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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

ekonews@boulder.swri.edu www.boulder.swri.edu/ekonews

CONTENTS

NEWS & ANNOUNCEMENTS

There were 96 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2013 PS76, 2013 SA101, 2013 SB101, 2013 SC101, 2013 SD101, 2013 SE101, 2013 SF101, 2013 SG101, 2013 SJ100, 2013 SL100, 2013 SM100, 2013 SN100, 2013 SO100, 2013 SP100, 2013 SQ100, 2013 SR100, 2013 SS100, 2013 ST100, 2013 SU100, 2013 SV100, 2013 SW100, 2013 SX100, 2013 SY100, 2013 SZ100, 2013 UA17, 2013 UA18, 2013 UB18, 2013 UC18, 2013 UD18, 2013 UE17, 2013 UE18, 2013 UF17, 2013 UF18, 2013 UG17, 2013 UG18, 2013 UH17, 2013 UJ17, 2013 UK17, 2013 UL17, 2013 UM17, 2013 UN17, 2013 UP17, 2013 UQ17, 2013 UR17, 2013 US17, 2013 UT17, 2013 UV17, 2013 UW16, 2013 UW17, 2013 UX16, 2013 UX17, 2013 UY16, 2013 UY17, 2013 UZ16, 2013 UZ17, 2014 UB229, 2014 UB230, 2014 UC228, 2014 UC229, 2014 UC230, 2014 UD229, 2014 UE229, 2014 UF228, 2014 UF229, 2014 UH228, 2014 UH229, 2014 UJ228, 2014 UJ229, 2014 UK229, 2014 UL228, 2014 UL229, 2014 UM228, 2014 UM229, 2014 UN228, 2014 UN229, 2014 UO228, 2014 UO229, 2014 UP228, 2014 UP229, 2014 UQ228, 2014 UR228, 2014 UR229, 2014 US228, 2014 UT228, 2014 UT229, 2014 UU228, 2014 UU229, 2014 UV228, 2014 UW228, 2014 UW229, 2014 UX228, 2014 UX229, 2014 UY228, 2014 UY229, 2014 UZ228, 2014 UZ229

and 19 new Centaur/SDO discoveries:

2013 SK100, 2013 UB17, 2013 UC17, 2013 UD17, 2013 UO17, 2013 UU17, 2014 UA229, 2014 UA230, 2014 UB228, 2014 UD228, 2014 UE228, 2014 UG228, 2014 UG229, 2014 UK228, 2014 UQ229, 2014 US229, 2014 UV229, 2017 UX51, 2017 WW14

Objects recently assigned numbers:

1998 HQ151 = (503858)
2000 YB2 = (506439)
2001 QF331 = (503883)
2003 HB57 = (506479)
2008 SO266 = (504555)
2010 RE188 = (504847)
2013 QO95 = (505412)
2013 SA100 = (505448)
2013 SP99 = (505446)
2013 SQ99 = (505447)
2013 UL15 = (505476)
2013 UM15 = (505477)
2013 UT15 = (505478)
2014 GU53 = (505624)
2014 WT69 = (505679)
2015 HO171 = (506028)
2015 SO20 = (508338)
2016 BP81 = (506121)

Current number of TNOs: 1910 (including Pluto)
Current number of Centaurs/SDOs: 740
Current number of Neptune Trojans: 17

Out of a total of 2667 objects:
- 704 have measurements from only one opposition
  - 696 of those have had no measurements for more than a year
    - 342 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

Water and Volatiles in the Outer Solar System

O. Grasset[1], J. Castillo-Rogez[2], T. Guillot[3], L.N. Fletcher[4], and F. Tosi[5]

[1] Laboratoire de Planétologie et Géodynamique, LPG-Nantes UMR 6112, France

[2] Jet Propulsion Laboratory, California Institute of Technology, USA

[3] Observatoire de la Côte d'Azur, France

[4] Department of Physics and Astronomy, University of Leicester, UK

[5] INAF-IAPS Istituto di Astrofisica e Planetologia Spaziali, Italy

Space exploration and ground-based observations have provided outstanding evidence of the diversity and the complexity of the outer solar system. This work presents our current understanding of the nature and distribution of water and water-rich materials from the water snow line to the Kuiper Belt. This synthesis is timely, since a thorough exploration of at least one object in each region of the outer solar system has now been achieved. Next steps, starting with the Juno mission now in orbit around Jupiter, will be more focused on understanding the processes at work than on describing the general characteristics of each giant planet systems.

Published in: Space Science Reviews, 212, 835 (2017 October)

Available on the web at `http://adsabs.harvard.edu/abs/2017SSRv..212..835G`

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Checking the Compatibility of the Cold Kuiper Belt with a Planetary Instability Migration Model

Rodney Gomes[1], David Nesvorny[2], Alessandro Morbidelli[3], Rogerio Deienno[4] and Erica Nogueira[5]

[1] Observatório Nacional, Rua General José Cristino 77, CEP 20921-400, Rio de Janeiro, RJ, Brazil

[2] Department of Space Studies, Southwest Research Institute, 1050 Walnut Street, Boulder, CO 80302, USA

[3] Laboratoire Lagrange, UMR7293, Université Côte d'Azur, CNRS, Observatoire de la Côte d'Azur, Boulevard de l'Observatoire, 06304 Nice Cedex 4, France

[4] Instituto Nacional de Pesquisas Espaciais, Avenida dos Astronautas 1758, CEP 12227-010 São José dos Campos, SP, Brazil

[5] Universidade Federal Fluminense, Niteroi, RJ, Brazil

The origin of the orbital structure of the cold component of the Kuiper belt is still a hot subject of investigation. Several features of the solar system suggest that the giant planets underwent a phase of global dynamical instability, but the actual dynamical evolution of the planets during the instability is still debated. To explain the structure of the cold Kuiper belt, Nesvorny (2015, AJ 150,68) argued for a "soft" instability, during which Neptune never achieved a very eccentric orbit. Here we investigate the possibility of a more violent instability, from an initially more compact fully resonant configuration of 5 giant planets. We show that the orbital structure of the cold Kuiper belt can be reproduced quite well provided that the cold population formed in situ, with an outer edge between 44-45 au and never had a large mass.

To appear in: Icarus

For preprints, contact `rodney@on.br`

or on the web at `https://arxiv.org/abs/1710.05178`

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A Possible Dynamically Cold Classical Contact Binary: (126719) 2002 CC_{249}

Audrey Thirouin[1] and Scott S. Sheppard[2]

[1] Lowell Observatory, 1400 W Mars Hill Rd, Flagstaff, Arizona, 86001, USA

[2] Department of Terrestrial Magnetism, Carnegie Institution for Science, 5241 Broad Branch Rd. NW, Washington, DC, 20015, USA

Images of the Kuiper Belt object (126719) 2002 CC_{249} obtained in 2016 and 2017 using the 6.5 m Magellan-Baade Telescope and the 4.3 m Discovery Channel Telescope are presented. A light curve with a periodicity of 11.87±0.01 hr and a peak-to-peak amplitude of 0.79±0.04 mag is reported. This high amplitude double-peaked light curve can be due to a single elongated body, but it is best explained by a contact binary system from its U-/V-shaped light curve. We present a simple full-width-at-half-maximum test that can be used to determine if an object is likely a contact binary or an elongated object based on its light curve. Considering that 2002 CC_{249} is in hydrostatic equilibrium, a system with a mass ratio $q_{min} = 0.6$, and a density $\rho_{min} = 1$ g cm^{-3}, or less plausible a system with $q_{max} = 1$, and $\rho_{max} = 5$ g cm^{-3} can interpret the light curve. Assuming a single Jacobi ellipsoid in hydrostatic equilibrium and an equatorial view, we estimate $\rho \geq 0.34$ g cm^{-3}, and a/b = 2.07. Finally, we report a new color study showing that 2002 CC_{249} displays an ultra red surface characteristic of a dynamically Cold Classical trans-Neptunian object.

Published in: The Astronomical Journal, 154, 241 (2017 December)

For preprints, contact `thirouin@lowell.edu`

or on the web at `http://adsabs.harvard.edu/abs/2017AJ....154..241T`

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The Curiously Warped Mean Plane of the Kuiper Belt

K. Volk[1] and R. Malhotra[1]

[1] Lunar and Planetary Laboratory, The University of Arizona, 1629 E. University Blvd., Tucson, AZ 85721, USA

We measured the mean plane of the Kuiper belt as a function of semi-major axis. For the classical Kuiper belt as a whole (the non-resonant objects in the semi-major axis range 42–48 au), we find a mean plane of inclination $i_m = 1.8^{\circ}{}^{+0.7^{\circ}}_{-0.4^{\circ}}$ and longitude of ascending node $\Omega_m = 77^{\circ}{}^{+18^{\circ}}_{-14^{\circ}}$ (in the J2000 ecliptic-equinox coordinate system), in accord with theoretical expectations of the secular effects of the known planets. With finer semi-major axis bins, we detect a statistically significant warp in the mean plane near semi-major axes 40–42 au. Linear secular theory predicts a warp near this location due to the ν_{18} nodal secular resonance, however the measured mean plane for the 40.3-42 au semi-major axis bin (just outside the ν_{18}) is inclined $\sim 13^{\circ}$ to the predicted plane, a nearly 3-σ discrepancy. For the more distant Kuiper belt objects of semi-major axes in the range 50–80 au, the expected mean plane is close to the invariable plane of the solar system, but the measured mean plane deviates greatly from this: it has inclination $i_m = 9.1^{\circ}{}^{+6.6^{\circ}}_{-3.8^{\circ}}$ and longitude of ascending node $\Omega_m = 227^{\circ}{}^{+18^{\circ}}_{-44^{\circ}}$. We estimate this deviation from the expected mean plane to be statistically significant at the $\sim 97-99\%$ confidence level. We discuss several possible explanations for this deviation, including the possibility that a relatively close-in ($a \lesssim 100$ au), unseen small planetary-mass object in the outer solar system is responsible for the warping.

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For preprints, contact `kvolk@lpl.arizona.edu`

or on the web at `http://adsabs.harvard.edu/abs/2017AJ....154...62V`

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Dynamical Evolution Induced by Planet Nine

Konstantin Batygin[1] and Alessandro Morbidelli[2]

[1] Division of Geological and Planetary Sciences, California Institute of Technology, 1200 E. California Blvd., Pasadena, CA 91125, USA

[2] Laboratoire Lagrange, Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, CS 34229, 06304 Nice, France

The observational census of trans-Neptunian objects with semi-major axes greater than ~ 250 AU exhibits unexpected orbital structure that is most readily attributed to gravitational perturbations induced by a yet-undetected, massive planet. Although the capacity of this planet to (i) reproduce the observed clustering of distant orbits in physical space, (ii) facilitate dynamical detachment of their perihelia from Neptune, and (iii) excite a population of long-period centaurs to extreme inclinations is well established through numerical experiments, a coherent theoretical description of the dynamical mechanisms responsible for these effects remains elusive. In this work, we characterize the dynamical processes at play, from semi-analytic grounds. We begin by considering a purely secular model of orbital evolution induced by Planet Nine, and show that it is at odds with the ensuing stability of distant objects. Instead, the long-term survival of the clustered population of long-period KBOs is enabled by a web of mean-motion resonances driven by Planet Nine. Then, by taking a compact-form approach to perturbation theory, we show that it is the secular dynamics embedded within these resonances that regulates the orbital confinement and perihelion detachment of distant Kuiper belt objects. Finally, we demonstrate that the onset of large-amplitude oscillations of orbital inclinations is accomplished through capture of low-inclination objects into a high-order secular resonance and identify the specific harmonic that drives the evolution. In light of the developed qualitative understanding of the governing dynamics, we offer an updated interpretation of the current observational dataset within the broader theoretical framework of the Planet Nine hypothesis.

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For preprints, contact `kbatygin@gps.caltech.edu`

or on the web at `http://adsabs.harvard.edu/abs/2017AJ....154..229B`

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Dynamically Correlated Minor Bodies in the Outer Solar System

C. de la Fuente Marcos[1] and R. de la Fuente Marcos[1]

[1] Universidad Complutense de Madrid, Ciudad Universitaria, E-28040 Madrid, Spain

The organization of the orbits of most minor bodies in the Solar system seems to follow random patterns, the result of billions of years of chaotic dynamical evolution. Much as heterogeneous orbital behaviour is ubiquitous, dynamically coherent pairs and groups of objects are also present everywhere. Although first studied among the populations of asteroids and comets that inhabit or traverse the inner Solar system, where they are very numerous, at least one asteroid family has been confirmed to exist in the outer Solar system and two other candidates have been proposed in the literature. Here, we perform a systematic search for statistically significant pairs and groups of dynamically correlated objects through those with semimajor axis greater than 25 au, applying a novel technique that uses the angular separations of orbital poles and perihelia together with the differences in time of perihelion passage to single out pairs of relevant objects. Our analysis recovers well-known, dynamically coherent pairs and groups of comets and trans-Neptunian objects and uncovers a number of new ones, prime candidates for further spectroscopic study.

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For preprints, contact `nbplanet@ucm.es`

or on the web at `http://adsabs.harvard.edu/abs/2018MNRAS.474..838D`

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The Dynamical History of 2060 Chiron and Its Proposed Ring System

Jeremy Wood[1,2], Jonti Horner[2,3], Tobias C. Hinse[4], and Stephen C. Marsden[2]

[1] Hazard Community and Technical College, 1 Community College Drive Hazard, KY 41701, USA

[2] University of Southern Queensland, Computational Engineering and Science Research Centre, West St, Toowoomba, QLD 4350, Australia

[3] Australian Centre for Astrobiology, UNSW Australia, Sydney, NSW 2052, Australia

[4] Korea Astronomy and Space Science Institute, 776 Daedukdae-ro, Yuseong-gu, Daejeon 305-348, Republic of Korea

The surprising discovery of a ring system around the Centaur 10199 Chariklo in 2013 led to a reanalysis of archival stellar occultation data for the Centaur 2060 Chiron by Ortiz et al. One possible interpretation of that data is that a system of rings exists around Chiron. In this work, we study the dynamical history of the proposed Chiron ring system by integrating nearly 36,000 clones of the Centaur backward in time for 100 Myr under the influence of the Sun and the four giant planets. The severity of all close encounters between the clones and planets while the clones are in the Centaur region is recorded, along with the mean time between close encounters. We find that severe and extreme close encounters are very rare, making it possible that the Chiron ring system has remained intact since its injection into the Centaur region, which we find likely occurred within the past 8.5 Myr. Our simulations yield a backward dynamical half-life for Chiron of 0.7 Myr. The dynamical classes of a sample of clones are found. It is found that, on average, the Centaur lifetimes of resonance hopping clones are twice those of random-walk clones because of resonance sticking in mean motion resonances. In addition, we present MEGNO and chaotic lifetime maps of the region bound by 13 au $\leq a \leq$ 14 au and $e \leq 0.5$. We confirm that the current mean orbital parameters of Chiron are located in a highly chaotic region of a-e phase space.

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Available on the web at `http://adsabs.harvard.edu/abs/2018AJ....155....2W`

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Searching for Moving Objects in HSC-SSP: Pipeline and Preliminary Results

Y.-T. Chen[1], H.-W. Lin[2,3], M. Alexandersen[1], M. Lehner[1,4,5], S.-Y. Wang[1], J.-H. Wang[1], F. Yoshida[6,7], Y. Komiyama[8], and S. Miyazaki[8,9]

[1] Institute of Astronomy and Astrophysics, Academia Sinica, P. O. Box 23-141, Taipei 106, Taiwan

[2] Institute of Astronomy, National Central University, 32001, Taiwan

[3] Department of Physics, University of Michigan, Ann Arbor, MI 48109, USA

[4] Department of Physics and Astronomy, University of Pennsylvania, 209 S. 33rd St., Philadelphia, PA 19125, USA

[5] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA

[6] Planetary Exploration Research Center, Chiba Institute of Technology, 2-17-1 Tsudanuma, Narashino, Chiba 275-0016, Japan

[7] Department of Planetology, Graduate School of Science, Kobe University, Kobe, 657-8501, Japan

[8] National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

[9] The Graduate University for Advanced Studies), Mitaka, Tokyo, 181-8588, Japan

The Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP) is currently the deepest wide-field survey in progress. The 8.2 m aperture of the Subaru telescope is very powerful in detecting faint/small moving objects, including near-Earth objects, asteroids, centaurs and Tran-Neptunian objects (TNOs). However, the cadence and dithering pattern of the HSC-SSP are not designed for detecting moving objects, making it difficult to do so systematically. In this paper, we introduce a new pipeline for detecting moving objects (specifically TNOs) in a non-dedicated survey. The HSC-SSP catalogs are sliced into `HEALPix` partitions. Then, the stationary detections and false positives are removed with a machine learning algorithm to produce a list of moving object candidates. An orbit linking algorithm and visual inspections are executed to generate the final list of detected TNOs. The preliminary results of a search for TNOs using this new pipeline on data

from the first HSC-SSP data release (Mar 2014 to Nov 2015) present 231 TNO/Centaurs candidates. The bright candidates with $H_r < 7.7$ and $i > 5$ show that the best fit slope of a single power law to absolute magnitude distribution is 0.77. The $g - r$ color distribution of hot HSC-SSP TNOs indicates a bluer peak at $g - r = 0.9$ which is consistent with the bluer peak of the bimodal color distribution in literature.

To appear in: Publications of the Astronomical Society of Japan, HSC special issue
Preprints available on the web at `https://arxiv.org/abs/1705.01722`

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Pipeline for the Detection of Serendipitous Stellar Occultations by Kuiper Belt Objects with the Colibri Fast-photometry Array

E. Pass[1,2,3], S. Metchev[1,3,4], P. Brown[1,3], and S. Beauchemin[5]

[1] Department of Physics and Astronomy, University of Western Ontario, London ON, Canada

[2] Department of Physics and Astronomy, University of Waterloo, Waterloo ON, Canada

[3] Centre for Planetary Science and Exploration, University of Western Ontario, London ON, Canada

[4] Department of Physics and Astronomy, Stony Brook University, Stony Brook NY, USA

[5] Department of Computer Science, University of Western Ontario, London ON, Canada

We report results from the preliminary trials of Colibri, a dedicated fast-photometry array for the detection of small Kuiper belt objects through serendipitous stellar occultations. Colibri's novel data processing pipeline analyzed 4000 star hours with two overlapping-field EMCCD cameras, detecting no Kuiper belt objects and one false positive occultation event in a high ecliptic latitude field. No occultations would be expected at these latitudes, allowing these results to provide a control sample for the upcoming main Colibri campaign. The empirical false positive rate found by the processing pipeline is consistent with the 0.002% simulation-determined false positive rate. We also describe Colibri's software design, kernel sets for modeling stellar occultations, and method for retrieving occultation parameters from noisy diffraction curves. Colibri's main campaign will begin in mid-2018, operating at a 40 Hz sampling rate.

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For preprints, contact `ekpass@edu.uwaterloo.ca`
or on the web at `https://arxiv.org/abs/1711.00358`

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Equilibrium Shapes of Large Trans-Neptunian Objects

N. Rambaux[1], D. Baguet[2], F. Chambat[3], and J.C. Castillo-Rogez[4]

[1] IMCCE, Observatoire de Paris PSL Research University, Sorbonne Universités UPMC Université Paris 06, Université Lille 1, CNRS UMR8028, 77 avenue Denfert-Rochereau, F-75014 Paris, France

[2] Institut UTINAM UMR6213, CNRS, Univ. Bourgogne Franche-Comté, OSU Theta F-25000 Besançon, France

[3] LGLTPE, CNRS UMR5276, ENS de Lyon, Site Monod, 15 parvis René Descartes; Lyon, F-69007, France

[4] Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, 91109 CA, USA

The large trans-Neptunian objects (TNO) with radii larger than 400 km are thought to be in hydrostatic equilibrium. Their shapes can provide clues regarding their internal structures that would reveal information on their formation and evolution. In this paper, we explore the equilibrium figures of five TNOs, and we show that the difference between the equilibrium figures of homogeneous and heterogeneous interior models can reach several kilometers for fast rotating and low density bodies. Such a difference could be measurable by ground-based techniques. This demonstrates the importance of developing the shape up to second and third order when modeling the shapes of large and rapid rotators.

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Available on the web at `http://adsabs.harvard.edu/abs/2017ApJ...850L...9R`

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Relevance of Tidal Heating on Large TNOs

P. Saxena[1], J. Renaud[2], W. Henning[1,3], M. Jutzi[4], and T. Hurford[1]

[1] NASA/Goddard Space Flight Center, 8800 Greenbelt Rd, Greenbelt, MD 20771, USA

[2] Department of Physics & Astronomy, George Mason University, 4400 University Drive, Fairfax, VA 22030, USA

[3] Department of Astronomy, University of Maryland, Physical Sciences Complex, College Park, MD 20742 USA

[4] Physics Institute: Space Research & Planetary Sciences, University of Bern, Sidlerstrasse 5, Bern 3012, Switzerland

We examine the relevance of tidal heating for large Trans-Neptunian Objects, with a focus on its potential to melt and maintain layers of subsurface liquid water. Depending on their past orbital evolution, tidal heating may be an important part of the heat budget for a number of discovered and hypothetical TNO systems and may enable formation of, and increased access to, subsurface liquid water. Tidal heating induced by the process of despinning is found to be particularly able to compete with heating due to radionuclide decay in a number of different scenarios. In cases where radiogenic heating alone may establish subsurface conditions for liquid water, we focus on the extent by which tidal activity lifts the depth of such conditions closer to the surface. While it is common for strong tidal heating and long lived tides to be mutually exclusive, we find this is not always the case, and highlight when these two traits occur together. We find cases where TNO systems experience tidal heating that is a significant proportion of, or greater than radiogenic heating for periods ranging from 100's of millions to a billion years. For subsurface oceans that contain a small antifreeze component, tidal heating due to very high initial spin states may enable liquid water to be preserved right up to the present day. Of particular interest is the Eris-Dysnomia system, which in those cases may exhibit extant cryovolcanism.

Published in: Icarus, 302, 245 (2018 March 1)

For preprints, contact `prabal.saxena@nasa.gov`

or on the web at `http://adsabs.harvard.edu/abs/2018Icar..302..245S`

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Photometric Observations of Nine Transneptunian Objects and Centaurs

T. Hromakina[1], D. Perna[2,3], I. Belskaya[1], E. Dotto[2], A. Rossi[4], and F. Bisi[2,5]

[1] Institute of Astronomy, Kharkiv V.N. Karazin National University, Sumska Str. 35, Kharkiv 61022, Ukraine

[2] INAF – Osservatorio Astronomico di Roma, Via Frascati 33, I-00078 Monte Porzio Catone (Roma), Italy

[3] LESIA – Observatoire de Paris, PSL Research University, CNRS, Sorbonne Universités, UPMC Univ. Paris 06, Univ. Paris Diderot, Sorbonne Paris Cité, 5 place Jules Janssen, 92195 Meudon, France

[4] IFAC-CNR, via Madonna del Piano 10, I-50019 Sesto Fiorentino (Firenze), Italy

[5] Dipartimento di Fisica, Università di Roma Tor Vergata, via della Ricerca Scientifica 1, 00133 Roma, Italy

We present the results of photometric observations of six Transneptunian objects and three Centaurs, estimations of their rotational periods and corresponding amplitudes. For six of them we present also lower limits of density values. All observations were made using 3.6-m TNG telescope (La Palma, Spain). For four objects – (148975) 2001 XA255, (281371) 2008 FC76, (315898) 2008 QD4, and 2008 CT190 – the estimation of short-term variability was made for the first time. We confirm rotation period values for two objects: (55636) 2002 TX300 and (202421) 2005 UQ513, and improve the precision of previously reported rotational period values for other three – (120178) 2003 OP32, (145452) 2005 RN43, (444030) 2004 NT33 – by using both our and literature data. We also discuss here that small distant bodies, similarly to asteroids in the Main belt, tend to have double-peaked rotational periods caused by the elongated shape rather than surface albedo variations.

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For preprints, contact `hromakina@astron.kharkov.ua`

or on the web at `https://arxiv.org/abs/1712.04284`

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Haze Heats Pluto's Atmosphere yet Explains its Cold Temperature

Xi Zhang[1], Darrell F. Strobel[2], and Hiroshi Imanaka[3,4]

[1] Department of Earth and Planetary Sciences, University of California Santa Cruz, Santa Cruz, CA 95064, USA

[2] Department of Earth & Planetary Sciences and Physics & Astronomy, Johns Hopkins University, Baltimore, MD 21218, USA

[3] SETI Institute, 189 North Bernardo Avenue, Suite 100, Mountain View, CA 94043, USA

[4] NASA Ames Research Center, Moffett Field, CA 94035, USA

Pluto's atmosphere is cold and hazy. Recent observations have shown it to be much colder than predicted theoretically, suggesting an unknown cooling mechanism. Atmospheric gas molecules, particularly water vapour, have been proposed as a coolant; however, because Pluto's thermal structure is expected to be in radiative-conductive equilibrium, the required water vapour would need to be supersaturated by many orders of magnitude under thermodynamic equilibrium conditions. Here we report that atmospheric hazes, rather than gases, can explain Pluto's temperature profile. We find that haze particles have substantially larger solar heating and thermal cooling rates than gas molecules, dominating the atmospheric radiative balance from the ground to an altitude of 700 km, above which heat conduction maintains an isothermal atmosphere. We conclude that Pluto's atmosphere is unique amongst Solar System planetary atmospheres, as its radiative energy equilibrium is controlled primarily by haze particles instead of gas molecules. We predict that Pluto is therefore several orders of magnitude brighter at mid-infrared wavelengths than previously thought — a brightness that could be detected by future telescopes.

Published in: Nature, 551, 352 (2017 November 16)

Available on the web at `https://www.nature.com/articles/nature24465`

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A Search for Temporal Changes on Pluto and Charon

J.D. Hofgartner[1], B.J. Buratti[1], S.L. Devins[1], R.A. Beyer[2,3], P. Schenk[4], S.A. Stern[5], H.A. Weaver[6], C.B. Olkin[5], A. Cheng[6], K. Ennico[3], T.R. Lauer[7], W.B. McKinnon[8], J. Spencer[5], L.A. Young[5], and the New Horizons Science Team

[1] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

[2] Sagan Center at the SETI Institute, Mountain View, CA, USA

[3] NASA Ames Research Center, Moffett Field, CA, USA

[4] Lunar and Planetary Institute, Houston, TX, USA

[5] Southwest Research Institute, Boulder, CO, USA

[6] Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA

[7] National Optical Astronomy Observatory, Tucson, AZ, USA

[8] Washington University in St. Louis, Saint Louis, MO, USA

A search for temporal changes on Pluto and Charon was motivated by (1) the discovery of young surfaces in the Pluto system that imply ongoing or recent geologic activity, (2) the detection of active plumes on Triton during the Voyager 2 flyby, and (3) the abundant and detailed information that observing geologic processes in action provides about the processes. A thorough search for temporal changes using New Horizons images was completed. Images that covered the same region were blinked and manually inspected for any differences in appearance. The search included full-disk images such that all illuminated regions of both bodies were investigated and higher resolution images such that parts of the encounter hemispheres were investigated at finer spatial scales. Changes of appearance between different images were observed but in all cases were attributed to variability of the imaging parameters (especially geometry) or artifacts. No differences of appearance that are strongly indicative of a temporal change were found on the surface or in the atmosphere of either Pluto or Charon. Limits on temporal changes as a function of spatial scale and temporal interval during the New Horizons encounter are determined. The longest time interval constraint is one Pluto/Charon rotation period ($\approx$ 6.4 Earth days). Contrast reversal and high-phase bright features that change in appearance with solar phase angle are identified. The change of appearance of these features is most likely due to the change in phase angle rather than a temporal change. Had active plumes analogous to the plumes discovered on Triton been present on the encounter hemispheres of either Pluto or Charon, they would have been detected. The absence of active plumes may be due to temporal variability (i.e., plumes do occur but none were active on the encounter hemispheres during the epoch of the New Horizons encounter) or because plumes do not occur. Several dark streak features that may be deposits from past plumes are identified.

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For preprints, on the web at `https://arxiv.org/abs/1711.02750`

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Ices on Charon: Distribution of H_2O and NH_3 from New Horizons LEISA observations

C. Morea Dalle Ore[1,2], S. Protopapa[3], J.C. Cook[4], W.M. Grundy[5], D.P. Cruikshank[1], A.J. Verbiscer[6], K. Ennico[1], C.B. Olkin[7], S.A. Stern[7], H.A. Weaver[8], L.A. Young[7], and the New Horizons Science Team

[1] NASA Ames Research Center, Moffett Field, CA 94035-1000, USA

[2] Carl Sagan Center, SETI Institute, 189 Bernardo Ave., Mountain View, CA 94043, USA

[3] University of Maryland, Department of Astronomy, College Park, MD 20742, USA

[4] Pinhead Institute, Telluride, CO, USA

[5] Lowell Observatory, Flagstaff, AZ 86001, USA

[6] University of Virginia, Charlottesville, VA, USA

[7] Southwest Research Institute, Boulder, CO, USA

[8] John Hopkins University, Applied Physics Laboratory, Laurel, MD, USA

Charon, the largest moon of Pluto, appeared as a fairly homogeneous, gray, icy world to New Horizons during closest approach on July 14th, 2015. Charon's sub-Pluto hemisphere was scanned by the Ralph/LEISA near-IR spectrograph providing an unprecedented opportunity to measure its surface composition. We apply a statistical clustering tool to identify spectrally distinct terrains and a radiative transfer approach to study the variations of the 2.0-μm H_2O ice band. We map the distribution of the ices previously reported to be present on Charon's surface, namely H_2O and the products of NH_3 in H_2O. We find that H_2O ice is mostly in the crystalline phase, confirming previous studies. The regions with the darkest albedos show the strongest signature of amorphous-phase ice, although the crystalline component is still strong. The brighter albedo regions, often corresponding to crater ejecta blankets, are characterized by larger H_2O grains, possibly an indication of a younger age. We observe two different behaviors for the two absorption bands representing NH_3 in H_2O. The 2.21-μm band tends to cluster more in the northern areas compared to the $\approx$2.01-μm band. Both bands are present in the brighter crater rays, but not all craters show both bands. The 2.21-μm band is also clearly present on the smaller moons Hydra and Nix. These results hint that different physical conditions may determine the appearance or absence of these two different forms of NH_3 in H_2O ice in the Pluto system. We also investigate the blue slope affecting the spectrum at wavelengths longer than $\sim$1.8 μm previously reported by several authors. We find that the slope is common among the objects in the Pluto system, Charon, the smaller moons Nix and Hydra, and the darkest terrains on Pluto. It also characterizes the analog ice tholin obtained from irradiation of Pluto-specific materials (a mixture of N_2, CH_4, and CO ices) in the laboratory. Our modeling results show that Pluto ice tholins are widespread almost uniformly on Charon suggesting a common distribution possibly part of the original reservoir of materials that made up Charon. This was irradiated over the years to yield the gray color characteristic of Charon today. On top of the 'primordial' Pluto ice tholin there is the redder component produced by irradiation of the CH_4 provided by Plutos atmospheric contribution as illustrated by Grundy et al. (2016, Nature 539, 65).

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For preprints, contact `Cristina.M.DalleOre@nasa.gov`

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PAPERS RECENTLY SUBMITTED TO JOURNALS

Chaotic Dynamics in the (47171) Lempo Triple System

Alexandre C. M. Correia[1,2]

[1] CIDMA, Dep. Física, Univ. Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal

[2] ASD, IMCCE-CNRS, Observatoire de Paris, 77 Av. Denfert-Rochereau, 75014 Paris, France

We investigate the dynamics of the (47171) Lempo triple system, also known by 1999 TC_{36}. We derive a full 3D N-body model that takes into account the orbital and spin evolution of all bodies, which are assumed triaxial ellipsoids. We show that, for reasonable values of the shapes and rotational periods, the present best fitted orbital solution is chaotic and unstable in short time-scales. The formation mechanism of this system is unknown, but the orbits can be stabilised when tidal dissipation is taken into account. The dynamics of this system is very rich, but depends on many parameters that are presently unknown. A better understanding of this systems thus requires more observations, which also need to be fitted with a complete model like the one presented here.

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For preprints, contact `correia@ua.pt`

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Chaotic Dynamics of Trans-Neptunian Objects Perturbed by Planet Nine

Sam Hadden[1], **Gongjie Li**[1], **Matthew J. Payne**[1], **and Matthew J. Holman**[1]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., MS 51, Cambridge, MA 02138, USA

Observations of clustering among the orbits of the most distant trans-Neptunian objects (TNOs) has inspired interest in the possibility of an undiscovered ninth planet lurking in the outskirts of the solar system (Trujillo & Sheppard 2014; Batygin & Brown 2016a). Numerical simulations by a number of authors have demonstrated that, with appropriate choices of planet mass and orbit, such a planet can maintain clustering in the orbital elements of the population of distant TNOs, similar to the observed sample. However, many aspects of the rich underlying dynamical processes induced by such a distant eccentric perturber have not been fully explored. We report the results of our investigation of the dynamics of coplanar test-particles which interact with a massive body on an circular orbit (Neptune) and a massive body on a more distant, highly eccentric orbit (the putative Planet Nine). We find that a detailed examination of our idealized simulations affords tremendous insight into the rich test-particle dynamics that are possible. In particular, we find that chaos and resonance overlap plays an important role in particles' dynamical evolution. We develop a simple mapping model that allows us to understand in detail the web of overlapped mean-motion resonances explored by chaotically evolving particles. We also demonstrate that gravitational interactions with Neptune can have profound effect on the orbital evolution of particles. Our results serve as a starting point for a better understanding of the dynamical behavior observed in more complicated simulations that can be used to constrain the mass and orbit of Planet Nine.

Submitted to: AAS Journals

Preprints available on the web at `https://arxiv.org/abs/1712.06547`

OTHER PAPERS OF INTEREST

Concentrating Small Particles in Protoplanetary Disks through the Streaming Instability

C.C. Yang[1], A. Johansen[1], and D. Carrera[1]

[1] Lund Observatory, Department of Astronomy and Theoretical Physics, Lund University, Box 43, 221 00 Lund, Sweden

Laboratory experiments indicate that direct growth of silicate grains via mutual collisions can only produce particles up to roughly millimeters in size. On the other hand, recent simulations of the streaming instability have shown that mm/cm-sized particles require an excessively high metallicity for dense filaments to emerge. Using a numerical algorithm for stiff mutual drag force, we perform simulations of small particles with significantly higher resolutions and longer simulation times than in previous investigations. We find that particles of dimensionless stopping time $\tau_{\rm s} = 10^{-2}$ and 10^{-3} – representing cm- and mm-sized particles interior of the water ice line – concentrate themselves via the streaming instability at a solid abundance of a few percent. We thus revise a previously published critical solid abundance curve for the regime of $\tau_{\rm s} \ll 1$. The solid density in the concentrated regions reaches values higher than the Roche density, indicating that direct collapse of particles down to mm sizes into planetesimals is possible. Our results hence bridge the gap in particle size between direct dust growth limited by bouncing and the streaming instability.

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Preprints are available at `https://arxiv.org/abs/1611.07014`

CONFERENCE INFORMATION

Scientific Workshop on the Transneptunian Solar System

2018 March 26-29
Coimbra, Portugal

This scientific workshop highlights the current knowledge and understanding of the Transneptunian Solar System. We invite you to register for the meeting and to propose contributed papers for the workshop sessions. The deadline for registration and abstract submissions is 2018 January 20. Presentations will cover the following topics:

- Physical properties of TNOs: Interior, surface, atmosphere
- The large TNOs: Pluto and others
- Satellites - Binaries and multiple systems
- Formation and evolution processes: Origin, planetesimals, multiples, dynamical and collisional evolution, physical processing
- Relationships with other populations: Centaurs, planetary Trojans, comets, Inner Oort Cloud
- Planet IX and related TNOs - Dynamical effects, indicators, properties
- Extra-solar KBO populations: Structure, properties
- Prospects for KBO research

The number of workshop participants is limited to 100 persons.

Details on the workshop framework (SOC, LOC, invited speakers, deadlines, venue, and travel and hotel information) as well as access for registration, hotel booking and abstract submission can be found at `http://www2.mps.mpg.de/services/coimbra/`

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