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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

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NEWS & ANNOUNCEMENTS

There were 7 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2013 VQ25, 2014 UK231, 2015 GY51, 2015 KL167, 2015 KM167, 2015 KN167, 2015 VD157

and 2 new Centaur/SDO discoveries:

2017 YG5, 2017 YK3

Reclassified objects:

2013 PV74 (TNO → SDO)

Objects recently assigned numbers:

1995 WY2 = (508770)
2000 CQ114 = (508788)
2000 FX53 = (508792)
2001 RX143 = (508823)
2002 VT130 = (508869)
2013 WV107 = (511130)
2014 UD225 = (511551)
2014 UE225 = (511552)
2014 UK225 = (511553)
2014 UL225 = (511554)
2014 UM225 = (511555)

Objects recently assigned names:

1992 QB1 = Albion

Deleted objects:

2017 AB5

Current number of TNOs: 1916 (including Pluto)
Current number of Centaurs/SDOs: 742
Current number of Neptune Trojans: 17

Out of a total of 2675 objects:

699 have measurements from only one opposition
690 of those have had no measurements for more than a year
343 of those have arcs shorter than 10 days

(for more details, see: `http://www.boulder.swri.edu/ekonews/objects/recov_stats.jpg`)

PAPERS ACCEPTED TO JOURNALS

Multi-band Photometry of Trans-Neptunian Objects in the Subaru Hyper Suprime-Cam Survey

T. Terai[1], F. Yoshida[2,3], K. Ohtsuki[3], P.S. Lykawka[4], N. Takato[1], A. Higuchi[5], T. Ito[6], Y. Komiyama[6,7], S. Miyazaki[6,7], and S-Y. Wang[8]

[1] Subaru Telescope, National Astronomical Observatory of Japan, National Institutes of Natural Sciences (NINS), 650 North A'ohoku Place, Hilo, HI 96720, USA

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

[3] Department of Planetology, Graduate School of Science, Kobe University, 1-1 Rokkodai-cho, Nada-ku, Kobe, Hyogo 657-8501, Japan

[4] School of Interdisciplinary Social andHumanSciences, Kindai University, Shinkamikosaka 228-3, Higashiosaka, Osaka 577-0813, Japan

[5] RISE project office, National Astronomical Observatory of Japan, National Institutes of Natural Sciences (NINS), 2-12 Hoshigaoka, Mizusawa, Oshu, Iwate 023-0861, Japan

[6] National Astronomical Observatory of Japan, National Institutes of Natural Sciences (NINS), 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

[7] The Graduate University for Advanced Studies (SOKENDAI), 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

[8] Institute of Astronomy and Astrophysics, Academia Sinica, PO Box 23-141, Taipei 10617, Taiwan

We present visible multi-band photometry of trans-Neptunian objects (TNOs) observed by the Subaru Telescope in the framework of the Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP) from 2014 March to 2016 September. We measured the five broad-band (g, r, i, z, and Y) colors over the wavelength range from 0.4 μm to 1.0 μm for 30 known TNOs using the HSC-SSP survey data covering $\sim$500 deg^2 of sky within $\pm30^\circ$ of ecliptic latitude. This dataset allows us to investigate the correlations between the dynamical classes and visible reflectance spectra of TNOs. Our results show that the hot classical and scattered populations with orbital inclination (I) of $I \gtrsim 6^\circ$ share similar color distributions, while the cold classical population with $I \lesssim 6^\circ$ has a different color distribution from the others. The low-I population has reflectance increasing toward longer wavelengths up to $\sim$0.8 μm, with a steeper slope than the high-I population at $\lesssim$ 0.6 μm. We also find a significant anti-correlation between $g-r/r-i$ colors and inclination in the high-I population, as well as a possible bimodality in the $g-i$ color vs. eccentricity plot.

Published in: Publications of the Astronomical Society of Japan, 70, S40 (2018 January 1)

For preprints, contact tsuyoshi.terai@nao.ac.jp
or on the web at http://ads.nao.ac.jp/abs/2018PASJ...70S..40T

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The Wavelet Theory Applied to the Study of Spectra of Trans-Neptunian Objects

A.C. Souza-Feliciano[1], A. Alvarez-Candal[1], and Y. Jiménez-Teja[1]

[1] Observatório Nacional. General José Cristino street, 77. Rio de Janeiro. Brazil

Reflection spectroscopy in the Near Infrared (NIR) is used to investigate the surface composition of Trans-Neptunian objects (TNOs). In general, these spectra are difficult to interpret due to the low apparent brightness of the TNOs, causing low signal-to-noise ratio even in spectra obtained with the largest telescopes available on the Earth, making necessary to use filtering techniques to analyze and interpret them.

The purpose of this poster is to present a methodology to analyze the spectra of TNOs. Specifically, we aim at filtering these spectra in the best possible way: maximizing the remotion of noise, while minimizing the loss of signal. To do this, we use the wavelets technique. The wavelets are a mathematical tool that decomposes the signal into its constituent parts, allowing to analyze the data in different areas of frequencies with the resolution of each component tied to its scale. To check the reliability of our method, we compare the filtered spectra with spectra of water and methanol ices to identify some common structures between them.

Of the 50 TNOs of our sample, we identify traces of the presence of water ices and methanol in the spectra of several of them, some with previous reports, while some of these objects there were no previous reports. Therefore, we conclude that the wavelet technique is successful in filtering TNOs spectra.

To appear in: Astronomy & Astrophysics

For preprints, contact carolinaastro@on.br

or on the web at https://arxiv.org/abs/1801.09152

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The Trojan Color Conundrum

David Jewitt[1]

[1] Department of Earth, Planetary and Space Sciences, UCLA, 595 Charles Young Drive East, Los Angeles, CA 90095, USA

The Trojan asteroids of Jupiter and Neptune are likely to have been captured from original heliocentric orbits in the dynamically excited ("hot") population of the Kuiper belt. However, it has long been known that the optical color distributions of the Jovian Trojans and the hot population are not alike. This difference has been reconciled with the capture hypothesis by assuming that the Trojans were resurfaced (for example, by sublimation of near-surface volatiles) upon inward migration from the Kuiper belt (where blackbody temperatures are ∼40 K) to Jupiter's orbit (∼125 K). Here, we examine the optical color distribution of the *Neptunian* Trojans using a combination of new optical photometry and published data. We find a color distribution that is statistically indistinguishable from that of the Jovian Trojans but unlike any sub-population in the Kuiper belt. This result is puzzling, because the Neptunian Trojans are very cold (blackbody temperature ∼50 K) and a thermal process acting to modify the surface colors at Neptune's distance would also affect the Kuiper belt objects beyond, where the temperatures are nearly identical. The distinctive color distributions of the Jovian and Neptunian Trojans thus present us with a conundrum: they are very similar to each other, suggesting either capture from a common source or surface modification by a common process. However, the color distributions differ from any plausible common source population, and there is no known modifying process that could operate equally at both Jupiter and Neptune.

Published in: The Astronomical Journal, 155, 56 (2018 February)

Preprints available on the web at http://www2.ess.ucla.edu/~jewitt/papers/2018/J18a.pdf

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Albedo Matters: Understanding Runaway Albedo Variations on Pluto

A.M. Earle[1], R.P. Binzel[1], L.A. Young[2], S.A. Stern[2], K. Ennico[3], W. Grundy[4], C.B. Olkin[2], H.A. Weaver[5], and the New Horizons Surface Composition Theme Team

[1] Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

[2] Southwest Research Institute, Boulder, CO 80302, USA

[3] National Aeronautics and Space Administration (NASA) Ames Research Center, Space Science Division, Moffett Field, CA 94035, USA

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

[5] Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA

The data returned from NASA's New Horizons reconnaissance of the Pluto system show striking albedo variations from polar to equatorial latitudes as well as sharp longitudinal boundaries. Pluto has a high obliquity (currently 119°) that varies by 23° over a period of less than 3 million years. This variation, combined with its regressing longitude of perihelion (360° over 3.7 million years), creates epochs of "Super Seasons" where one pole is pointed at the Sun at perihelion, thereby experiencing a short, relatively warm summer followed by its longest possible period of winter darkness. In contrast, the other pole experiences a much longer, less intense summer and a short winter season. We use a simple volatile sublimation and deposition model to explore the relationship between albedo variations, latitude, and volatile sublimation and deposition for the current epoch as well as historical epochs during which Pluto experienced these "Super Seasons." Our investigation quantitatively shows that Pluto's geometry creates the potential for runaway albedo and volatile variations, particularly in the equatorial region, which can sustain stark longitudinal contrasts like the ones we see between Tombaugh Regio and the informally named Cthulhu Regio.

To appear in: Icarus, 303, 1 (2018 March 15)
For preprints, contact aearle@mit.edu
or on the web at http://adsabs.harvard.edu/abs/2018Icar..303....1E

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Solid-phase Equilibria on Pluto's Surface

Sugata P. Tan[1] and Jeffrey S. Kargel[1]

[1] Planetary Science Institute, Tucson, AZ 85719, USA

Pluto's surface is covered by volatile ices that are in equilibrium with the atmosphere. Multicomponent phase equilibria may be calculated using a thermodynamic equation of state and, without additional assumptions, result in methane-rich and nitrogen-rich solid phases. The former is formed at temperature range between the atmospheric pressure-dependent sublimation and condensation points, while the latter is formed at temperatures lower than the sublimation point. The results, calculated for the observed 11 microbar atmospheric pressure and composition, are consistent with recent work derived from observations by New Horizons.

To appear in: Monthly Notices of the Royal Astronomical Society, 474, 4254 (2018 March 1)
For preprints, contact stan@psi.edu
or on the web at http://adsabs.harvard.edu/abs/2018MNRAS.474.4254T

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Photochemistry on Pluto — I. Hydrocarbons and Aerosols

A. Luspay-Kuti[1], K.E. Mandt[1,2,3], K.-L. Jessup[1], J. Kammer[1], V. Hue[1], M. Hamel[1,2], and R. Filwett[1,2]

[1] Space Science and Engineering Division, Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78238, USA
[2] Department of Physics and Astronomy, University of Texas at San Antonio, One UTSA Blvd., San Antonio, TX 78249, USA
[3] Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD 20723, USA

In light of the recent *New Horizons* flyby measurements, we present a coupled ion-neutral-photochemistry model developed for simulating the atmosphere of Pluto. Our model results closely match the observed density profiles of CH_4, N_2 and the C_2 hydrocarbons in the altitude range where available *New Horizons* measurements are most accurate (above ∼100–200 km). We found a high eddy coefficient of 10^6 cm^2 s^{-1} from the surface to an altitude of 150 km, and 3×10^6 cm^2 s^{-1} above 150 km for Pluto's atmosphere. Our results demonstrate that C_2 hydrocarbons must stick to and be removed by aerosol particles in order to reproduce the C_2 profiles observed by *New Horizons*. Incorporation into aerosols in Pluto's atmosphere is a significantly more effective process than condensation, and we found that condensation alone cannot account for the observed shape of the vertical profiles. We empirically determined the sticking efficiency of C_2 hydrocarbons to aerosol particles as a function of altitude, and found that the sticking efficiency of C_2 hydrocarbons is inversely related to the aerosol surface area. Aerosols must harden and become less sticky as they age in Pluto's atmosphere. Such hardening with ageing is both necessary and sufficient to explain the vertical profiles of C_2 hydrocarbons in Pluto's atmosphere. This result is in agreement with the fundamental idea of aerosols hardening as they age, as proposed for Titan's aerosols.

Published in: Monthly Notices of the Royal Astronomical Society, 472, 104 (2017 November)
For preprints, contact aluspaykuti@swri.edu
or on the web at http://adsabs.harvard.edu/abs/2017MNRAS.472..104L

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Photochemistry on Pluto. Part II: HCN and Nitrogen Isotope Fractionation

K.E. Mandt[1,2,3], A. Luspay-Kuti[1], M. Hamel[2,1], K.-L. Jessup[1], V. Hue[1], J. Kammeri[1], and R. Filwett[2,1]

[1] Southwest Research Institute, 6220 Culebra Rd., San Antonio, TX 78238, USA
[2] University of Texas at San Antonio, San Antonio, TX, USA
[3] Johns Hopkins Applied Physics Laboratory, Laurel, MD, USA

We have converted our Titan one-dimensional photochemical model to simulate the photochemistry of Pluto's atmosphere and include condensation and aerosol trapping in the model. We find that condensation and aerosol trapping are important processes in producing the HCN altitude profile observed by the Atacama Large Millimeter Array (ALMA). The nitrogen isotope chemistry in Pluto's atmosphere does not appear to significantly fractionate the isotope ratio between N_2 and HCN as occurs at Titan. However, our simulations only cover a brief period of time in a Pluto year, and thus only a brief portion of the solar forcing conditions that Pluto's atmosphere experiences. More work is needed to evaluate photochemical fractionation over a Pluto year. Condensation and aerosol trapping appear to have a major impact on the altitude profile of the isotope ratio in HCN. Since ALMA did not detect HC^15N in Pluto's atmosphere, we conclude that condensation and aerosol trapping must be much more efficient for $HC^{15}N$ compared to $HC^{14}N$. The large uncertainty in photochemical fractionation makes it difficult to use any potential current measurement of $^{14}N/^{15}N$ in N_2 to determine the origin of Pluto's nitrogen. More work is needed

to understand photochemical fractionation and to evaluate how condensation, sublimation and aerosol trapping will fractionate N_2 and HCN.

Published in: Monthly Notices of the Royal Astronomical Society, 472, 118 (2017 November)
For preprints, contact Kathleen.Mandt@jhuapl.edu
or on the web at http://adsabs.harvard.edu/abs/2017MNRAS.472..118M

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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 for the Lempo system 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 the Lempo 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.

Published in: Icarus, 305, 250 (2018 May)
For preprints, contact correia@ua.pt
or on the web at http://adsabs.harvard.edu/abs/2018Icar..305..250C

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Producing Distant Planets by Mutual Scattering of Planetary Embryos

Kedron Silsbee[1] **and Scott Tremaine**[2]
[1] Department of Astrophysical Sciences, Princeton University, Ivy Lane, Princeton, NJ 08544, USA
[2] Institute for Advanced Study, 1 Einstein Drive, Princeton, NJ 08540, USA

It is likely that multiple bodies with masses between those of Mars and Earth ("planetary embryos") formed in the outer planetesimal disk of the solar system. Some of these were likely scattered by the giant planets into orbits with semi-major axes of hundreds of AU. Mutual torques between these embryos may lift the perihelia of some of them beyond the orbit of Neptune, where they are no longer perturbed by the giant planets so their semi-major axes are frozen in place. We conduct N-body simulations of this process, and its effect on smaller planetesimals in the region of the giant planets and the Kuiper belt. We find that (i) there is a significant possibility that one sub-Earth mass embryo, or possibly more, is still present in the outer solar system; (ii) the orbit of the surviving embryo(s) typically has perihelion of 40–70 AU, semi-major axis less than 200 AU, and inclination less than 30°; (iii) it is likely that any surviving embryos could be detected by current or planned optical surveys or have a significant effect on solar-system ephemerides; (iv) whether or not an embryo has survived to the present day, their dynamical influence earlier in the history of the solar system can explain the properties of the detached disk (defined in this paper as containing objects with perihelia >38 AU and semi-major axes between 80 and 500 AU).

To appear in: The Astronomical Journal
on the web at https://arxiv.org/abs/1712.03961

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Activity of (2060) Chiron Possibly Caused by Impacts?

S. Cikota[1], E. Fernández-Valenzuela[2], J.L. Ortiz[2], N. Morales[2], R. Duffard[2], J. Aceituno[3], A. Cikota[4], and P. Santos-Sanz[2]

[1] University of Zagreb, Faculty of Electrical Engineering and Computing, Department of Applied Physics, Unska 3, 10000 Zagreb, Croatia

[2] Instituto de Astrofísica de Andalucía - CSIC, Apt 3004, 18008 Granada, Spain

[3] Centro Astronómico Hispano Alemán de Calar Alto (CSIC-MPG), C/ Jesús Durbán Remón 2-2, E-4004 Almería, Spain.

[4] European Southern Observatory, Karl-Schwarzschild-Str. 2, 85748 Garching b. München, Germany

The centaur 95P/(2060) Chiron is showing comet-like activity since its discovery, but the mass-loss mechanisms triggering its activity remained unexplained. Although the collision rates in the centaur region are expected to be very low, and impacts are thought not to be responsible for the mass-loss, since the recent indications that Chiron might possess a ring similar to Chariklo's, and assuming that there is debris orbiting around, the impact triggered mass-loss mechanism should not be excluded as a possible cause of its activity. From time series observations collected on Calar Alto Observatory in Spain between 2014 and 2016, we found that the photometric scatter in Chiron's data is larger than a control star's scatter, indicating a possible microactivity, possibly caused by debris falling back to Chiron's surface and lifting small clouds of material. We also present rotational light curves, and measurements of Chiron's absolute magnitudes, that are consistent with the models supporting the presumption that Chiron possesses rings. By co-adding the images acquired in 2015, we have detected a $\sim$5 arcsec long tail, showing a surface brightness of 25.3 mag(V)/arcsec^2.

Published in: Monthly Notices of the Royal Astronomical Society, 475, 2512 (2018 April)

Available on the web at `http://adsabs.harvard.edu/abs/2018MNRAS.475.2512C`

PAPERS RECENTLY SUBMITTED TO JOURNALS

The New Horizons Kuiper Belt Extended Mission

S.A. Stern[1], H.A. Weaver[2], and J.R. Spencer[1], H.A. Elliott[3], and the New Horizons Team

[1] Southwest Research Institute, 1050 Walnut St., Suite 300, Boulder, CO 80302, USA

[2] Johns Hopkins Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723, USA

[3] Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78238, USA

The central objective of the New Horizons prime mission was to make the first exploration of Pluto and its system of moons. Following that, New Horizons has been approved for its first extended mission, which has the objectives of extensively studying the Kuiper Belt environment, observing numerous Kuiper Belt Objects (KBOs) and Centaurs in unique ways, and making the first close flyby of the KBO 486958 2014 MU_{69}. This review summarizes the objectives and plans for this approved mission extension, and briefly looks forward to potential objectives for subsequent extended missions by New Horizons.

Submitted to: Space Science Reviews

For preprints, contact `astern@swri.edu`

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OSSOS: VIII. Two Size Distribution Slopes in the Scattering Disk

S.M. Lawler[1], C. Shankman[2,1,3], JJ. Kavelaars[1,2], M. Alexandersen[4], M.T. Bannister[5], Y.-T. Chen[4], B. Gladman[6], W. C. Fraser[5], S. Gwyn[1], N. Kaib[7], J.-M. Petit[8], and K. Volk[9]

[1] NRC-Herzberg Astronomy and Astrophysics, National Research Council of Canada, Victoria, BC, Canada

[2] Department of Physics and Astronomy, University of Victoria, Victoria, BC, Canada

[3] City of Toronto, Toronto, ON, Canada

[4] Institute of Astronomy and Astrophysics, Academia Sinica, Taipei, Taiwan

[5] Astrophysics Research Centre, Queen's University Belfast, Belfast, UK

[6] Department of Physics and Astronomy, The University of British Columbia, Vancouver, BC, Canada

[7] HL Dodge Department of Physics & Astronomy, University of Oklahoma, Norman, OK, USA

[8] Institut UTINAM, UMR 6213 CNRS-Université de Franche Comté, Besançon, France

[9] Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA

The scattering trans-Neptunian Objects (TNOs) can be measured to smaller sizes than any other distant small-body population. We use the largest sample yet obtained, 68 discoveries by the Outer Solar System Origins Survey (OSSOS), to constrain the slope of its luminosity distribution, with sensitivity to much fainter absolute H magnitudes than previous work. Using the analysis technique in Shankman et al. (2016), we confirm that a single slope for the H-distribution is not an accurate representation of the scattering TNOs and Centaurs, and that a break in the distribution is required, in support of previous conclusions. A bright-end slope of $\alpha_b = 0.9$ transitioning to a faint-end slope α_f of 0.4-0.5 with a differential number contrast c from 1 (a knee) to 10 (a divot) provides an acceptable match to our data. We find that break magnitudes H_b of 7.7 and 8.3, values both previously suggested for dynamically hot Kuiper belt populations, are equally non-rejectable for a range of α_f and c in our statistical analysis. Our preferred divot H-distribution transitions to $\alpha_f = 0.5$ with a divot of contrast $c = 3$ at $H_b = 8.3$, while our preferred knee H-distribution transitions to $\alpha_f = 0.4$ at $H_b = 7.7$. The intrinsic population of scattering TNOs

required to match the OSSOS detections is 3×10^6 for $H_r < 12$, and 9×10^4 for $H_r < 8.66$ ($D \gtrsim 100$ km), with Centaurs having an intrinsic population two orders of magnitude smaller.

Submitted to: The Astronomical Journal
For preprints, contact lawler.astro@gmail.com

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OSSOS: X. How to use a Survey Simulator: Statistical Testing of Dynamical Models Against the Real Kuiper Belt

S.M. Lawler [1], JJ. Kavelaars [1,2], M. Alexandersen[3], M.T. Bannister[4], B. Gladman[5], J.-M. Petit[6], and C. Shankman[2,1,7]

[1] NRC-Herzberg Astronomy and Astrophysics, National Research Council of Canada, Victoria, BC, Canada

[2] Department of Physics and Astronomy, University of Victoria, Victoria, BC, Canada

[3] Institute of Astronomy and Astrophysics, Academia Sinica, Taipei, Taiwan

[4] Astrophysics Research Centre, Queen's University Belfast, Belfast, UK

[5] Department of Physics and Astronomy, The University of British Columbia, Vancouver, BC, Canada

[6] Institut UTINAM, UMR 6213 CNRS-Université de Franche Comté, Besançon, France

[7] Current affiliation: City of Toronto, Toronto, ON, Canada

All surveys include observational biases, which makes it impossible to directly compare properties of discovered trans-Neptunian Objects (TNOs) with dynamical models. However, by carefully keeping track of survey pointings on the sky, detection limits, tracking fractions, and rate cuts, the biases from a survey can be modelled in Survey Simulator software. A Survey Simulator takes an intrinsic orbital model (from, for example, the output of a dynamical Kuiper belt emplacement simulation) and applies the survey biases, so that the biased simulated objects can be directly compared with real discoveries. This methodology has been used with great success in the Outer Solar System Origins Survey (OSSOS) and its predecessor surveys. In this chapter, we give four examples of ways to use the OSSOS Survey Simulator to gain knowledge about the true structure of the Kuiper Belt. We demonstrate how to statistically compare different dynamical model outputs with real TNO discoveries, how to quantify detection biases within a TNO population, how to measure intrinsic population sizes, and how to use upper limits from non-detections. We hope this will provide a framework for dynamical modellers to statistically test the validity of their models.

Submitted to: "Frontiers in Astronomy and Space Sciences"
research topic "From Comets to Pluto and Beyond"
For preprints, contact lawler.astro@gmail.com
or on the web at https://arxiv.org/abs/1802.00460

CONFERENCE INFORMATION

Pluto After New Horizons

July 12-16, 2019
The Johns Hopkins University Applied Physics Laboratory in Laurel, MD, USA

The dates for the international science conference on the Pluto system and the Kuiper Belt have been moved to 2019 July 12-16 (Friday-Tuesday). Please mark your calendars accordingly! Unfortunately, these new dates span a weekend, but that was unavoidable owing to conflicts with two other major conferences (a lunar conference coinciding with the 50th anniversary of Apollo 11 and the Ninth International Conference on Mars). The venue remains the same: The Johns Hopkins University Applied Physics Laboratory in Laurel, MD, USA.

There will be a reception commemorating the 4th anniversary of the Pluto flyby during the evening of July 14th.

This conference will provide an opportunity to summarize our understanding of the Pluto system and the Kuiper belt following the New Horizons encounters with Pluto and 2014 MU69. Contributions spanning all relevant research on the Kuiper belt, including both observations and theory, will be solicited. The conference will also serve as a nucleus for a forthcoming volume "Pluto After New Horizons" in the University of Arizona Space Science Series. With a projected 2020 publication date, this new book will be the successor to "Pluto-Charon" published in 1997.

A registration website with further details will be set up this summer, approximately one year prior to the conference. Again, please put this conference on your calendar and join us at the Kossiakoff Center at APL in mid-July 2019!

With best regards (on behalf of the SOC),
Hal Weaver (JHU-APL)
Alan Stern (SwRI)
Rick Binzel (MIT)

For further information, contact `hal.weaver@jhuapl.edu`

JOB & SCHOLARSHIP ANNOUNCEMENTS

Five Postdoctoral Positions in Dynamics and Planetology

São Paulo State University - UNESP in Guaratinguetá
National Institute for Space Research - INPE in São José dos Campos

The Group of Orbital Dynamics and Planetology invites applications for post-doc positions. There are 5 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:

- Orbits of satellites and planetary rings derived from space mission data;
- Attitude and orbit analysis for a mission to a triple asteroid system;
- Spin-orbit coupling in Solar System dynamics;
- Dynamics involving small bodies under gravitational close approaches;
- Planetary Formation.

The projects will be developed in one of the following institutions:

- São Paulo State University - UNESP in Guaratinguetá
- 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. Silvia Giuliatti Winter (`giuliattiwinter@gmail.com`).

Deadline of applications: March, 3, 2018

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PhD Scholarships

São Paulo State University - UNESP
National Institute for Space Research - INPE in São José dos Campos-Brazil

The Group of Orbital Dynamics & Planetology invites applications for PhD scholarships that will be funded by FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo). The PhD Program and the scholarships have duration of four years. The candidates should not have obtained the Master Degree. The projects to be developed are in the following topics:

- Origin, formation and evolution of satellites and planetary rings;
- Deflection of an asteroid in a collision route to the Earth.

The projects will be developed in the São Paulo State University - UNESP or in the National Institute for Space Research - INPE in São José dos Campos-Brazil.

Applicants should send a statement of research interest and a curriculum vitae to Prof. Giuliatti Winter (`giuliattiwinter@gmail.com`).

Deadline of applications: April, 13, 2018

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:

`http://www.boulder.swri.edu/ekonews`

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Moving ... ??

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