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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 5 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2013 RP98, 2014 QE442, 2014 SQ350, 2015 PL312, 2015 RS245

and 3 new Centaur/SDO discoveries:

2013 SV99, 2013 SY99, 2014 SR350

Reclassified objects:

2014 FA72 (TNO → SDO)
2015 UK84 (SDO → TNO)

Objects recently assigned numbers:

2014 MU69 = (486958) – this is the target of the next New Horizons flyby on Jan 1, 2019
2015 BE519 = (487581)

Current number of TNOs: 1803 (including Pluto)
Current number of Centaurs/SDOs: 695
Current number of Neptune Trojans: 17

Out of a total of 2515 objects:

706 have measurements from only one opposition
704 of those have had no measurements for more than a year
343 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: V. Diffusion in the Orbit of a High-perihelion Distant Solar System Object

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We report the discovery of the minor planet 2013 SY_{99}, on an exceptionally distant, highly eccentric orbit. With a perihelion of 50.0 au, 2013 SY_{99}'s orbit has a semi-major axis of 730 ± 40 au, the largest known for a high-perihelion trans-Neptunian object (TNO), well beyond those of (90377) Sedna and 2012 VP_{113}. Yet, with an aphelion of 1420 ± 90 au, 2013 SY_{99}'s orbit is interior to the region influenced by Galactic tides. Such TNOs are not thought to be produced in the current known planetary architecture of the Solar System, and they have informed the recent debate on the existence of a distant giant planet. Photometry from the Canada-France-Hawaii Telescope, Gemini North and Subaru indicate 2013 SY_{99} is $\sim$ 250 km in diameter and moderately red in colour, similar to other dynamically excited TNOs. Our dynamical simulations show that Neptune's weak influence during 2013 SY_{99}'s perihelia encounters drives diffusion in its semi-major axis of hundreds of astronomical units over 4 Gyr. The overall symmetry of random walks in semi-major axis allow diffusion to populate 2013 SY_{99}'s orbital parameter space from the 1000–2000 au inner fringe of the Oort cloud. Diffusion affects other known TNOs on orbits with perihelia of 45 to 49 au and semi-major axes beyond 250 au, providing a formation mechanism that implies an extended population, gently cycling into and returning from the inner fringe of the Oort cloud.

To appear in: The Astronomical Journal
on the web at `https://arxiv.org/abs/1704.01952`

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Discovery and Physical Characterization of a Large Scattered Disk Object at 92 AU

D. Gerdes[1,2], M. Sako[3], S. Hamilton[1], K. Zhang[2], T. Khain[1], J. Becker[2], J. Annis[4], W. Wester[4], G. Bernstein[3], C. Scheibner[1,5], L. Zullo[1], F. Adams[1,2], E. Bergin[2], A. Walker[6], J. Mueller[4,7], *et al.* (Dark Energy Survey Collaboration)

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We report the observation and physical characterization of the possible dwarf planet 2014 UZ_{224} ("DeeDee"), a dynamically detached trans-Neptunian object discovered at 92 AU. This object is currently the second-most distant known trans-Neptunian object with reported orbital elements, surpassed in distance only by the dwarf planet Eris. The object was discovered with an r-band magnitude of 23.0 in data collected by the Dark Energy Survey between 2014 and 2016. Its 1140-year orbit has $(a, e, i) = (109\ \mathrm{AU}, 0.65, 26.8^\circ)$. It will reach its perihelion distance of 38 AU in the year 2142. Integrations of its orbit show it to be dynamically stable on Gyr timescales, with only weak interactions with Neptune. We have performed followup observations with ALMA, using 3 hours of on-source integration time to measure the object's thermal emission in the Rayleigh-Jeans tail. The signal is detected at 7σ significance, from which we determine a V-band albedo of $13.1^{+3.3}_{-2.4}(\mathrm{stat})^{+2.0}_{-1.4}(\mathrm{sys})$ percent and a diameter of $635^{+57}_{-61}(\mathrm{stat})^{+32}_{-39}(\mathrm{sys})$ km, assuming a spherical body with uniform surface properties.

Published in: The Astrophysical Journal Letters, 839, L15 (2017 Apr 10)
For preprints, contact `gerdes@umich.edu`
or on the web at `https://arxiv.org/abs/1702.00731`

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Discovery of a Satellite of the Large Trans-Neptunian Object (225088) 2007 OR_{10}

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2007 OR_{10} is currently the third largest known dwarf planet ($D \approx 1535$ km) in the trans-Neptunian region. It has a slow rotation period of $\sim$45 h that was suspected to be caused by tidal interactions with a satellite undetected at that time. Here we report on the discovery of a likely moon of 2007 OR_{10}, identified on archival Hubble Space Telescope WFC3/UVIS system images. Although the satellite is detected at two epochs this does not allow an unambiguous determination of the orbit

and the orbital period. A feasible 1.5-5.8·10^{21} kg estimate for the system mass leads to a likely 35 to 100 d orbital period. The moon is about 4.2 mag fainter than 2007 OR_{10} in HST images that corresponds to a diameter of 237 km assuming equal albedos with the primary. Due to the relatively small size of the moon the previous size and albedo estimates for the primary remains unchanged. With this discovery all trans-Neptunian objects larger than 1000 km are now known to harbour satellites, an important constraint for moon formation theories in the young Solar system.

Published in: The Astrophysical Journal Letters, 2017, 838, L1 (2017 March 20)
For preprints, contact kiss.csaba@csfk.mta.hu
or on the web at https://arxiv.org/abs/1703.01407

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Towards an Explanation of Orbits in the Extreme Trans-Neptunian Region: The Effect of Milgromian Dynamics

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Milgromian dynamics (MD or MOND) uniquely predicts motion in a galaxy from the distribution of its stars and gas in a remarkable agreement with observations so far. In the solar system, MD predicts the existence of some possibly non-negligible dynamical effects, which can be used to constrain the freedom in MD theories. Known extreme trans-Neptunian objects (ETNOs) have their argument of perihelion, longitude of ascending node, and inclination distributed in highly non-uniform fashion; ETNOs are bodies with perihelion distances greater than the orbit of Neptune and with semimajor axes greater than 150 au and less than $\sim$ 1500 au. It is as if these bodies have been systematically perturbed by some external force. We investigated a hypothesis that the puzzling orbital characteristics of ETNOs are a consequence of MD. We set up a dynamical model of the solar system incorporating the external field effect (EFE), which is anticipated to be the dominant effect of MD in the ETNOs region. We used constraints available on the strength of EFE coming from radio tracking of the Cassini spacecraft. We performed several numerical experiments, concentrating on the long-term orbital evolution of primordial (randomised) ETNOs in MD. The EFE could produce distinct non-uniform distributions of the orbital elements of ETNOs that are related to the orientation of an orbit in space. If we demand that EFE is solely responsible for the detachment of Sedna and 2012 VP_{113}, then these distributions are at odds with the currently observed statistics on ETNOs unless the EFE quadrupole strength parameter Q_2 has values that are unlikely (with probability $< 1\%$) in light of the Cassini data.

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For preprints, contact pauco@fmph.uniba.sk
or on the web at https://arxiv.org/abs/1703.06682

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The Long-term Evolution of Known Resonant Trans-Neptunian Objects

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Aims. Numerous trans-Neptunian objects are known to be in mean-motion resonance with Neptune. We aim to describe their long-term orbital evolution (both past and future) by means of a one-degree-of-freedom secular model. In this paper, we focus only on objects with a semi-major axis larger than 50 astronomical units (au).

Methods. For each resonant object considered, a 500,000-year numerical integration is performed. The output is digitally filtered to get the parameters of the resonant secular model. Their long-term (Giga-year) orbital evolution is then represented by the level curves of the secular Hamiltonian.

Results. For the majority of objects considered, the mean-motion resonance has little impact on the long-term trajectories (the secular dynamics is similar to a non-resonant one). However, a subset of objects is strongly affected by the resonance, producing moderately-high-amplitude oscillations of the perihelion distance and/or libration of the argument of perihelion around a fixed centre. Moreover, the high perihelion distance of the object $2015\,\mathrm{FJ}_{345}$ is plainly explained by long-term resonant dynamics, allowing us to also deduce its orbital elements at the time of capture in resonance (at least 15 million years ago). The same type of past evolution is expected for $2014\,\mathrm{FZ}_{71}$.

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

or on the web at `https://arxiv.org/abs/1704.05881`

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Carbon Monoxide in the Distantly Active Centaur (60558) 174P/Echeclus at 6 au

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(60558) 174P/Echeclus is an unusual object that belongs to a class of minor planets called Centaurs, which may be intermediate between Kuiper Belt Objects and Jupiter Family comets. It is sporadically active throughout its orbit at distances too far for water ice to sublimate, the source of activity for most comets. Thus, its coma must be triggered by another mechanism. In 2005, Echeclus had a strong outburst with peculiar behavior that raised questions about the nucleus' homogeneity. In order to test nucleus models, we performed the most sensitive search to date for the highly volatile CO molecule via its J=2-1 emission toward Echeclus during 2016 May-June (at 6.1 astronomical units from the Sun) using the Arizona Radio Observatory 10-m Submillimeter Telescope. We obtained a 3.6-σ detection with a slightly blue-shifted (δv = -0.55 $\pm$ 0.10 km s^{-1}) and narrow ($\Delta \mathrm{v}_{FWHM}$ = 0.53 $\pm$ 0.23 km s^{-1}) line. The data are consistent with emission from a cold gas from the sunward side of the nucleus, as seen in two other comets at 6 au. We derive a production rate of $\mathrm{Q(CO)} = (7.7 \pm 3.3) \times 10^{26}$ mol s^{-1}, which is capable of driving the estimated dust production rates. Echeclus' CO outgassing rate is $\sim$ 40 times lower than what is typically seen for another Centaur at this distance, 29P/Schwassmann-Wachmann 1. We also used the IRAM 30-m telescope to search for the CO J=2-1 line, and derive an upper limit that is above the SMT detection. Compared to

the relatively unprocessed comet C/1995 O1 (Hale-Bopp), Echeclus produces significantly less CO, as do Chiron and four other Centaurs.

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For preprints, contact kacperwierzchos@gmail.com
or on the web at https://arxiv.org/abs/1703.07660

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CO and Other Volatiles in Distantly Active Comets

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The activity of most comets near the Sun is dominated by the sublimation of frozen water, the most abundant ice in comets. Some comets, however, are active well beyond the water-ice sublimation limit of ∼3 au. Three bodies dominate the observational record and modeling efforts for distantly active comets: the long-period comet C/1995 O1 (Hale-Bopp), and the short-period comets (with Centaur orbits) 29P/Schwassmann-Wachmann 1 and 2060 Chiron. We summarize what is known about these three objects with an emphasis on their gaseous comae. We calculate their CN/CO and CO_2/CO production rate ratios from the literature and discuss implications, such as HCN and CO_2 outgassing are not significant contributors to their comae. Using our own data we derive CO production rates, Q(CO), for all three objects to examine whether there is a correlation between gas production and different orbital histories and/or size. The CO measurements of Hale-Bopp (4-11 AU) and 29P are consistent with a nominal production rate of $Q(CO) = 3.5 \times 10^{29} r^2$ superimposed with sporadic outbursts. The similarity of Hale-Bopp CO production rates for pre- and post-perihelion suggests that thermal inertia was not very important and therefore most of the activity is at or near the surface of the comet. We further examine the applicability of existing models in explaining the systematic behavior of our small sample. We find that orbital history does not appear to play a significant role in explaining 29P's CO production rates. 29P outproduces Hale-Bopp at the same heliocentric distance, even though it has been subjected to much more solar heating. Previous modeling work on such objects predicts that 29P should have been devolatilized over a fresher comet like Hale-Bopp. This may point to 29P having a different orbital history than current models predict, with its current orbit acquired more recently. On the other hand, Chiron's CO measurements are consistent with it being significantly depleted over its original state, perhaps due to increased radiogenic heating made possible by its much larger size or its higher processing due to orbital history. Observed spectral line profiles for several volatiles are consistent with the development and sublimation of icy grains in the coma at about 5-6 au for 29P and Hale-Bopp, and this is probably a common feature in distantly active comets, and an important source of volatiles for all comets within 5 au. In contrast, the narrow CO line profiles indicate a nuclear, and not extended, origin for CO beyond ∼4 au.

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For preprints, contact mariawomack@gmail.com
or on the web at http://adsabs.harvard.edu/abs/2017PASP..129c1001W

PAPERS RECENTLY SUBMITTED TO JOURNALS

New Horizons Upper Limits on O_2 in Pluto's Present Day Atmosphere

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The surprising discovery by the Rosetta spacecraft of molecular oxygen (O_2) in the coma of comet 67P/Churyumov-Gerasimenko (Bieler et al. 2015) challenged our understanding of the inventory of this volatile species on and inside bodies from the Kuiper Belt. That discovery motivated our search for oxygen in the atmosphere of Kuiper Belt planet Pluto, because O_2 is volatile even at Pluto's surface temperatures. During the New Horizons flyby of Pluto in July 2015, the spacecraft probed the composition of Pluto's atmosphere using a variety of observations, including an ultraviolet solar occultation observed by the Alice UV spectrograph (Stern et al. 2015; Gladstone et al. 2016; Young et al. 2017). As described in these reports, absorption by molecular species in Pluto's atmosphere yielded detections of N_2, as well as hydrocarbon species such as CH_4, C_2H_2, C_2H_4, and C_2H_6. Our work here further examines this data to search for UV absorption from molecular oxygen (O_2), which has a significant cross section in the Alice spectrograph bandpass. We find no evidence for O_2 absorption, and place an upper limit on the total amount of O_2 in Pluto's atmosphere as a function of tangent height up to 700 km. In most of the atmosphere this upper limit in line of sight abundance units is $\sim 3 \times 10^{15}$ cm^{-2}, which depending on tangent height corresponds to a mixing ratio of 10^{-6} to 10^{-4}, far lower than in comet 67P.

Submitted to: The Astronomical Journal

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Evidence for Possible Clouds in Pluto's Present Day Atmosphere

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Several trace constituents of Pluto's present day atmosphere can reach saturation vapor pressure in Pluto's present day atmosphere. We describe a search for discrete cloud features in Pluto's atmosphere using New Horizons data obtained on 14-15 July 2015, during the Pluto flyby closest approach. We report that Pluto's present day atmosphere is at least largely (¿99% by surface area) free of discrete clouds. We also report a handful of features that may plausibly be clouds, all of which were detected near the terminator and at high phase angle observing geometry. No cloud candidates were identified elsewhere, such as at high altitudes, away from the terminators, or in low phase (backscattering geometry) images.

Submitted to: The Astronomical Journal

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:

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