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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

Invitation to contribute to the JWST Solar System focus group on TNO science

The JWST Solar System Working Group has recently convened a series of focus groups to develop case studies for observations with JWST and advise the project on specific needs or capabilities necessary for enabling their science. The input of these focus groups will help guide the development and implementation of JWST capabilities.

The focus groups will develop and present specific science questions, observation scenarios, and data products relevant to their target science areas. They will also review the expected performance of JWST and its instruments with respect to the group's target area. The focus groups will present their results at the fall DPS meeting and produce a white paper summarizing their results.

The focus group on trans-Neptunian Object science is being led by Dr. Alex Parker at the University of California, Berkeley. If you are interested in contributing to this effort at any level, please contact the team lead at `alexharrisonparker@gmail.com`.

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There were 2 new Centaur/SDO discoveries announced since the previous issue of *Distant EKOs*:

2011 WU92, 2014 AT28

Objects recently assigned numbers:

1993 RO = (385185)
1997 RT5 = (385191)
1998 KG62 = (385194)
1999 OE4 = (385199)
1999 RN215 = (385201)
2001 QB298 = (385266)
2002 PT170 = (385362)
2002 PW170 = (385363)
2003 GH55 = (385437)
2003 QF113 = (385447)
2003 QH91 = (385445)
2003 QW111 = (385446)
2003 SP317 = (385458)
2004 OK14 = (385527)
2004 OR15 = (385528)
2004 QD29 = (385533)
2004 UP10 = (385571)
2005 EO297 = (385607)
2005 TO74 = (385695)
2009 YE7 = (386723)
2012 BR61 = (386968)

Objects recently assigned names:

2003 MW12 = Varda

Current number of TNOs: 1259 (including Pluto)
Current number of Centaurs/SDOs: 384
Current number of Neptune Trojans: 9

PAPERS ACCEPTED TO JOURNALS

Atlas of Three Body Mean Motion Resonances in the Solar System

T. Gallardo[1]

[1] Departamento de Astronomía, Instituto de Física, Facultad de Ciencias, Universidad de la República, Iguá 4225, 11400 Montevideo, Uruguay

We present a numerical method to estimate the strengths of arbitrary three body mean motion resonances between two planets in circular coplanar orbits and a massless particle in an arbitrary orbit. This method allows us to obtain an atlas of the three body resonances in the Solar System showing where are located and how strong are thousands of resonances involving all the planets from 0 to 1000 au. This atlas confirms the dynamical relevance of the three body resonances involving Jupiter and Saturn in the asteroid belt but also shows the existence of a family of relatively strong three body resonances involving Uranus and Neptune in the far Trans-Neptunian region and relatively strong resonances involving terrestrial and jovian planets in the inner planetary system. We calculate the density of relevant resonances along the Solar System resulting that the main asteroid belt is located in a region of the planetary system with the lowest density of three body resonances. The method also allows the location of the equilibrium points showing the existence of asymmetric librations ($\sigma \neq 0°$ or $180°$). We obtain the functional dependence of the resonance's strength with the order of the resonance and the eccentricity and inclination of the particle's orbit. We identify some objects evolving in or very close to three body resonances with Earth-Jupiter, Saturn-Neptune and Uranus-Neptune apart from Jupiter-Saturn, in particular the NEA 2009 SJ18 is evolving in the resonance 1-1E-1J and the centaur 10199 Chariklo is evolving under the influence of the resonance 5-2S-2N.

To appear in: Icarus
For preprints, contact gallardo@fisica.edu.uy
or on the web at http://www.fisica.edu.uy/~gallardo/atlas

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Dynamical formation of Detached Trans-Neptunian Objects Close to the 2:5 and 1:3 Mean Motion Resonances with Neptune

P.I.O Brasil[1], **R.S. Gomes**[2], **and J.S. Soares**[2]

[1] Instituto Nacional de Pesquisas Espaciais (INPE), ETE/DMC, Av. dos Astronautas, 1758, São José dos Campos, Brazil

[2] Observatório Nacional (ON), GPA, Rua General José Cristino, 77, Rio de Janeiro, Brazil

It is widely accepted that the past dynamical history of the solar system included a scattering of planetesimals from a primordial disk by the major planets. The primordial scattered population is likely the origin of the current scattering disk and possibly the detached objects. In particular, an important argument has been presented for the case of 2004 XR_{190} as having an origin in the primordial scattered disk through a mechanism including the 3:8 mean motion resonance (MMR) with Neptune (Gomes 2011). Here we aim at developing a similar study for the cases of the 1:3 and 2:5 resonances that are stronger than the 3:8 resonance. Through a semi-analytic approach of the Kozai resonance inside a MMR, we show phase diagrams (e, ω) that suggest the possibility of a scattered particle, after being captured in a mean motion resonance with Neptune, to become a detached object. We ran several numerical integrations with thousands of particles perturbed by the four major planets, and there are cases with and without Neptune's residual migration. These were developed to check the semi-analytic approach and to better understand the dynamical mechanisms that produce the detached objects close to a MMR. The numerical simulations with and without a residual migration for Neptune stress the importance of a particular resonance mode, which we name the hibernating mode, on the formation of fossilized detached objects close to MMRs. When considering Neptune's residual migration we are able to show the formation of detached orbits. These objects are fossilized and cannot be trapped in the MMRs again. We find a ratio of the number of fossilized objects with moderate perihelion distance ($35 < q < 40$ au) to the number of objects with high perihelion distance ($q > 40$ au) as 3.0/1 for objects close to the 2:5, and 1.7/1 for objects close to the 1:3 resonance. We estimate that the two fossilized population have a total mass between 0.1 and 0.3 Pluto's mass.

To appear in: Astronomy & Astrophysics
For preprints, contact pedro_brasil87@hotmail.com

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Complete Tidal Evolution of Pluto-Charon

W.H. Cheng[1], M.H. Lee[1,2], and S.J. Peale[3]

[1] Department of Earth Sciences, The University of Hong Kong, Pokfulam Road, Hong Kong
[2] Department of Physics, The University of Hong Kong, Pokfulam Road, Hong Kong
[3] Department of Physics, University of California, Santa Barbara, CA 93106, USA

Both Pluto and its satellite Charon have rotation rates synchronous with their orbital mean motion. This is the theoretical end point of tidal evolution where transfer of angular momentum has ceased. Here we follow Pluto's tidal evolution from an initial state having the current total angular momentum of the system but with Charon in an eccentric orbit with semimajor axis $a \approx 4R_P$ (where R_P is the radius of Pluto), consistent with its impact origin. Two tidal models are used, where the tidal dissipation function $Q \propto 1/\text{frequency}$ and $Q = \text{constant}$, where details of the evolution are strongly model dependent. The inclusion of the gravitational harmonic coefficient C_{22} of both bodies in the analysis allows smooth, self consistent evolution to the dual synchronous state, whereas its omission frustrates successful evolution in some cases. The zonal harmonic J_2 can also be included, but does not cause a significant effect on the overall evolution. The ratio of dissipation in Charon to that in Pluto controls the behavior of the orbital eccentricity, where a judicious choice leads to a nearly constant eccentricity until the final approach to dual synchronous rotation. The tidal models are complete in the sense that every nuance of tidal evolution is realized while conserving total angular momentum — including temporary capture into spin-orbit resonances as Charon's spin decreases and damped librations about the same.

To appear in: Icarus
Preprints available on the web at http://arxiv.org/abs/1402.0625

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A Peculiar Stable Region Around Pluto

S.M. Giuliatti Winter[1], O.C. Winter[1], E. Vieira Neto[1], and R. Sfair[1]
[1] UNESP - Univ. Estadual Paulista, Guaratinguetá, CEP 12516-410, SP, Brazil

Giuliatti Winter et al. 2010 found several stable regions for a sample of test particles located between the orbits of Pluto and Charon. One peculiar stable region in the space of the initial orbital elements is located at $a = (0.5d, 0.7d)$ and $e = (0.2, 0.9)$, where a and e are the initial semi-major axis and eccentricity of the particles, respectively, and d is the Pluto-Charon distance. This peculiar region (hereafter called sailboat region) is associated to a family of periodic orbits derived from the circular, restricted 3-body problem (Pluto-Charon-particle). In the present work we study the origin of this stable region by analysing the evolution of such family of periodic orbits. We show that they are not in resonances with Charon. The period of the periodic orbit varies along the family. The period decreases with the increase of the Jacobi Constant. We also explored the extent of the sailboat region by adopting different initial values of the orbital inclination (I) and argument of the pericentre (ω) of the particles. The sailboat region is present for $I = [0°, 90°]$, and for two intervals of ω: $\omega = [-10°, 10°]$ and $\omega = (160°, 200°)$. A crude estimative of the size of the hypothetical bodies located at the sailboat region can be derived by computing the tidal damping in their eccentricities. If we neglect the orbital evolution of Pluto and Charon, the timescale for circularization of their orbits is smaller than the age of the Solar System if these bodies were smaller than 500m in radius.

To appear in: Monthly Notices of the Royal Astronomical Society
For preprints, contact silvia@feg.unesp.br

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Origin of the Peculiar Eccentricity Distribution of the Inner Cold Kuiper Belt

A. Morbidelli[1], H. Gaspar[2], and D. Nesvorny[3]
[1] Observatoire de la Côte d'Azur, Nice, France
[2] Univ. Estadual Paulista, Guaratinguetá, Brazil
[3] Southwest Research Institute, Boulder, Colorado

Dawson and Murray-Clay (2012) pointed out that the inner part of the cold population in the Kuiper belt (that with semi major axis $a < 43.5$ AU) has orbital eccentricities significantly smaller than the limit imposed by stability constraints. Here, we confirm their result by looking at the orbital distribution and stability properties in proper element space. We show that the observed distribution could have been produced by the slow sweeping of the 4/7 mean motion resonance with Neptune that accompanied the end of Neptune's migration process. The orbital distribution of the hot Kuiper belt is not significantly affected in this process, for the reasons discussed in the main text. Therefore, the peculiar eccentricity distribution of the inner cold population can not be unequivocally interpreted as evidence that the cold population formed in-situ and was only moderately excited in eccentricity; it can simply be the signature of Neptune's radial motion, starting from a moderately eccentric orbit. We discuss how this agrees with a scenario of giant planet evolution following a dynamical instability and, possibly, with the radial transport of the cold population.

To appear in: Icarus
Preprints available on the web at http://arxiv.org/abs/1312.7536

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"TNOs are Cool": A Survey of the Trans-Neptunian Region, XI: A Herschel-PACS View of 16 Centaurs

R. Duffard[1], N. Pinilla-Alonso[1,2], P. Santos-Sanz[1], E. Vilenius[3], J.L. Ortiz[1], T. Mueller[3], S. Fornasier[4], E. Lellouch[4], M. Mommert[5], A. Pal[6], C. Kiss[6], M. Mueller[7], J. Stansberry[8], A. Delsanti[9], N. Peixinho[10], and D. Trilling[11]

[1] Instituto de Astrofísica de Andalucia - CSIC, Glorieta de la Astronomía s/n, Granada, Spain

[2] Department of Earth and Planetary Sciences, University of Tennessee, 1412 Circle Dr, Knoxville TN 37996-1410, USA

[3] Max-Planck-Institut für extraterrestrische Physik, Postfach 1312, Giessenbachstr., 85741 Garching, Germany

[4] LESIA-Observatoire de Paris, CNRS, UPMC Univ. Paris 6, Univ. Paris-Diderot, 5 place J. Janssen, 92195 Meudon Cedex, France

[5] Deutsches Zentrum fur Luft- und Raumfahrt e.V., Institute of Planetary Research, Rutherfordstr. 2, 12489 Berlin, Germany

[6] Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Konkoly Thege 15-17, H-1121 Budapest, Hungary

[7] SRON, Netherlands Institute for Space Research, Low Energy Astrophysics, Groningen, Netherlands

[8] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore MD 21218. USA

[9] Laboratoire d'Astrophysique de Marseille, CNRS & Universite de Provence, 38 rue Frédéric Joliot-Curie, 13388 Marseille Cedex 13, France

[10] Unidad de Astronomía, Fac. de Ciencias Básicas, Universidad de Antofagasta, Avda. U. de Antofagasta 02800, Antofagasta, Chile

[11] Department of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ 86001, USA

Centaurs are the transitional population between trans-Neptunian objects (TNOs) and Jupiter-family comets. Their physical properties provide an insight into TNO properties, but only under restricted conditions since Centaurs are closer to the Sun and Earth. For this reason it is possible to access the smaller ones, which is more difficult to do with the TNO population. The goal of this work is to characterize a set of 16 Centaurs in terms of their size, albedo, and thermal properties. We study the correlations, for a more extended sample obtained from the literature, of diameter, albedo, orbital parameters, and spectral slopes.

We performed three-band photometric observations using Herschel-PACS and used a consistent method for the data reduction and aperture photometry of this sample to obtain monochromatic flux densities at 70, 100, and 160 μm. Additionally, we used Spitzer-MIPS flux densities at 24 and 70 μm when available. We also included in our Centaur sample scattered disk objects (SDOs), a dynamical family of TNOS, using results previously published by our team, and some Centaurs observed only with the Spitzer/MIPS instrument. We have determined new radiometric sizes and albedos of 16 Centaurs. The first conclusion is that the albedos of Centaur objects are not correlated with their orbital parameters. Similarly, there is no correlation between diameter and orbital parameters. Most of the objects in our sample are dark ($pv < 7\%$) and most of them are small ($D < 120$ km). However, there is no correlation between albedo and diameter, in particular for the group of the small objects as albedo values are homogeneously distributed between 4 to 16%. The correlation with the color of the objects showed that red objects are all small (mean diameter 65 km), while the gray ones span a wide range of sizes (mean diameter 120 km). Moreover, the gray objects tend to be darker, with a mean albedo of 5.6%, compared with a mean of 8.5% (ranging from 5 to 15%) for the red objects.

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For preprints, contact duffard@iaa.es

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The Absolute Magnitude Distribution of Kuiper Belt Objects

Wesley C. Fraser[1,2], Michael E. Brown[2], Alessandro Morbidelli[3], Alex Parker[4], and Konstantin Batygin[5]

[1] Herzberg Institute of Astrophysics, 5071 W. Saanich Rd. Victoria, BC V9E 2E7, Canada

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

[3] Laboratoire Lagrange, UMR7293, Université de Nice Sophia-Antipolis, CNRS, Observatoire de la Côte d'Azur, France

[4] Department of Astronomy, University of California at Berkeley, Berkeley, CA, 94720, USA

[5] Institute for Theory and Computation, Harvard-Smithsonian Center for Astrophysics, 60 Garden St. MS 51, Cambridge MA 02138, USA

Here we measure the absolute magnitude distributions (H-distribution) of the dynamically excited and quiescent (hot and cold) Kuiper Belt objects (KBOs), and test if they share the same H-distribution as the Jupiter Trojans. From a compilation of all useable ecliptic surveys, we find that the KBO H-distributions are well described by broken power-laws. The cold population has a bright-end slope, $\alpha_1 = 1.5^{+0.4}_{-0.2}$, and break magnitude, $H_B = 6.9^{+0.1}_{-0.2}$ (r'-band). The hot population has a shallower bright-end slope of $\alpha_1 = 0.87^{+0.07}_{-0.2}$, and break magnitude $H_B = 7.7^{+1.0}_{-0.5}$. Both populations share similar faint end slopes of $\alpha_2 \sim 0.2$. We estimate the masses of the hot and cold populations are ~ 0.01 and $\sim 3 \times 10^{-4}$ $M_\oplus$. The broken power-law fit to the Trojan H-distribution has $\alpha_1 = 1.0 \pm 0.2$, $\alpha_2 = 0.36 \pm 0.01$, and $H_B = 8.3$. The KS test reveals that the probability that the Trojans and cold KBOs share the same parent H-distribution is less than 1 in 1000. When the bimodal albedo distribution of the hot objects is accounted for, there is no evidence that the H-distributions of the Trojans and hot KBOs differ. Our findings are in agreement with the predictions of the Nice model in terms of both mass and H-distribution of the hot and Trojan populations. Wide field survey data suggest that the brightest few hot objects, with $H_{r'} \lesssim 3$, do not fall on the steep power-law slope of fainter hot objects. Under the standard hierarchical model of planetesimal formation, it is difficult to account for the similar break diameters of the hot and cold populations given the low mass of the cold belt.

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For preprints, contact `wesley.fraser@nrc.ca`
or on the web at `http://arxiv.org/abs/1401.2157`

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Rotationally Resolved Spectroscopy of (20000) Varuna in the Near-infrared

V. Lorenzi[1], N. Pinilla-Alonso[2], J. Licandro[3], C.M. Dalle Ore[4] and J.P. Emery[2]

[1] Fundación Galileo Galilei-INAF, Spain

[2] University of Tennessee, TN, USA

[3] Instituto Astrofísico de Canarias, IAC, Spain

[4] Carl Sagan Center, SETI Institute and NASA Ames Research Center, CA, USA

Context. Models of the escape and retention of volatiles by minor icy objects exclude any presence of volatile ices on the surface of trans-Neptunian objects (TNOs) smaller than ~ 1000 km in diameter at the typical temperature in this region of the solar system, whereas the same models show that water ice is stable on the surface of objects over a wide range of diameters. Collisions and cometary activity have been used to explain the process of surface refreshing of TNOs and

Centaurs. These processes can produce surface heterogeneity that can be studied by collecting information at different rotational phases.

Aims. The aims of this work are to study the surface composition of (20000) Varuna, a TNO with a diameter 668^{+154}_{-86} km and to search for indications of rotational variability.

Methods. We observed (20000) Varuna during two consecutive nights in January 2011 with the near-infrared camera and spectrometer NICS at the Telescopio Nazionale Galileo, La Palma, Spain. We used the low resolution mode with the AMICI prism to obtain a set of spectra covering the whole rotation period of Varuna ($Pr = 6.34$ hr). We fit the resulting relative reflectance with radiative transfer models of the surface of atmosphereless bodies.

Results. After studying the spectra corresponding to different rotational phases of Varuna, we did not find any indication of surface variability at 2σ level. In all the spectra, we detect an absorption at 2.0 μm, suggesting the presence of water ice on the surface. We do not detect any other volatiles on the surface, although the S/N is not high enough to discard their presence in small quantities. Based on scattering models, we present two possible compositions compatible with our set of data and discuss their implications in the framework of the collisional history of the trans-Neptunian belt.

Conclusions. We find that the most probable composition for the surface of Varuna is a mixture of amorphous silicates, complex organics, and water ice. This composition is compatible with all the materials being primordial, so no replenishment mechanism is needed in the equation. However, our data can also be fitted by models containing up to a 10% of methane ice. For an object with the characteristics of Varuna, this volatile could not be primordial, so an event, such as an energetic impact, would be needed to explain its presence on the surface.

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Preprints available on the web at `http://arxiv.org/abs/1401.5962`
and `http://dx.doi.org/10.1051/0004-6361/201322251`

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Near-Infrared Spectral Monitoring of Pluto's Ices II: Recent Decline of CO and N_2 Ice Absorptions

W.M. Grundy[1,2], C.B. Olkin[2,3], L.A. Young[2,3], and B.J. Holler[2,4]

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

[2] Visiting/remote observer at the Infrared Telescope Facility, operated by the University of Hawaii under Cooperative Agreement NNX-08AE38A with the National Aeronautics and Space Administration, Science Mission Directorate, Planetary Astronomy Program

[3] Southwest Research Institute, 1050 Walnut St., #300, Boulder CO 80302, USA

[4] Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder, 1234 Innovation Dr., Boulder CO 80303, USA

IRTF/SpeX observations of Pluto's near-infrared reflectance spectrum during 2013 show vibrational absorption features of CO and N_2 ices at 1.58 and 2.15 μm, respectively, that are weaker than had been observed during the preceding decade. To reconcile declining volatile ice absorptions with a lack of decline in Pluto's atmospheric pressure, we suggest these ices could be getting harder to see because of increasing scattering by small CH_4 crystals, rather than because they are disappearing from the observed hemisphere.

To appear in: Icarus
Preprints available on the web at
`http://www2.lowell.edu/~grundy/abstracts/2014.IRTF-Pluto.html`

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Pluto and Charon's UV Spectra From IUE to New Horizons

Eric Schindhelm[1], Alan Stern[1], Randy Gladstone[2], and Amanda Zangari[1]

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

[2] Southwest Research Institute, San Antonio, TX, USA

We compare Mid-Ultraviolet (MUV) spectra of Pluto taken over a period of 20 years by the International Ultraviolet Explorer, the HST-Faint Object Spectrograph, and the HST-Cosmic Origins Spectrograph. We extract Pluto-only spectra from the IUE data and associate them with corrected longitudes when necessary. Comparing them with HST spectra provides further evidence of temporal changes in Pluto's geometric albedo between 2000 and 3200 Å. These various spectra are used to explore the contributions of atmospheric or surface changes to Pluto's reflectance. We also provide predictions for the Far-Ultraviolet (FUV) surface reflectance and atmospheric emission spectra of Pluto that will be measured by the Alice spectrograph (Stern et al. 2008) during the New Horizons flyby of Pluto in 2015. FUV surface reflectance predictions are also made for Charon, Hydra, and Nix.

To appear in: Icarus

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First Ultraviolet Reflectance Measurements of Several KBOs, KBO Satellites, and New Ultraviolet Measurements of a Centaur

S.A. Stern[1], N.J. Cunningham[2], and E. Schindhelm[1]

[1] Southwest Research Institute, 1050 Walnut Street, Boulder, CO 80302, USA

[2] Nebraska Wesleyan University, 5000 Saint Paul Avenue, Lincoln, NE 68504, USA

We observed the 2600–3200 Å (hereafter, mid-UV) reflectance of two Kuiper Belt Objects (KBOs), two KBO satellites, and a Centaur, using the Hubble Space Telescope (HST) Cosmic Origins Spectrograph (COS). Other than measurements of the Pluto system, these constitute the first UV measurements obtained of KBOs, and KBO satellites, and new HST UV measurements of the Centaur 2060 Chiron. We find significant differences among these objects, constrain the sizes and densities of Haumea's satellites, and report the detection of a possible spectral absorption band in Haumea's spectrum near 3050 Å. Comparisons of these objects to previously-published UV reflectance measurements of Pluto and Charon are also made here.

To appear in: The Astronomical Journal

For preprints, contact `astern@swri.edu`

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Transient Atmospheres on Charon and Water-Ice Covered KBOs Resulting from Comet Impacts

S. Alan Stern[1], Randall Gladstone[2], Amanda Zangari[1], Thadeus Fleming[3], and David Goldstein[3]

[1] Southwest Research Institute, 1050 Walnut Street, Boulder, CO 80302, USA

[2] Southwest Research Institute, 6220 Culebra Rd, San Antonio, TX 78238, USA

[3] University of Texas, Austin, TX 78212, USA

Evidence from stellar occultation datasets and Charon's H_2O-ice dominated surface composition has long suggested a lack of any current atmosphere around this satellite planet. However, impacts from both Kuiper Belt and Oort Cloud comets must from time to time import N_2, CH_4, and other cometary super-volatiles that can create temporary atmospheres around Charon. Here we estimate the frequency of such cometary impacts on Charon and the imported mass of super-volatiles from each such impact. We then examine the characteristics of such transient atmospheric events, including their column densities, mean molecular weights, scale heights, and loss timescales. We then report on the detectability of such a transient atmosphere by New Horizons, and discuss the generalized case of cometary impact-created transient atmospheres on other satellites of Pluto and water-ice covered KBOs across the Kuiper Belt.

To appear in: Icarus

For preprints, contact `astern@swri.edu`

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Interplanetary Dust Flux to the Pluto-Charon System

A.R. Poppe[1]

[1] Space Sciences Laboratory, University of California at Berkeley, Berkeley, CA, 94720, USA

The influx of interplanetary dust grains (IDPs) to the Pluto-Charon system is expected to drive several physical processes, including the formation of tenuous dusty rings and/or exospheres, the deposition of neutral material in Pluto's atmosphere through ablation, the annealing of surface ices, and the exchange of ejecta between Pluto and its satellites. The characteristics of these physical mechanisms are dependent on the total incoming mass, velocity, variability, and composition of interplanetary dust grains; however, our knowledge of the IDP environment in the Edgeworth-Kuiper Belt has, until recently, remained rather limited. Newly-reported measurements by the New Horizons Student Dust Counter combined with previous Pioneer 10 meteoroid measurements and a dynamical IDP tracing model have improved the characterization of the IDP environment in the outer solar system, including at Pluto-Charon. Here we report on this modeling and data comparison effort, including a discussion of the IDP influx to Pluto and its moons, and the implications thereof.

To appear in: Icarus

For preprints, contact `poppe@ssl.berkeley.edu`

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Pan-STARRS 1 Observations of the Unusual Active Centaur P/2011 S1 (Gibbs)

H.W. Lin[1], Y.T. Chen[2], P. Lacerda[3], W.H. Ip[1], M. Holman[4], P. Protopapas[4], W.P. Chen[1], W.S. Burgett[5], K.C. Chambers[5], H. Flewelling[5], M.E. Huber[5], R. Jedicke[5], N. Kaiser[5], E.A. Magnier[5], N. Metcalfe[5], and P.A. Price[6]

[1] Institute of Astronomy, National Central University, Taoyuan 32001, Taiwan

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

[3] Astrophysics Research Centre, School of Mathematics and Physics, Queen's University Belfast, Belfast BT7 1NN, UK

[4] Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

[5] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu HI 96822, USA

[6] Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544, USA

P/2011 S1 (Gibbs) is an outer solar system comet or active Centaur with a similar orbit to that of the famous 29P/Schwassmann-Wachmann 1. P/2011 S1 (Gibbs) has been observed by the Pan-STARRS 1 (PS1) sky survey from 2010 to 2012. The resulting data allow us to perform multi-color studies of the nucleus and coma of the comet. Analysis of PS1 images reveals that P/2011 S1 (Gibbs) has a small nucleus < 4 km radius, with colors $g_{P1} - r_{P1} = 0.5 \pm 0.02$, $r_{P1} - i_{P1} = 0.12 \pm 0.02$ and $i_{P1} - z_{P1} = 0.46 \pm 0.03$. The comet remained active from 2010 to 2012, with a model-dependent mass-loss rate of ~ 100 kg s^{-1}. The mass-loss rate per unit surface area of P/2011 S1 (Gibbs) is as high as that of 29P/Schwassmann-Wachmann 1, making it one of the most active Centaurs. The mass-loss rate also varies with time from ~ 40 kg s^{-1} to 150 kg s^{-1}. Due to its rather circular orbit, we propose that P/2011 S1 (Gibbs) has 29P/Schwassmann-Wachmann 1-like outbursts that control the outgassing rate. The results indicate that it may have a similar surface composition to that of 29P/Schwassmann-Wachmann 1.

Our numerical simulations show that the future orbital evolution of P/2011 S1 (Gibbs) is more similar to that of the main population of Centaurs than to that of 29P/Schwassmann-Wachmann 1. The results also demonstrate that P/2011 S1 (Gibbs) is dynamically unstable and can only remain near its current orbit for roughly a thousand years.

To appear in: The Astronomical Journal

Preprints available on the web at `http://arxiv.org/abs/1402.6403`

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The Size and Shape of the Oblong Dwarf Planet Haumea

Alexandra C. Lockwood[1], Michael E. Brown[1], and John Stansberry[2]

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

[2] JWST/NIRCam Team, Space Telescope Science Institute, Baltimore, MD 21218, USA

We use thermal radiometry and visible photometry to constrain the size, shape, and albedo of the large Kuiper belt object Haumea. The correlation between the visible and thermal photometry demonstrates that Haumea's high amplitude and quickly varying optical light curve is indeed due to Haumea's extreme shape, rather than large scale albedo variations. However, the well-sampled high precision visible data we present does require longitudinal surface heterogeneity to account for the shape of lightcurve. The thermal emission from Haumea is consistent with the expected Jacobi ellipsoid shape of a rapidly rotating body in hydrostatic equilibrium. The best Jacobi ellipsoid fit to the visible photometry implies a triaxial ellipsoid with axes of length 1920 x 1540 x 990 km

and density 2.6 g cm^{-3}, as found by Lellouch et al. (2010). While the thermal and visible data cannot uniquely constrain the full non-spherical shape of Haumea, the match between the predicted and measured thermal flux for a dense Jacobi ellipsoid suggests that Haumea is indeed one of the densest objects in the Kuiper belt.

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For preprints, contact alock@caltech.edu
or on the web at http://arxiv.org//abs/1402.4456

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The UT 7/8 February 2013 Sila-Nunam Mutual Event & Future Predictions

S.D. Benecchi[1,2], K.S. Noll[3], A. Thirouin[4], E. Ryan[3], W.M. Grundy[5], A. Verbiscer[6], A. Doressoundiram[7], D. Hestroffer[8], R. Beaton[6], D. Rabinowitz[9], and N. Chanover[10]

[1]Planetary Science Institute, 1700 East Fort Lowell, Suite 106, Tucson, AZ 85719, USA

[2] Carnegie Institution of Washington, Department of Terrestrial Magnetism, 5241 Broad Branch Road, NW, Washington, DC 20015, USA

[3] NASA Goddard Space Fight Center, 8800 Greenbelt Rd. Code 693, Greenbelt, MD 20771, USA

[4] Instituto de Astrofísica de Andalucía (IAA-CSIC), Glorieta de la Astronomia S/N 18080, Granada, Spain

[5] Lowell Observatory, 1400 W Mars Hill Rd Flagstaff, AZ 86001, USA

[6] University of Virginia, Department of Astronomy, PO Box 400325, Charlottesville, VA 22904, USA

[7] Observatoire de Paris, 5 Place Jules Janssen, Lesia, Meudon, Cedex 92195, France

[8] IMCCE/ Observatoire de Paris, 77 Av. Denfert-Rochereau, Paris, F-74014, France

[9] Yale University, Department of Physics, P.O. Box 208120, New Haven, CT 06520, USA

[10] New Mexico State University, Astronomy Department, Box 30001/MSC 4500, Las Cruces, NM 88003, USA

A superior mutual event of the Kuiper Belt binary system (79360) Sila-Nunam was observed over 15.47 hours on UT 7/8 February 2013 by a coordinated effort at four different telescope facilities; it started $\sim$ 1.5 hours earlier than anticipated, the duration was $\sim$ 9.5 hours (about 10% longer than predicted), and was slightly less deep then predicted. It is the first full event observed for a comparably sized binary Kuiper Belt object. We provide predictions for future events refined by this and other partial mutual event observations obtained since the mutual event season began.some of our objects; our values are not significantly different from those presented in the literature for other samples.

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Candidate Stellar Occultations by Centaurs and Trans-Neptunian Objects up to 2014

J.I.B. Camargo[1], R. Vieira-Martins[1,2], M. Assafin[2], F. Braga-Ribas[1,3], B. Sicardy[3,4], J. Desmars[1], A.H. Andrei[1,2], G. Benedetti-Rossi[1], and A. Dias-Oliveira[1,3]

[1] Observatório Nacional/MCTI, R. General José Cristino 77, CEP 20921-400, Rio de Janeiro, RJ, Brazil

[2] Observatório do Valongo/UFRJ, Ladeira do Pedro Antônio 43, CEP 20080-090, Rio de Janeiro, RJ, Brazil

[3] Observatoire de Paris-Meudon/LESIA, 5 place Jules Janssen, 92195 Meudon, France

[4] Université Pierre et Marie Curie, Institut Universitaire de France, Paris, France

Context. We study trans-Neptunian objects (TNOs) from stellar occultations.

Aims. We predict stellar occultations from 2012.5 to the end of 2014 by 5 Centaurs and 34 TNOs.

Methods. These predictions were achieved in two ways: first, we built catalogues with precise astrometric positions of the stellar content around the paths on the sky of these targets, as seen by a ground-based observer; second, the observed positions of the targets were determined with the help of these same catalogues so that we could improve their ephemerides and the reliability of the predictions. The reference system is the International Celestial Reference System (ICRS) as realised by the Fourth US Naval Observatory CCD Astrograph Catalog (UCAC4). All the sky paths as well as the selected targets were observed from Oct. 2011 to May 2013 with the ESO/MPG 2.2 m telescope equipped with the Wide Field Imager (WFI). All astrometric results were obtained with the platform for reduction of astronomical images automatically (PRAIA) after correcting the images for overscan, bias, and flatfield.

Results. The catalogues with the stellar content around the sky path of each selected target are complete down to magnitude $R = 19$ and have an average positional accuracy of about 50 milliarcseconds. This same average accuracy also holds for the observed positions of the targets. In the catalogues from the sky paths, stellar proper motions for non-UCAC4 objects were derived from the combination of the current epoch WFI observations with either the 2MASS or the USNO-B1 catalogues. The offsets between the observed and (JPL) ephemeris positions of the targets frequently reach absolute values of some hundreds of milliarcseconds.

Conclusions. We present here stellar occultation predictions for the selected 5 Centaurs and 34 TNOs from 2012.5 to the end of 2014. This work is also an extension of two previous prediction works by us, the first one for Pluto, Charon, Nix, and Hydra, and the second for ten other large TNOs. The use of catalogues from the observations of the sky paths in the astrometry of the TNOs and Centaurs enhanced the coherence between their positions and those of the respective occulted candidate stars. New observations of these TNOs and Centaurs are continuously used to redetermine their ephemerides.

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On the Use of Meteor Camera Systems in the Detection of Kuiper Belt Objects through Serendipitous Stellar Occultations

Dilini Subasinghe[1] and Paul A. Wiegert[1]

[1] Department of Physics and Astronomy, The University of Western Ontario, London, ON N6A 3K7, Canada

The direct detection of Kuiper Belt Objects (KBOs) by telescopic imaging is not currently practical for objects much less than 100 km in diameter. However, indirect methods such as serendipitous stellar occultations might still be employed to detect these bodies. The method of

serendipitous stellar occultations has been previously used with some success in detecting KBOs – Roques et al. (AJ 132(2):819-822, 2006) detected three Trans-Neptunian objects; Schlichting et al. (Nature 462(7275):895-897, 2009) and Schlichting et al. (ApJ 761:150, 2012) each detected a single object in archival Hubble Space Telescope data. However, previous assessments of KBO occultation detection rates have been calculated only for telescopes – we extend this method to video camera systems, and we apply this derivation to the automated meteor camera systems currently in use at the University of Western Ontario. We find that in a typical scenario we can expect one occultation per month. However recent studies such as those of Shankman et al. (ApJL 764. doi:10.1088/2041-8205/764/1/L2, 2013) and Gladman et al. (AAS/DPS Meeting Abstracts, 2012) which indicate that the population of small KBOs may be smaller than has been assumed in the past may result in a sharp reduction of these rates. Nonetheless, a survey for KBO occultations using existing meteor camera systems may provide valuable information about the number density of KBOs.

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For preprints, contact dsubasi@uwo.ca

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The Multifaceted Planetesimal Formation Process

A. Johansen[1], J. Blum[2], H. Tanaka[3], C. Ormel[4], M. Bizzarro[5], and H. Rickman[6,7]
[1] Lund University, Sweden
[2] Technische Universität Braunschweig, Germany
[3] Hokkaido University, Japan
[4] University of California, Berkeley, USA
[5] Copenhagen University, Denmark
[6] Uppsala University, Denmark
[7] Polish Academy of Sciences Space Research Center, Poland

Accumulation of dust and ice particles into planetesimals is an important step in the planet formation process. Planetesimals are the seeds of both terrestrial planets and the solid cores of gas and ice giants forming by core accretion. Left-over planetesimals in the form of asteroids, trans-Neptunian objects and comets provide a unique record of the physical conditions in the solar nebula. Debris from planetesimal collisions around other stars signposts that the planetesimal formation process, and hence planet formation, is ubiquitous in the Galaxy. The planetesimal formation stage extends from micrometer-sized dust and ice to bodies which can undergo run-away accretion. The latter ranges in size from 1 km to 1000 km, dependent on the planetesimal eccentricity excited by turbulent gas density fluctuations. Particles face many barriers during this growth, arising mainly from inefficient sticking, fragmentation and radial drift. Two promising growth pathways are mass transfer, where small aggregates transfer up to 50% of their mass in high-speed collisions with much larger targets, and fluffy growth, where aggregate cross sections and sticking probabilities are enhanced by a low internal density. A wide range of particle sizes, from mm to 10 m, concentrate in the turbulent gas flow. Overdense filaments fragment gravitationally into bound particle clumps, with most mass entering planetesimals of contracted radii from 100 to 500 km, depending on local disc properties. We propose a hybrid model for planetesimal formation where particle growth starts unaided by self-gravity but later proceeds inside gravitationally collapsing pebble clumps to form planetesimals with a wide range of sizes.

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Preprints available on the web at http://arxiv.org/abs/1402.1344

OTHER PAPERS OF INTEREST

Pluto and the Kuiper Belt

E. Lakdawalla

Sky and Telescope, 127, 18 (2014 February)

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Perihelion Advances for the Orbits of Mercury, Earth and Pluto from Extended Theory of General Relativity (ETGR)

Luis Santiago Ridao[1], Rodrigo Avalos[1], Martín Daniel De Cicco[1], Mauricio Bellini[1,2]

[1] Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata, Funes 3350, C.P. 7600, Mar del Plata, Argentina

[2] Instituto de Investigaciones Físicas de Mar del Plata (IFIMAR), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina

For preprints, contact `mbellini@mdp.edu.ar`
or on the web at `http://arxiv.org/abs/1402.4511v1`

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