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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

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CONTENTS

NEWS & ANNOUNCEMENTS

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

2013 TH159

and 1 new Centaur/SDO discovery:

2015 PJ311

Current number of TNOs: 1373 (including Pluto)
Current number of Centaurs/SDOs: 457
Current number of Neptune Trojans: 12

Out of a total of 1842 objects:
660 have measurements from only one opposition
635 of those have had no measurements for more than a year
327 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

Physical Properties of the Extreme Centaur and Super-comet Candidate 2013 AZ_{60}

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We present estimates of the basic physical properties – including size and albedo – of the extreme Centaur 2013 AZ_{60}. These properties have been derived from optical and thermal infrared measurements. Our optical measurements revealed a likely full period of ≈ 9.4 h with a shallow amplitude of 4.5%. By combining optical brightness information and thermal emission data, we are able to derive a diameter of 62.3 ± 5.3 km and a geometric albedo of 2.9% – corresponding to an extremely dark surface. Additionally, our finding of $\gtrsim 50\ \mathrm{J\,m^{-2}\,K^{-1}\,s^{-1/2}}$ for the thermal inertia is also noticeably for objects in such a distance. The results of dynamical simulations yield an unstable orbit, with a 50% probability that the target will be ejected from the Solar System within 700,000 years. The current orbit of this object as well as its instability could imply a pristine cometary surface. This possibility is in agreement with the observed low geometric albedo and red photometric colour indices for the object, which are a good match for the surface of a dormant comet – as would be expected for a long-period cometary body approaching perihelion. Despite the fact it was approaching ever closer to the Sun, however, the object exhibited star-like profiles in each of our observations, lacking any sign of cometary activity. By the albedo, 2013 AZ_{60} is a candidate for the darkest body among the known TNOs.

To appear in: Astronomy & Astrophysics
For preprints, contact `apal@szofi.net`
or on the web at `http://arxiv.org/abs/1507.05468` and `http://www.aanda.org/`

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The Composition of "Ultra-red" TNOs and Centaurs

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We present an analysis of the colors available for seven trans-neptunian objects (TNOs) and three Centaurs among the reddest known, aimed at characterizing their surface chemical properties. In particular we seek to obtain evidence in support of the proposed correlation between the visible coloration of the surface of TNOs and their surface compositions (Brown et al. 2011).

The analysis focuses on nine available colors in the visible-near IR (0.3-4.5 μm) spectral range scaled to the V albedo to provide a proxy for the spectral shape of the objects. The colors include Spitzer IRAC data never published before, key in providing an effective constraint in the discrimination of ices contributing to the surface composition of the objects.

Compositions are obtained by comparing the data to a grid of radiative transfer models convolved by the filter response functions of the colors adopted in the spectrum-proxies to match the resolution of the observations. We find evidence suggesting the presence of hydrocarbons and/or methanol on the surfaces of most objects in our sample, supporting the hypothesis by Brown et al. (2011) that the coloration of red TNOs could be linked to their methanol content.

From our finding of methanol/hydrocarbon ices on the surfaces of the objects in our sample of very red TNOs and Centaurs we infer that ultra-red objects in general might contain these ices and therefore might have formed in the outer part of the Solar System. We also deduce that the surfaces of most of the very red TNOs in our dataset are probably still quite pristine, and that their organic materials could have been produced by irradiation of the volatile ices whose traces are still present on their surface. Although our sample is small, we infer that the irradiation process is still in progress, as hinted by the Centaurs' slightly elevated organic amounts at smaller perihelion distances. However, considering the relatively similar amounts of organics found in our data at a wide variety of perihelion distances, we also infer that it could have started before Neptune's migration.

The technique used to constrain the composition described as part of this study introduces a new approach at investigating the surface chemistry of the very small and numerous objects that constitute the bulk of the TNO and Centaur populations. This innovative method has the potential to provide constraints for irradiation theories and for models of dynamical and chemical evolution of the Solar System.

Published in: Icarus, 252, 311 (2015 May)

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Asteroid 2015 DB_{216}: A Recurring Co-orbital Companion to Uranus

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Minor bodies trapped in 1:1 co-orbital resonances with a host planet could be relevant to explain the origin of captured satellites. Among the giant planets, Uranus has one of the smallest known populations of co-orbitals, three objects, and all of them are short-lived. Asteroid 2015 DB_{216} has an orbital period that matches well that of Uranus, and here we investigate its dynamical state. Direct N-body calculations are used to assess the current status of this object, reconstruct its immediate dynamical past, and explore its future orbital evolution. A covariance matrix-based Monte Carlo scheme is presented and applied to study its short-term stability. We find that 2015 DB_{216} is trapped in a temporary co-orbital resonance with Uranus, the fourth known minor body to do so. A detailed analysis of its dynamical evolution shows that it is an unstable but recurring co-orbital companion to Uranus. It currently follows an asymmetric horseshoe trajectory that will last for at least 10 kyr, but it may remain inside Uranus' co-orbital zone for millions of years. As in the case of other transient Uranian co-orbitals, complex multibody ephemeral mean motion resonances trigger the switching between the various resonant co-orbital states. The new Uranian co-orbital exhibits a secular behaviour markedly different from that of the other known Uranian co-orbitals because of its higher inclination, nearly 38°. Given its rather unusual discovery circumstances, the presence of 2015 DB_{216} hints at the existence of a relatively large population of objects moving in similar orbits.

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For preprints, contact carlosdlfmarcos@gmail.com
or on the web at http://arxiv.org/abs/1507.07449

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The Observation of Large Semi-major Axis Centaurs: Testing for the Signature of a Planetary-mass Solar Companion

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Several objects whose perihelion lies between Jupiter and Neptune have large semi-major axes $a > 100$ au, two of them having semi-major axis above 1000 au. Since these objects' perihelia share the same region as the classical Centaurs, a coherent nomenclature for them could be large semi-major axis Centaurs (Laces). It has been argued that the classical Centaurs, with semi-major axes below 50 au, originate from the Scattered Disk. However, the Laces most likely originate from the Oort Cloud. We determine the brightest object in the Laces, classical Centaurs (with semi-major axis >20 au) and Scattered Disk populations using a procedure that introduces observational bias to a set of objects in orbits obtained from numerical simulations of the evolution of the Oort cloud and Scattered Disk in the framework of the Nice model. The application of the procedure consistently determines that the brightest distant Lace (semi-major axis above 500 au) is fainter than the brightest classical Centaur by about one magnitude, no matter what parameters were used for the procedure. However, reality shows a reversed situation: there is an excess of Laces with lower visual magnitudes. It is not clear why this is the case. We test whether a planetary-mass solar companion could produce an excess of bright Laces in comparison with classical Centaurs. We find that with the companion there is an excess of luminous Laces compared to when there is no companion. However, the companion model also produces many classical Centaurs with lower visual magnitudes than the observed ones. Thus we conclude that the companion does not solve this visual magnitude inconsistency, although the results are in general more coherent under the model with the companion than without.

Published in: Icarus, 258, 37
For preprints, contact rodney@on.br

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On the Escape of CH_4 from Pluto's Atmosphere

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We adapted a multi-species escape model, developed for close-in extrasolar planets, to calculate the escape rates of CH_4 and N_2 from Pluto. In the absence of escape, CH_4 should overtake N_2 as the dominant species below the exobase. The CH_4 profile depends strongly on the escape rate, however, and the typical escape rates predicted for Pluto lead to a nearly constant mixing ratio of less than 1% below the exobase. In this case the CH_4 escape rate is only 5–10% of the N_2 escape rate. Observations of the CH_4 profile by the New Horizons/ALICE spectrograph can constrain the CH_4 escape rate and provide a unique test for escape models.

To appear in: Geophysical Research Letters
For preprints, contact `tommi@lpl.arizona.edu`
on the web at `http://arxiv.org/abs/1508.02672`

PAPERS RECENTLY SUBMITTED TO JOURNALS

Observation of Two New L4 Neptune Trojans in the Dark Energy Survey Supernova Fields

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We report the discovery of the eighth and ninth known Trojans in stable orbits around Neptune's leading Lagrange point, L4. The objects 2014 QO_{441} and 2014 QP_{441} were detected in data obtained during the 2013-14 and 2014-15 observing seasons by the Dark Energy Survey, using the Dark Energy Camera (DECam) on the 4-meter Blanco telescope at Cerro Tololo Inter-American Observatory. Both are in high-inclination orbits (18.8° and 19.4° respectively). With an eccentricity of 0.104, 2014 QO_{441} has the most eccentric orbit of the eleven known stable Neptune Trojans. Here we describe the search procedure and investigate the objects' long-term dynamical stability and physical properties.

Submitted to: The Astronomical Journal
For preprints, contact `gerdes@umich.edu`
or on the web at `http://arxiv.org/abs/1507.05177`

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A Deep Search for Additional Satellites around the Dwarf Planet Haumea

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Haumea is a dwarf planet with two known satellites, an unusually high spin rate, and a large collisional family, making it one of the most interesting objects in the outer solar system. A fully self-consistent formation scenario responsible for the satellite and family formation is still elusive, but some processes predict the initial formation of many small moons, similar to the small moons recently discovered around Pluto. Deep searches for regular satellites around KBOs are difficult due to observational limitations, but Haumea is one of the few for which sufficient data exist. We analyze Hubble Space Telescope (HST) observations, focusing on a ten-consecutive-orbit sequence obtained in July 2010, to search for new very small satellites. To maximize the search depth, we develop, implement, and validate a non-linear shift-and-stack method. No additional satellites of Haumea are found, but by implanting and recovering artificial sources, we characterize our sensitivity. At distances between $\sim$10,000 km and $\sim$150,000 km from Haumea, satellites with radii as small as $\sim$10 km are ruled out, assuming an albedo ($p \simeq 0.7$) similar to Haumea. This search method rules out objects similar in size to the small moons of Pluto. By developing clear criteria for determining the number of non-linear rates to use, we find that far fewer shift rates are required ($\sim$35) than might be expected, suggesting that this method is more tractable than commonly assumed, particularly as applied to satellite searches.

Submitted to: The Astronomical Journal

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OTHER PAPERS OF INTEREST

Realistic Detectability of Close Interstellar Comets

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During the planet formation process, billions of comets are created and ejected into interstellar space. The detection and characterization of such interstellar comets (also known as extra-solar planetesimals or extra-solar comets) would give us *in situ* information about the efficiency and properties of planet formation throughout the galaxy. However, no interstellar comets have ever been detected, despite the fact that their hyperbolic orbits would make them readily identifiable as unrelated to the solar system. Moro-Martín et al. 2009 have made a detailed and reasonable estimate of the properties of the interstellar comet population. We extend their estimates of detectability with a numerical model that allows us to consider "close" interstellar comets, e.g., those that come within the orbit of Jupiter. We include several constraints on a "detectable" object that allow for realistic estimates of the frequency of detections expected from the Large Synoptic Survey Telescope (LSST) and other surveys. The influence of several of the assumed model parameters on the frequency of detections is explored in detail. Based on the expectation from Moro-Martín et al. 2009, we expect that LSST will detect 0.01-100 interstellar comets during its lifetime, with most of the uncertainty from the unknown number density of small ($\sim$0.1-1 km) interstellar comets. Both asteroid and comet cases are considered, where the latter includes various empirical prescriptions of brightening. Using simulated LSST-like astrometric data, we study the problem of orbit determination for these bodies, finding that LSST could identify their orbits as hyperbolic and determine an ephemeris sufficiently accurate for follow-up in about 4–7 days. We give the hyperbolic orbital parameters of the most detectable interstellar comets. Taking the results into consideration, we give recommendations to future searches for interstellar comets.

Submitted to The Astrophysical Journal
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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`

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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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`ekonews@boulder.swri.edu`