubble Space Telescope* data, we report no resolved companion orbiting 2004 TT_{357}. Despite an expected high fraction of contact binaries in the trans-Neptunian belt, 2001 QG_{298} is the unique confirmed contact binary in the trans-Neptunian belt, and 2004 TT_{357} is only the second candidate to this class of systems, with 2003 SQ_{317}.

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For preprints, contact thirouin@lowell.edu
or on the web at https://arxiv.org/abs/1707.09927
and http://iopscience.iop.org/article/10.3847/1538-4357/aa7ed3

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Col-OSSOS: z Band Photometry Reveals Three Distinct TNO Surface Types

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Several different classes of trans-Neptunian objects (TNOs) have been identified based on their optical and near-infrared colors. As part of the Colours of the Outer Solar System Origins Survey, we have obtained g, r, and z band photometry of 26 TNOs using Subaru and Gemini Observatories. Previous color surveys have not utilized z band reflectance, and the inclusion of this band reveals significant surface reflectance variations between sub-populations. The colors of TNOs in $g-r$ and $r-z$ show obvious structure, and appear consistent with the previously measured bi-modality in $g-r$. The distribution of colors of the two dynamically excited surface types can be modeled using the two-component mixing models from Fraser & Brown (2012). With the combination of $g-r$ and $r-z$, the dynamically excited classes can be separated cleanly into red and neutral surface classes. In $g-r$ and $r-z$, the two dynamically excited surface groups are also clearly distinct from the cold classical TNO surfaces, which are red, with $g-r \gtrsim 0.85$ and $r-z \lesssim 0.6$, while all dynamically excited objects with similar $g-r$ colors exhibit redder $r-z$ colors. The z band photometry makes it possible for the first time to differentiate the red excited TNO surfaces from the red cold classical TNO surfaces. The discovery of different $r-z$ colors for these cold classical TNOs makes it possible to search for cold classical surfaces in other regions of the Kuiper belt and to completely separate cold classical TNOs from the dynamically excited population, which overlaps in orbital parameter space.

To appear in: The Astronomical Journal
Preprints available on the web at `http://arxiv.org/abs/1708.03079`

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Properties of the Irregular Satellite System around Uranus Inferred from K2, Herschel and Spitzer Observations

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In this paper we present visible range light curves of the irregular Uranian satellites Sycorax, Caliban, Prospero, Ferdinand and Setebos taken with Kepler Space Telescope in the course of the K2 mission. Thermal emission measurements obtained with the Herschel/PACS and Spitzer/MIPS instruments of Sycorax and Caliban were also analysed and used to determine size, albedo and surface characteristics of these bodies. We compare these properties with the rotational and surface characteristics of irregular satellites in other giant planet systems and also with those of main belt and

Trojan asteroids and trans-Neptunian objects. Our results indicate that the Uranian irregular satellite system likely went through a more intense collisional evolution than the irregular satellites of Jupiter and Saturn. Surface characteristics of Uranian irregular satellites seems to resemble the Centaurs and trans-Neptunian objects more than irregular satellites around other giant planets, suggesting the existence of a compositional discontinuity in the young Solar system inside the orbit of Uranus.

To appear in: The Astronomical Journal
Preprints available on the web at `https://arxiv.org/abs/1706.06837`

CONFERENCE INFORMATION

Pluto After New Horizons

July 15-19, 2019
JHU-APL, Laurel, Maryland, USA

Dear Colleagues,

We are planning an international science conference on the Pluto system and the Kuiper Belt to be held July 15-19, 2019 at the Johns Hopkins University Applied Physics Laboratory in Laurel, MD, USA.

Please mark your calendars accordingly!

This conference will provide an opportunity to summarize our understanding of the Pluto system and the Kuiper belt following the *New Horizons* encounters with the Pluto system and 2014 MU_{69}. Contributions spanning all relevant research on the Kuiper belt, including both observations and theory, will be solicited.

The conference will also serve as a nucleus for a forthcoming volume *Pluto After New Horizons* in the University of Arizona Space Science Series. With a projected 2020 publication date, this new book will be the successor to *Pluto-Charon* published in 1997.

A registration website with further details will be set up next summer, approximately one year prior to the conference.

Again, please put this conference on your calendar and join us at the Kossiakoff Center at APL in mid-July 2019!

With best regards,
Hal Weaver (JHU-APL), Alan Stern (SwRI), Rick Binzel (MIT), on behalf of the SOC

For further information, contact `hal.weaver@jhuapl.edu`

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 papers submitted, in press, or recently published in refereed journals
⋆ Titles of conference presentations
⋆ 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 ... ??

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`