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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

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CONTENTS

NEWS & ANNOUNCEMENTS

There were 71 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2013 EM149, 2013 GA138, 2013 GB138, 2013 GC137, 2013 GC138, 2013 GD137, 2013 GD138, 2013 GE137, 2013 GE138, 2013 GF137, 2013 GF138, 2013 GG137, 2013 GG138, 2013 GH137, 2013 GJ137, 2013 GK137, 2013 GL137, 2013 GM137, 2013 GN137, 2013 GO136, 2013 GO137, 2013 GP137, 2013 GQ136, 2013 GQ137, 2013 GR136, 2013 GR137, 2013 GS137, 2013 GT136, 2013 GT137, 2013 GU136, 2013 GU137, 2013 GV136, 2013 GV137, 2013 GW136, 2013 GW137, 2013 GX136, 2013 GX137, 2013 GY137, 2013 GZ137, 2013 HR156, 2013 HS156, 2013 HT156, 2013 JA65, 2013 JB65, 2013 JC65, 2013 JD65, 2013 JE64, 2013 JE65, 2013 JF65, 2013 JG64, 2013 JG65, 2013 JH65, 2013 JJ64, 2013 JJ65, 2013 JK65, 2013 JL65, 2013 JM64, 2013 JM65, 2013 JN65, 2013 JO65, 2013 JP65, 2013 JQ65, 2013 JR65, 2013 JS64, 2013 JS65, 2013 JT64, 2013 JT65, 2013 JU64, 2013 JY64, 2013 JZ64, 2014 VT37

and 19 new Centaur/SDO discoveries:

2013 GA137, 2013 GP136, 2013 GS136, 2013 GY136, 2013 GZ136, 2013 JC64, 2013 JD64, 2013 JF64, 2013 JH64, 2013 JK64, 2013 JL64, 2013 JN64, 2013 JO64, 2013 JP64, 2013 JQ64, 2013 JR64, 2013 JV64, 2014 QR441, 2015 PN291

Reclassified objects:
- 2002 GG166 (TNO → SDO)
- 2011 UR412 (SDO → TNO)
- 2013 GA137 (SDO → TNO)

Objects recently assigned numbers:
- 1999 ON4 = (439858)
- 2010 VZ98 = (445473)
- 2001 FO185 = (443843)
- 2004 EU95 = (444018)
- 2004 HJ79 = (444025)
- 2004 NT33 = (444030)
- 2007 JF43 = (444745)

Deleted/Re-identified objects:
- 2015 KB157 = 2013 LU28

Current number of TNOs: 1445 (including Pluto)
Current number of Centaurs/SDOs: 474
Current number of Neptune Trojans: 12

Out of a total of 1931 objects:
- 661 have measurements from only one opposition
  - 638 of those have had no measurements for more than a year
    - 329 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

The Pluto System: Initial Results from its Exploration by New Horizons

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The Pluto system was recently explored by NASA's New Horizons spacecraft, making closest approach on 14 July 2015. Pluto's surface displays diverse landforms, terrain ages, albedos, colors, and composition gradients. Evidence is found for a water-ice crust, geologically young surface units, surface ice convection, wind streaks, volatile transport, and glacial flow. Pluto's atmosphere is highly extended, with trace hydrocarbons, a global haze layer, and a surface pressure near 10 microbars. Pluto's diverse surface geology and long term activity raise fundamental questions about how small planets remain active many billions of years (Gyr) after formation. Pluto's large moon Charon displays tectonics and evidence for a heterogeneous crustal composition; its North Pole displays puzzling dark terrain. Small satellites Hydra and Nix have higher albedos than expected.

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Available on the web at `http://www.sciencemag.org/content/350/6258/aad1815`

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New Constraints on the Surface of Pluto

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Spectroscopic investigation of the surface of Pluto allows us to constrain the chemical properties of the volatile species of the solar system reservoir. This permits us to obtain the relative abundances of various molecules, their physical properties, as well as their spatial and temporal variation. This also could tell us about the origin of various minor chemical compounds formed during the solar system formation or generated later on by space weathering. This will give us critical information about the evolution processes that may occur in the entire trans-Neptunian objects population, and in particular the biggest objects, which could retain tenuous atmospheres.

New observations of the surface of Pluto have been carried out along with reanalyses of older observations carried out with the ESO-VLT telescopes and the SINFONI instrument at a mean spectral resolution of 1500. We present three new near-infrared spectra of Pluto observed at different

epochs, and covering the H and K spectral bands showing absorption features of methane, nitrogen, and carbon monoxide ices. We ran different spectral models, based on Hapke theory, to constrain the physical and chemical properties of different sides of Pluto.

We have confirmed the spatial and secular variation of the spectral properties of the surface of Pluto. The abundances, sizes, and temperatures of different ices, such as CH_4, CO, and N_2 have been constrained for different parts of the surface of Pluto. The results suggest a temperature probably just above the alpha-beta transition phase of N_2 (close to 36.5 K), and a probable stratification of the dilution state of CO and CH_4. The presence of minor chemical compounds, such as C_2H_6, has been confirmed too, and for data obtained at several sub-Earth east longitudes. Solid C_2H_4 is suggested by the spectral modeling with abundance variation following that of solid C_2H_6 and solid CH_4.

Published in: Astronomy & Astrophysics, 582, A39 (2015 October)
For preprints, contact frederic.merlin@obspm.fr

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Solar Wind at 33 AU: Setting Bounds on the Pluto Interaction for New Horizons

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NASA's New Horizons spacecraft flies past Pluto on July 14, 2015, carrying two instruments that detect charged particles. Pluto has a tenuous, extended atmosphere that is escaping the planet's weak gravity. The interaction of the solar wind with Pluto's escaping atmosphere depends on solar wind conditions as well as the vertical structure of Pluto's atmosphere. We have analyzed Voyager 2 particles and fields measurements between 25 and 39 AU and present their statistical variations. We have adjusted these predictions to allow for the Sun's declining activity and solar wind output. We summarize the range of SW conditions that can be expected at 33 AU and survey the range of scales of interaction that New Horizons might experience. Model estimates for the solar wind stand-off distance vary from $\sim$7 to $\sim$1000 R_P with our best estimate being around 40 R_P (where we take Pluto's radius to be R_P=1184 km).

To appear in: Journal of Geophysical Research: Planets, v. 120
For preprints, contact bagenal@colorado.edu
and available on the web at http://arxiv.org/abs/1509.04660

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(50000) Quaoar: Surface Composition Variability

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The goal of this work is to investigate the composition of the surface of (50000) Quaoar and its spatial variability.

We present new continuous spectra from visible to near-infrared (0.3-2.3 μm) obtained with the X-Shooter instrument at the VLT-ESO at four different epochs on the surface of Quaoar. The data, which, for this object, represent the highest spectral resolution data ever obtained and the first near-IR dataset acquired in a single exposure over the entire wavelength range, are complemented by previously published photometric observations obtained in the near-infrared (3.6, 4.5 μm) with the Spitzer Space Telescope, which provide an extra set of constraints in the model calculation. Spectral modeling was performed for the entire wavelength range by means of a code based on the Shkuratov radiative transfer formulation and using an updated value of albedo obtained from recent Herschel observations.

We obtain compositional information for different observed areas which can cover about 40% of the assumed rotational period of 8.84 hrs. Our analysis supports the presence of CH_4 and C_2H_6, as previously reported, along with indications of possible presence of $NH_3{\cdot}H_2O$. New evidence for the presence of N_2 is inferred from the shift of the CH_4 bands. The albedo at the two Spitzer bands suggests, for one of the surface locations, the possible presence of CO diluted in N_2, and CO_2.

The spectral similarities indicate overall homogeneity of the surface composition of one hemisphere of Quaoar, while some subtle variations are apparent when modeling is performed. The presence of $NH_3{\cdot}H_2O$ would support the idea that Quaoar's surface may be relatively young as previously suggested by Jewitt and Luu (2004).

To appear in: Astronomy & Astrophysics
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Rotationally Resolved Spectroscopy of Dwarf Planet (136472) Makemake

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Icy dwarf planets are key for studying the chemical and physical states of ices in the outer solar system. The study of secular and rotational variations gives us hints of the processes that contribute

to the evolution of their surface. The aim of this work is to search for rotational variability on the surface composition of the dwarf planet (136472) Makemake

We observed Makemake in April 2008 with the medium-resolution spectrograph ISIS, at the William Herschel Telescope (La Palma, Spain) and obtained a set of spectra in the 0.28-0.52 μm and 0.70-0.95 μm ranges, covering 82% of its rotational period. For the rotational analysis, we organized the spectra in four different sets corresponding to different rotational phases, and after discarding one with low signal to noise, we analyzed three of them that cover 71% of the surface. For these spectra we computed the spectral slope and compared the observed spectral bands of methane ice with reflectances of pure methane ice to search for shifts of the center of the bands, related to the presence of CH_4/N_2 solid solution.

All the spectra have a red color with spectral slopes between 20%/1000 Å and 32%/1000 Å in accordance with previously reported values. Some variation in the spectral slope is detected, pointing to the possibility of a variation in the surface content or the particle size of the solid organic compound. The absorption bands of methane ice present a shift toward shorter wavelengths, indicating that methane (at least partially) is in solid solution with nitrogen. There is no variation within the errors of the shifts with the wavelength or with the depth of the bands, so there is no evidence of variation in the CH_4/N_2 mixing ratio with rotation. By comparing with all the available data in the literature, no secular compositional variations between 2005 and 2008 is found.

Published in: Astronomy & Astrophysics, 577, A86 (2015 May)
Preprint available on the web at `http://arxiv.org/abs/1504.02350`

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A Digital Video System for Observing and Recording Occultations

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Stellar occultations by asteroids and outer solar system bodies can offer ground based observers with modest telescopes and camera equipment the opportunity to probe the shape, size, atmosphere, and attendant moons or rings of these distant objects. The essential requirements of the camera and recording equipment are: good quantum efficiency and low noise; minimal dead time between images; good horological faithfulness of the image timestamps; robustness of the recording to unexpected failure; and low cost. We describe an occultation observing and recording system which attempts to fulfill these requirements and compare the system with other reported camera and recorder systems. Five systems have been built, deployed, and tested over the past three years, and we report on three representative occultation observations: one being a 9±1.5 s occultation of the trans-Neptunian object 28978 Ixion ($m_v = 15.2$) at 3 seconds per frame; one being a 1.51±0.017 s occultation of Deimos, the 12 km diameter satellite of Mars, at 30 frames per second; and one being a 11.04±0.4 s occultation, recorded at 7.5 frames per second, of the main belt asteroid 361 Havnia, representing a low magnitude drop ($\Delta m_v \sim 0.4$) occultation.

Published in: Publications of the Astronomical Society of Australia, 32, 31
Preprint available the web at `http://arxiv.org/abs/1507.05151`

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JWST Observations of Stellar Occultations by Solar System Bodies and Rings

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In this paper we investigate the opportunities provided by the James Webb Space Telescope (JWST) for significant scientific advances in the study of solar system bodies and rings using stellar occultations. The strengths and weaknesses of the stellar occultation technique are evaluated in light of JWST's unique capabilities. We identify several possible JWST occultation events by minor bodies and rings, and evaluate their potential scientific value. These predictions depend critically on accurate a priori knowledge of the orbit of JWST near the Sun-Earth Lagrange-point 2 (L2). We also explore the possibility of serendipitous stellar occultations by very small minor bodies as a by-product of other JWST observing programs. Finally, to optimize the potential scientific return of stellar occultation observations, we identify several characteristics of JWST's orbit and instrumentation that should be taken into account during JWST's development.

To appear in: Publications of the Astronomical Society of the Pacific

For preprints, contact `psantos@iaa.es`

PAPERS RECENTLY SUBMITTED TO JOURNALS

The Spectrum of Pluto, 0.40-0.93 μm I. Secular and Longitudinal Distribution of Ices and Complex Organics

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During the last 30 years the surface of Pluto has been characterized, and its variability has been monitored, through continuous near-infrared spectroscopic observations. But in the visible range only few data are available. The aim of this work is to define the Pluto's relative reflectance in the visible range to characterize the different components of its surface, and to provide ground based observations in support of the *New Horizons* mission. We observed Pluto on six nights between May and July 2014, with the imager/spectrograph ACAM at the *William Herschel* Telescope (La Palma, Spain). The six spectra obtained cover a whole rotation of Pluto ($P_{rot} = 6.4$ days). For all the spectra we computed the spectral slope and the depth of the absorption bands of methane ice between 0.62 and 0.90 μm. To search for shifts of the center of the methane bands, associated with dilution of CH_4 in N_2, we compared the bands with reflectances of pure methane ice. All the new spectra show the methane ice absorption bands between 0.62 and 0.90 μm. The computation of the depth of the band at 0.62 μm in the new spectra of Pluto, and in the spectra of Makemake and Eris from the literature, allowed us to estimate the Lambert coefficient at this wavelength, at a temperature of 30 K and 40 K, never measured before. All the detected bands are blue shifted with respect to the position for pure methane ice, with minimum shifts in correspondence with the regions where the abundance of methane is higher. This could be indicative of a dilution of CH_4:N_2 more saturated in CH_4. The longitudinal and secular variations of the parameters measured in the spectra are in accordance with results previously reported in the literature and with the distribution of the dark and bright material that show the Pluto's albedo maps from *New Horizons*.

Submitted to: Astronomy & Astrophysics
Preprint available on the web at `http://arxiv.org/abs/1509.00417`

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Forming the Cold Classical Kuiper Belt in a Light Disk

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Large Kuiper Belt Objects are conventionally thought to have formed out of a massive planetesimal belt that is a few thousand times its current mass. Such a picture, however, is incompatible with multiple lines of evidence. Here, we present a new model for the conglomeration of Cold Classical Kuiper belt objects, out of a solid belt only a few times its current mass, or a few percent of the solid density in a Minimum Mass Solar Nebula. This is made possible by depositing most of the primordial mass in grains of size centimetre or smaller. These grains collide frequently and maintain a dynamically cold belt out of which large bodies grow efficiently: an order-unity fraction of the solid mass can be converted into large bodies, in contrast to the $\sim 10^{-3}$ efficiency in conventional models. Such a light belt may represent the true outer edge of the Solar system, and it may have effectively halted the outward migration of Neptune. In addition to the high efficiency, our model can also produce a mass spectrum that peaks at an intermediate size, similar to the observed Cold Classicals, if one includes the effect of cratering collisions. In particular, the observed power-law break observed at ~ 30 km for Cold Classicals, one that has been interpreted as a result of collisional erosion, may be primordial in origin.

Submitted to: The Astrophysical Journal
For preprints, contact shannon@ast.cam.ac.uk
or on the web at http://arxiv.org/abs/1510.01323

JOB ANNOUNCEMENTS

Post-Doc Positions in Brazil

The Group of Orbital Dynamics & Planetology invites applications for post-doc positions. There are 4 positions that will be funded by FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo). The candidates must have experience on Planetary Dynamics and/or Spacecraft Dynamics.

The projects to be developed are the following:
Spin-orbit coupling in solar system dynamics;
Problems in orbital dynamics involving small bodies under gravitational close approaches;
Dynamics of narrow planetary rings and small satellites;
Attitude and orbit analysis for a mission to a triple asteroid system;

The projects will be developed in one of the following institutions: I) São Paulo State University - UNESP in Guaratinguetá; II) National Institute for Space Research - INPE in São José dos Campos. Applicants should send a statement of research interest and a curriculum vitae with a list of publications to: Prof. Othon Winter (email: ocwinter@gmail.com)

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:

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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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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:

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