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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

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CONTENTS

NEWS, ANNOUNCEMENTS, COMMENTARY

On the Insensitive Use of the Term "Planet 9" for Objects Beyond Pluto

We the undersigned wish to remind our colleagues that the IAU planet definition adopted in 2006 has been controversial and is far from universally accepted. Given this, and given the incredible accomplishment of the discovery of Pluto, the harbinger of the solar system's third zone – the Kuiper Belt – by planetary astronomer Clyde W. Tombaugh in 1930, we the undersigned believe the use of the term "Planet 9" for objects beyond Pluto is insensitive to Professor Tombaugh's legacy.

We further believe the use of this term should be discontinued in favor of culturally and taxonomically neutral terms for such planets, such as Planet X, Planet Next, or Giant Planet Five.

Paul Abell, Michael Allison, Nadine Barlow, David Bartlett, James Bauer, Gordon Bjoraker, Paul Byrne, Eric Christiansen, Rajani Dhingra, Timothy Dowling, David Dunham, Tony L. Farnham, Harold Geller, Alvero Gonzalez, David Grinspoon, Will Grundy, George Hindman, Kampalayya M. Hiremath, Brian Holler, Stephanie Jarmak, Martin Knapmeyer, Rosaly Lopes, Amy Lovell, Ralph McNutt, Phil Metzger, Sripada Murty, Michael Paul, Kirby Runyon, Ray Russell, John Stansberry, Alan Stern, Mike Summers, Henry Throop, Hal Weaver, Larry Wasserman, Sloane Wiktorowicz

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The full orbital database of the Outer Solar System Origins Survey (OSSOS) has started appearing in the Minor Planet Center, and will continue over the next month as many hundreds of TNO orbits are released. The most convenient compilation, and the important "OSSOS Survey simulator" will be released via the project web pages at `http://www.ossos-survey.org`

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There were 164 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2014 HR208, 2015 DA249, 2015 DA250, 2015 DB249, 2015 DB250, 2015 DC249, 2015 DD249, 2015 DE249, 2015 DF249, 2015 DG249, 2015 DH249, 2015 DJ249, 2015 DK249, 2015 DL249, 2015 DM249, 2015 DN249, 2015 DO248, 2015 DO249, 2015 DP248, 2015 DP249, 2015 DQ248, 2015 DR248, 2015 DS248, 2015 DT249, 2015 DU248, 2015 DV248, 2015 DV249, 2015 DW248, 2015 DW249, 2015 DX248, 2015 DX249, 2015 DY248, 2015 DY249, 2015 DZ248, 2015 DZ249, 2015 GC55, 2015 GD55, 2015 GE55, 2015 GF54, 2015 GF55, 2015 GG54, 2015 GG55, 2015 GH54, 2015 GH55, 2015 GJ54, 2015 GJ55, 2015 GK54, 2015 GK55, 2015 GL54, 2015 GL55, 2015 GM54, 2015 GN54, 2015 GO54, 2015 GP54, 2015 GQ54, 2015 GR54, 2015 GS54, 2015 GT54, 2015 GU54, 2015 GV54, 2015 GW54, 2015 GX54, 2015 GY54, 2015 GZ54, 2015 KA174, 2015 KB174, 2015 KC173, 2015 KD173, 2015 KE173, 2015 KF173, 2015 KG173, 2015 KH173, 2015 KJ173, 2015 KK173, 2015 KL173, 2015 KM173, 2015 KN173, 2015 KO173, 2015 KP173, 2015 KQ173, 2015 KR173, 2015 KS173, 2015 KT173, 2015 KU173, 2015 KV173, 2015 KW173, 2015 KX173, 2015 RC278, 2015 RD278, 2015 RE278, 2015 RF278, 2015 RG277, 2015 RG278, 2015 RJ277, 2015 RR277, 2015 RS277, 2015 RT277, 2015 RU277, 2015 RV277, 2015 RX277, 2015 RY277, 2015 VA165, 2015 VA166, 2015 VA167, 2015 VB165, 2015 VB166, 2015 VB167, 2015 VC165, 2015 VC166, 2015 VC167, 2015 VD165, 2015 VD166, 2015 VE165, 2015 VE166, 2015 VF165, 2015 VF166, 2015 VG165, 2015 VG166, 2015 VH165, 2015 VH166, 2015 VJ164, 2015 VJ165, 2015 VJ166, 2015 VK164, 2015 VK165, 2015 VK166, 2015 VL164, 2015 VL165, 2015 VL166, 2015 VM164, 2015 VM165, 2015 VN164, 2015 VN165, 2015 VO164, 2015 VO165, 2015 VP164, 2015 VP165, 2015 VQ164, 2015 VQ165, 2015 VQ166, 2015 VR164, 2015 VR165, 2015 VR166, 2015 VS164, 2015 VS165, 2015 VS166, 2015 VT164, 2015 VT165, 2015 VT166, 2015 VU164, 2015 VU165, 2015 VU166, 2015 VV164, 2015 VV166, 2015 VW164, 2015 VW166, 2015 VX164, 2015 VX166, 2015 VY164, 2015 VY165, 2015 VY166, 2015 VZ164, 2015 VZ165, 2015 VZ166

and 30 new Centaur/SDO discoveries:

2014 VR39, 2015 DQ249, 2015 DS249, 2015 DT248, 2015 DU249, 2015 GA54, 2015 GA55, 2015 GB54, 2015 GB55, 2015 GY53, 2015 GZ53, 2015 KH172, 2015 KJ172, 2015 KY173, 2015 KZ173, 2015 RA278, 2015 RB278, 2015 RD277, 2015 RF277, 2015 RH277, 2015 RK277, 2015 RZ277, 2015 TG387, 2015 VE164, 2015 VF164, 2015 VM166, 2015 VN166, 2015 VO166, 2015 VP166, 2018 RR2

and 2 new Neptune Trojan discoveries:

2013 VX30, 2014 UU240

Reclassified objects:

2004 KV18 (NTrojan $\rightarrow$ TNO)
2014 FF72 (SDO $\rightarrow$ TNO)
2017 YK3 (SDO $\rightarrow$ TNO)

Objects recently assigned numbers:

2000 CN105 = (523588)
2001 QD298 = (523591)
2002 QX47 = (523597)
2003 UY413 = (523601)
2006 UO321 = (523615)
2007 PS45 = (523617)
2007 RH283 = (523620)
2007 RT15 = (523618)
2007 TG422 = (523622)
2008 CT190 = (523624)
2008 QB43 = (523627)
2008 SP266 = (523629)
2010 AH2 = (523634)
2010 DN93 = (523635)
2010 RE64 = (523639)
2010 RO64 = (523640)
2010 SS43 = (523642)
2010 TY53 = (523643)
2010 VK201 = (523645)
2010 VL201 = (523646)
2010 VV224 = (523647)
2010 VX11 = (523644)
2010 XZ78 = (523649)
2011 LZ28 = (523652)
2011 OA60 = (523653)
2011 VJ24 = (523655)
2012 DW98 = (523658)
2012 HG84 = (523659)
2013 FJ28 = (523672)
2013 FZ27 = (523671)
2013 MA12 = (523674)
2013 MZ11 = (523673)
2013 PV74 = (523675)
2013 UF15 = (523677)
2013 UL10 = (523676)
2013 XB26 = (523678)
2013 YJ151 = (523680)
2014 BV64 = (523681)
2014 CN23 = (523682)
2014 CP23 = (523683)
2014 CQ23 = (523684)
2014 DB143 = (523686)
2014 DF143 = (523687)
2014 DK143 = (523688)
2014 DL143 = (523689)
2014 DN143 = (523690)
2014 DO143 = (523691)
2014 EZ51 = (523692)
2014 FT71 = (523693)
2014 GD54 = (523698)
2014 GH54 = (523699)
2014 GM54 = (523700)
2014 GS53 = (523695)
2014 GW53 = (523696)
2014 GY53 = (523697)
2014 HB200 = (523704)
2014 HE200 = (523705)
2014 HF200 = (523706)
2014 HT199 = (523701)
2014 HW199 = (523702)
2014 HX199 = (523703)
2014 JB80 = (523708)
2014 JD80 = (523709)
2014 JF80 = (523710)
2014 JH80 = (523711)
2014 JS80 = (523712)
2014 JX80 = (523713)
2014 KR101 = (523714)
2014 KU101 = (523715)
2014 KW101 = (523716)
2014 KY101 = (523717)
2014 KZ101 = (523718)
2014 LM28 = (523719)
2014 LN28 = (523720)
2014 LR28 = (523721)
2014 LV28 = (523722)
2014 MA70 = (523724)
2014 MC70 = (523725)
2014 MJ70 = (523726)
2014 MY69 = (523723)
2014 NW65 = (523727)

2014 OH394 = (523730)	2014 UR224 = (523749)	2014 WU509 = (523761)
2014 OK394 = (523731)	2014 US224 = (523750)	2014 WV508 = (523753)
2014 OX393 = (523729)	2014 UT114 = (523746)	2014 WX508 = (523754)
2014 PR70 = (523733)	2014 UU224 = (523751)	2014 WX509 = (523762)
2014 QA442 = (523736)	2014 VU37 = (523752)	2014 WZ508 = (523755)
2014 QV441 = (523734)	2014 WC510 = (523764)	2014 WZ509 = (523763)
2014 QX441 = (523735)	2014 WD509 = (523756)	2014 XO40 = (523770)
2014 SH349 = (523738)	2014 WD510 = (523765)	2014 XP40 = (523771)
2014 TA86 = (523743)	2014 WF510 = (523766)	2014 XR40 = (523772)
2014 TC86 = (523744)	2014 WH509 = (523757)	2014 XS40 = (523773)
2014 TD86 = (523745)	2014 WH510 = (523767)	2014 XV40 = (523774)
2014 TV85 = (523740)	2014 WJ509 = (523758)	2014 YB50 = (523776)
2014 TY85 = (523741)	2014 WK509 = (523759)	2014 YF50 = (523777)
2014 TZ33 = (523739)	2014 WQ509 = (523760)	2014 YK50 = (523778)
2014 TZ85 = (523742)	2014 WQ510 = (523768)	
2014 UP224 = (523748)	2014 WS510 = (523769)	

Objects recently assigned names:
  2010 EK139 = Dziewanna

Deleted objects (removed from MPC lists, but both still appear in the JPL Small-Body Database):
  2015 GZ53
  1997 UF25

Current number of TNOs: 2100 (including Pluto)
Current number of Centaurs/SDOs: 795
Current number of Neptune Trojans: 18

Out of a total of 2913 objects:
  710 have measurements from only one opposition
    705 of those have had no measurements for more than a year
      370 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

Mass of the Kuiper Belt

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The Kuiper belt includes tens of thousand of large bodies and millions of smaller objects. The main part of the belt objects is located in the annular zone between 39.4 and 47.8 au from the Sun; the boundaries correspond to the average distances for orbital resonances 3:2 and 2:1 with the motion of Neptune. One-dimensional, two-dimensional, and discrete rings to model the total gravitational attraction of numerous belt objects are considered. The discrete rotating model most correctly reflects the real interaction of bodies in the Solar system. The masses of the model rings were determined within EPM2017 – the new version of ephemerides of planets and the Moon at IAA RAS – by fitting spacecraft ranging observations. The total mass of the Kuiper belt was calculated as the sum of the masses of the 31 largest trans-Neptunian objects directly included in the simultaneous integration and the estimated mass of the model of the discrete ring of TNO. The total mass is $(1.97 \pm 0.35) \times 10^{-2} m_\oplus$. The gravitational influence of the Kuiper belt on Jupiter, Saturn, Uranus, and Neptune exceeds at times the attraction of the hypothetical 9th planet with a mass of $\sim 10 m_\oplus$ at the distances assumed for it. It is necessary to take into account the gravitational influence of the Kuiper belt when processing observations and only then to investigate residual discrepancies to discover a possible influence of a distant large planet.

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For preprints, contact `evp@iaaras.ru`
or on the web at `http://adsabs.harvard.edu/abs/2018CeMDA.130...57P`

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Interplanetary Dust Delivery of Water to the Atmospheres of Pluto and Triton

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Both Pluto and Triton possess thin, N_2-dominated atmospheres controlled by sublimation of surface ices. We aim to constrain the influx and ablation of interplanetary dust grains into the atmospheres of both Pluto and Triton in order to estimate the rate at which oxygen-bearing species are introduced into both atmospheres.

We use (i) an interplanetary dust dynamics model to calculate the flux and velocity distributions of interplanetary dust grains relevant for both Pluto and Triton and (ii) a model for the ablation of interplanetary dust grains in the atmospheres of both Pluto and Triton. We sum the individual ablation profiles over the incoming mass and velocity distributions of interplanetary dust grains in order to determine the vertical structure and net deposition of water to both atmospheres.

Our results show that $<2\%$ of silicate grains ablate at either Pluto or Triton while approximately 75% and $>99\%$ of water ice grains ablate at Pluto and Triton, respectively. From ice grains, we calculate net water influxes to Pluto and Triton of ≈ 3.8 kg day^{-1} (8.5×10^3 H_2O cm^{-2} s^{-1}) and ≈ 370 kg day^{-1} (6.2×10^5 H_2O cm^{-2} s^{-1}), respectively. The significant difference in total water deposition between Pluto and Triton is due to the presence of Triton within Neptune's gravity well, which both enhances IDP fluxes due to gravitational focusing and accelerates grains before entry into Triton's atmosphere, thereby causing more efficient ablation.

We conclude that water deposition from dust ablation plays only a minor role at Pluto due to its relatively low flux. At Triton, water deposition from IDPs is more significant and may play a role in the alteration of atmospheric and ionospheric chemistry. We also suggest that meteoric smoke and smaller, un-ablated grains may serve as condensation nuclei for the formation of hazes at both worlds.

To appear in: Astronomy and Astrophysics, 617, L5 (2018 September)
For preprints, contact `poppe@ssl.berkeley.edu`
or on the web at `https://doi.org/10.1051/0004-6361/201833980`

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The New Horizons Kuiper Belt Extended Mission

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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.

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For preprints, contact `astern@swri.edu`
or on the web at `http://adsabs.harvard.edu/abs/2018SSRv..214...77S`

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Great Expectations: Plans and Predictions for New Horizons Encounter with Kuiper Belt Object 2014 MU_{69} ("Ultima Thule")

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The New Horizons encounter with the cold classical Kuiper Belt object 2014 MU_{69} (informally named "Ultima Thule", hereafter Ultima) on 1 January 2019 will be the first time a spacecraft has ever closely observed one of the free-orbiting small denizens of the Kuiper Belt. Related to but not thought to have formed in the same region of the solar system as the comets that been explored so far, it will also be the most distant, and most primitive body yet visited by spacecraft. In this letter we begin with a brief overview of cold classical Kuiper Belt objects, of which Ultima is a prime example. We give a short preview of our encounter plans. We note what is currently known about Ultima from Earth-based observations. We then review our expectations and capabilities to evaluate Ultima's composition, surface geology, structure, near space environment, small moons, rings, and the search for activity.

To appear in: Geophysical Research Letters
Preprints available or on the web at `https://arxiv.org/abs/1808.02118`

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"TNOs are Cool": A Survey of the Trans-Neptunian Region XIV. Size/Albedo Characterization of the Haumea Family Observed with *Herschel* and *Spitzer*

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A group of trans-Neptunian objects (TNO) are dynamically related to the dwarf planet 136108 Haumea. Ten of them show strong indications of water ice on their surfaces, are assumed to have resulted from a collision, and are accepted as the only known TNO collisional family. Nineteen other dynamically similar objects lack water ice absorptions and are hypothesized to be dynamical interlopers. We have made observations to determine sizes and geometric albedos of six of the accepted Haumea family members and one dynamical interloper. Ten other dynamical interlopers have been measured by previous works. We compare the individual and statistical properties of the family members and interlopers, examining the size and albedo distributions of both groups. We also examine implications for the total mass of the family and their ejection velocities. We use far-infrared space-based telescopes to observe the target TNOs near their thermal peak and combine these data with optical magnitudes to derive sizes and albedos using radiometric techniques. Using measured and inferred sizes together with ejection velocities we determine the power-law slope of ejection velocity as a function of effective diameter. The detected Haumea family members have a diversity of geometric albedos ∼0.3-0.8, which are higher than geometric albedos of dynamically similar objects without water ice. The median geometric albedo for accepted family members is $p_V = 0.48^{+0.28}_{-0.18}$, compared to $0.08^{+0.07}_{-0.05}$ for the dynamical interlopers. In the size range $D = 175 - 300$ km, the slope of the cumulative size distribution is $q = 3.2^{+0.7}_{-0.4}$ for accepted family members, steeper than the $q = 2.0 \pm 0.6$ slope for the dynamical interlopers with $D < 500$ km. The total mass of Haumea's moons and family members is 2.4% of Haumea's mass. The ejection velocities required to emplace them on their current orbits show a dependence on diameter, with a power-law slope of 0.21-0.50.

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For preprints, contact vilenius@mps.mpg.de
or on the web at https://doi.org/10.1051/0004-6361/201732564

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Solar System Science with the Wide-Field InfraRed Survey Telescope (WFIRST)

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We present a community-led assessment of the solar system investigations achievable with NASA's next-generation space telescope, the Wide Field InfraRed Survey Telescope (WFIRST). WFIRST will provide imaging, spectroscopic, and coronagraphic capabilities from 0.43-2.0 μm and will be a potential contemporary and eventual successor to JWST. Surveys of irregular satellites and minor bodies are where WFIRST will excel with its 0.28 deg^2 field of view Wide Field Instrument (WFI). Potential ground-breaking discoveries from WFIRST could include detection of the first minor bodies orbiting in the Inner Oort Cloud, identification of additional Earth Trojan asteroids, and the discovery and characterization of asteroid binary systems similar to Ida/Dactyl. Additional investigations into asteroids, giant planet satellites, Trojan asteroids, Centaurs, Kuiper Belt Objects, and comets are presented. Previous use of astrophysics assets for solar system science and synergies between WFIRST, LSST, JWST, and the proposed NEOCam mission are discussed. We also present the case for implementation of moving target tracking, a feature that will benefit from the heritage of JWST and enable a broader range of solar system observations.

To appear in: Journal of Astronomical Telescopes, Instrumentation, and Systems
Preprints on the web at `https://arxiv.org/abs/1709.02763`

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Dynamical Effects on the Classical Kuiper Belt during the Excited-Neptune Model

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The link between the dynamical evolution of the giant planets and the Kuiper Belt orbital structure can provide clues and insight about the dynamical history of the Solar System. The classical region of the Kuiper Belt has two populations (the cold and hot populations) with completely different physical and dynamical properties. These properties have been explained in the framework of a sub-set of the simulations of the *Nice Model*, in which Neptune remained on a low-eccentricity orbit (Neptune's eccentricity is never larger than 0.1) throughout the giant planet instability (Nesvorný 2015a,b). However, recent simulations (Gomes et al. 2018) have showed that the remaining *Nice model* simulations, in which Neptune temporarily acquires a large-eccentricity orbit (larger than 0.1), are also consistent with the preservation of the cold population (inclination smaller than 4 degrees), if the latter formed *in situ*. However, the resulting cold population showed in many of the simulations eccentricities larger than those observed for the real population. The purpose of this work is to discuss

the dynamical effects on the Kuiper belt region due to an excited Neptune phase. We focus on a short period of time, of about six hundred thousand years, which is characterized by Neptune's large eccentricity and smooth migration with a slow precession of Neptune's perihelion. This phase was observed during a full simulation of the *Nice Model* (Gomes et al. 2018) just after the last jump of Neptune's orbit due to an encounter with another planet. We show that if self-gravity is considered in the disk, the precession rate of the particles' longitude of perihelion ϖ is slowed down, which in turn speeds up the cycle of $\varpi_N - \varpi$ (the subscript $_N$ referring to Neptune), associated to the particles' eccentricity evolution. This, combined with the effect of mutual scattering among the bodies, which spreads all orbital elements, allows some objects to return to low eccentricities. However, we show that if the cold population originally had a small total mass, this effect is negligible. Thus, we conclude that the only possibilities to keep at low eccentricity some cold-population objects during a high-eccentricity phase of Neptune are that (i) either Neptune's precession was rapid, as suggested by Batygin et al. (2011) or (ii) Neptune's slow precession phase was long enough to allow some particles to experience a full secular cycle of $\varpi - \varpi_N$.

To appear in: Icarus
For preprints, contact rafanw72@gmail.com
or on the web at http://arxiv.org/abs/1808.02146

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The Threat of Centaurs for Terrestrial Planets and Their Orbital Evolution as Impactors

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Centaurs are the solar system objects whose orbits are found between those of the giant planets. They originate mainly from the Trans-Neptunian objects, and are among the sources of Near-Earth Objects. Thus, it is crucial to understand their orbital evolution which in some cases might end in collision with terrestrial planets and produce catastrophic events. We study the orbital evolution of the Centaurs toward the inner solar system, and estimate the number of close encounters and impacts with the terrestrial planets after the Late Heavy Bombardment assuming a steady state population of Centaurs. We also estimate the possible crater sizes. We compute the approximate amount of water released: on the Earth, which is about 10^{-5} the total water present now. We also found subregions of the Centaurs where the possible impactors originate from. While crater sizes could extend up to hundreds of kilometers in diameter given the presently known population of Centaurs the majority of the craters would be less than ∼10 km. For all the planets and an average impactor size of ∼12 km in diameter, the average impact frequency since the Late Heavy Bombardment is one every ∼1.9 Gyr for the Earth and 2.1 Gyr for Venus. For smaller bodies (e.g. >1 km), the impact frequency is one every 14.4 Myr for the Earth, 13.1 Myr for Venus and, 46.3 for Mars, in the recent solar system. Only 53% of the Centaurs can enter into the terrestrial planet region and ∼7% can interact with terrestrial planets.

To appear in: Monthly Notices of the Royal Astronomical Society
Available on the web at https://doi.org/10.1093/mnras/sty2614

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Rings Under Close Encounters with the Giant Planets: Chariklo versus Chiron

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In 2014, the discovery of two well-defined rings around the Centaur (10199) Chariklo were announced. This was the first time that such structures were found around a small body. In 2015, it was proposed that the Centaur (2060) Chiron may also have a ring. In a previous study, we analyzed how close encounters with giant planets would affect the rings of Chariklo. The most likely result is the survival of the rings. In the present work, we broaden our analysis to (2060) Chiron. In addition to Chariklo, Chiron is currently the only known Centaur with a presumed ring. By applying the same method as Araujo, Sfair and Winter (2016), we performed numerical integrations of a system composed of 729 clones of Chiron, the Sun, and the giant planets. The number of close encounters that disrupted the ring of Chiron during one half-life of the study period was computed. This number was then compared to the number of close encounters for Chariklo. We found that the probability of Chiron losing its ring due to close encounters with the giant planets is about six times higher than that for Chariklo. Our analysis showed that, unlike Chariklo, Chiron is more likely to remain in an orbit with a relatively low inclination and high eccentricity. Thus, we found that the bodies in Chiron-like orbits are less likely to retain rings than those in Chariklo-like orbits. Overall, for observational purposes, we conclude that the bigger bodies in orbits with high inclinations and low eccentricities should be prioritized.

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For preprints, contact ran.araujo@gmail.com

or on the web at https://arxiv.org/abs/1807.02096

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Measuring the Severity of Close Encounters Between Ringed Small Bodies and Planets

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Rings have recently been discovered around the TNO 136108 Haumea and the Centaur 10199 Chariklo. Rings are also suspected around the Centaur 2060 Chiron. As planetary close encounters with ringed small bodies can affect ring longevity, we previously measured the severity of such encounters of Chariklo and Chiron using the minimum encounter distance, d_{min}. The value of d_{min} which separates noticeable encounters from non-noticeable encounters we called the "Ring Limit", R. R was then approximated as ten tidal disruption distances, $10R_{td}$. In this work, we seek to find analytical expressions for R which fully account for the effects of the planet mass, small body mass, m_s, ring orbital radius, r, and velocity at infinity, v_∞, for fictitious ringed Centaurs using ranges

2×10^{20} kg $\leq m_s \leq 1$ Pluto Mass and 25,000 km $\leq r \leq$ 100,000 km. To accomplish this, we use numerical integration to simulate close encounters between each giant planet and ringed Centaurs in the three-body planar problem. The results show that R has a lower bound of approximately $1.8R_{td}$. We compare analytical and experimental R values for a fictitious Haumea, Chariklo and Chiron with $r = 50,000$ km. The agreement is excellent for Haumea, but weaker for Chariklo and Chiron. The agreement is best for Jupiter and Saturn. The ring limits of the real Haumea, Chariklo and Chiron are $< 4R_{td}$. Experimental R values for the fictitious bodies make better approximations for the R values of the real bodies than does $10R_{td}$. Analytical values make good first approximations.

To appear in: Monthly Notices of the Royal Astronomical Society, 480, 4183 (2018 November)
Available on the web at https://doi.org/10.1093/mnras/sty2047

PAPERS RECENTLY SUBMITTED TO JOURNALS

Evidence for Color Dichotomy in the Primordial Neptunian Trojan Population

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In the current model of early Solar System evolution, the stable members of the Jovian and Neptunian Trojan populations were captured into resonance from the protoplanetesimal disk during the outward migration of the giant planets. As a result, both Jovian and Neptunian Trojans share a common origin with the primordial disk population, whose other surviving members constitute today's trans-Neptunian object (TNO) populations. The cold classical TNOs are ultra-red, while the dynamically excited "hot" population of TNOs contains a mixture of red and blue objects. In contrast, Jovian and Neptunian Trojans are observed to be blue. While the absence of ultra-red Jovian Trojans can be readily explained by the sublimation of volatile material from their surfaces due to the high flux of solar radiation at 5 AU, the lack of red Neptunian Trojans presents both a puzzle and a challenge to formation models. In this work we report the discovery by the Dark Energy Survey (DES) of two new dynamically stable L4 Neptunian Trojans, 2013 VX30 and 2014 UU240, both with inclinations >30 degrees, making them the highest-inclination known stable Neptunian Trojans. We have measured the colors of these and three other dynamically stable Neptunian Trojans previously observed by DES, and find that 2013 VX30 is ultra-red, the first such Neptunian Trojan in its class. As such, 2013 VX30 may be a "missing link" between the Trojan and TNO populations. Using a simulation of the DES TNO detection efficiency, we find that there are 162 ± 73 Trojans with $H_r < 10$ at the L4 Lagrange point of Neptune. Moreover, the blue-to-red Neptunian Trojan population ratio should be higher than 5:1. Based on this result, we discuss the possible origin of the red Neptunian Trojan population and its implications for the formation history of Neptunian Trojans.

Submitted to: Icarus
For preprints, contact hsingwel@umich.edu
or on the web at https://arxiv.org/abs/1806.09696

BOOKS

Chasing New Horizons: Inside the Epic First Mission to Pluto

by Alan Stern and David Grinspoon

Picador Press, 2018. 320 pages
https://us.macmillan.com/books/9781250098962

Contents:

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Pluto and Lowell Observatory: A History of Discovery at Flagstaff

by Kevin Schindler and Will Grundy
with Contributions by Annette & Alden Tombaugh, W. Lowell Putnam, S. Alan Stern, Jeff Hall, and Gerard van Belle

The History Press, 2018. 174 pages
https://www.arcadiapublishing.com/Products/9781625859792

Chapters:

CONFERENCE CONTRIBUTIONS

Presentations at the 50th DPS meeting
2018 October 21-26, Knoxville, Tennessee, USA
The following are Kuiper belt related presentations I found in the DPS program. (Apologies for any that I missed.) Please note that in the "Conference Information" in the next section, I also list all the Kuiper belt related workshops happening at the DPS.

Tuesday, October 23

Session 208 (3:00-3:45). Gerard P. Kuiper Prize
- The Transneptunian Belt. Past, Present and Future (Julio Fernandez)

Session 221 (3:35-6:05). iPosters
- Ammonia on Pluto: its detection and implications (Dalle Ore)
- The Pluto System story told by resonances (De Santana)

Wednesday, October 24

Session 302 (8:30-9:35). Centaurs/TNOs I: Observational Surveys
- OSSOS observes planet-formation structure in the main Kuiper Belt (Gladman)
- OSSOS: The Missing Small Members of the Haumea Family (Pike)
- OSSOS exposes the complex size-frequency distribution of the main Kuiper Belt (Kavelaars)
- Col-OSSOS: The Compositional Structure of the Protoplanetesimal Disk (Fraser)
- Lightcurves of the Dynamically Cold Classical Trans-Neptunian Objects (Thirouin)
- A Combined Study of Extreme Trans-Neptunian Objects From Three Surveys and Implications for Planet Nine (Hamilton)

Session 305 (10:00-12:05). Centaurs/TNOs II: Dynamics, Origins, Theory
- Tightly-bound transneptunian binaries have prograde mutual orbits (Grundy)
- K2 light curves of eight Centaurs (Marton)
- Exploring Gravitational Collapse of a Pebble Cloud - A Route to TNO Binaries (Robinson)
- Bayesian Modeling of the Formation of the Haumea Family (Proudfoot)
- Equilibrium Figure of a Rapidly Rotating, Differentiated Haumea (Dunham)
- Searching for More Collisional Families in the Kuiper Belt (Ragozzine)
- Finding a Lower Bound on the Ring Limit for Planetary Close Encounters with Ringed Centaurs (Wood)
- Searching for KBO Binaries in the HST Archive (Smith)
- A Saturnian horseshoe coorbital & predictions for temporary coorbitals of the giant planets (Alexandersen)
- Exploring the Kuiper Belt Close to Home: A Mission to Explore Centaurs (Stern)
- Evidence for Very Early Migration of the Solar System Planets (Nesvorny)
- How KBO bulk density constrains their formation time (Bierson)

Session 311 (4:10-6:05). Centaurs/TNOs Posters
- The 2017 occultation by Vanth: a revised analysis (Bosh)
- The mass and density of the dwarf planet 2007 OR10 (Kiss)
- Searches for KBO Binaries using New Horizons LORRI (Weaver)

- A New, Unusual, and Diagnostic Band in Near-Infrared Spectra of Laboratory Ice Samples and Triton (Tegler)
- Commissioning of the Transneptunian Automated Occultation Survey - TAOS II (Lehner)
- Searching for activity on 15 Centaurs discovered in the Pan-STARRS detection catalog (Lilly)
- Search for a Pluto-like Satellite System Around Eris (Murray)
- A New Inner Oort Cloud Object (Trujillo)

Session 314 (4:10-6:05). Pluto System Posters

- The highest spatial resolution compositional maps of Pluto and what they tell us about surface composition and geology (Earle)
- Pluto's atmosphere with ALMA: disk-resolved observations of CO and HCN, and first detection of HNC (Lellouch)

Session 315 (4:10-6:05). iPosters

- Signatures of a low perihelion Planet 9 on the classical Kuiper belt and distant TNOs (Gomes)
- Rings under close encounters with the giant planets: Chariklo vs Chiron (Sfair)
- A Database of Fluxes and Albedos of Kuiper Belt Objects at 3.6 and 4.5 μm from Observations with the Spitzer Space Telescope (Perkins)

Friday, October 26

Session 502 (8:30-10:00). Pluto System I: Atmosphere and Surfaces

- The 15-AUG-2018 stellar occultation by Pluto: evidence for and against changes in haze opacity and atmospheric oblateness (Young)
- Pluto's atmosphere after New Horizons: results from stellar occultations in 2017 and 2018 (Sickafoose)
- Retrieval of Haze Properties in Pluto's Atmosphere from New Horizons Observations (Fan)
- Pluto's Minimum Pressure in the Current Season from a Thermophysical Model (Johnson)
- Haze formation on Pluto on million-year timescales (Young)
- Resolved Thermal Images of Pluto and Charon with ALMA (Butler)
- Triton: Atmosphere and Surface Observed with ALMA and Comparison with Pluto (Gurwell)
- Radiometric Polarization Anomalies on Pluto's Winter Night (Linscott)
- Ultraviolet Reflectance of Charon (Parker)

Session 506 (10:30-12:05). Pluto System II: Composition and Geology

- Are multiple coloring agents present across the surface of Pluto and its large satellite Charon? (Protopapa)
- Evidence of local CH4 stratification on Pluto from New Horisons LEISA data and a complete N2 ice map (Schmitt)
- Laboratory study of ammonia indices of refraction with water ice (Roser)
- Cryovolcanic Constructs on Pluto (Singer)
- Recent cryovolcanism on Pluto (Cruikshank)
- Prebiotic Chemistry of Pluto (Cruikshank)
- Long-term Evolution of Sputnik Planitia: Cryo-clastic Eruptions and their Implications (Stansberry)
- The Nature and Origin of Charon's Smooth Plains (Beyer)
- Young Surface of Pluto's Sputnik Planitia Caused by Viscous Relaxation (Wei)

Session 509 (1:30-3:30). Centaurs/TNOs III: Dwarf Planets and Physical Characteristics

- Dwarf Planets: Their Diameters, Albedos, Colors and Satellites Compared (Sheppard)
- The Mass, Density, and Figure of the Kuiper Belt Dwarf Planet Makemake (Parker)
- Breaking the degeneracy of Eris' pole orientation B. J. Holler)
- "Stay Active My Friend": 29P/S-W1, The Most Interesting Comet in the World (Sarid)
- Great Expectations: Anticipating Results from the First Encounter with a Cold Classical Kuiper Belt Object (Olkin)
- Pre-encounter update on (486958) 2014 MU69 and occultation results from 2017 and 2018 (Buie)
- New Horizons Distant Observations of Cold Classical KBOs (Porter)
- Solar Phase Curves of Distant Kuiper Belt Objects Observed by New Horizons' LOng-Range Reconnaissance Imager (LORRI) (Verbiscer)
- Physical properties of trans-Neptunian objects and centaurs (Fernandez-Valenzuela)
- Status and results from the Research and Education Collaborative Occultation Network (RECON) (Leiva)
- Uncovering Signatures of Refractory Materials on KBOs and Centaurs by Reflectance Spectroscopy (Seccull)

CONFERENCE INFORMATION

The first five items listed below are workshops presented at the upcoming DPS meeting. These workshops are open to all DPS attendees.

Earth- and Space-Based Support for the New Horizons Kuiper Belt Extended Mission Targets

50th DPS meeting, Knoxville, TN
Monday, October 22, 2018. 12:30-1:30 pm

The centerpiece of the New Horizons Kuiper Belt Extended Mission is a very close flyby of the cold classical KBO (486958) 2014 MU_69 on 1 January 2019. However, as a small observatory located inside the Kuiper Belt, the New Horizons long-range reconnaissance Imager (LORRI) is well placed to observe about two dozen other known KBOs The New Horizons team seeks ongoing supporting Earth-based and space-based observations to maximize the science return of the Kuiper Belt Extended Mission. We are specifically requesting observations yielding colors, absolute photometry at low phase angles, as well as rotational lightcurve periods and amplitudes of our targets. A DPS workshop will describe the New Horizons Kuiper Belt Extended Mission and bring together interested observers to discuss and coordinate plans for our target list, which will be shared at the workshop.

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JWST Solar System Observers Town Hall

50th DPS meeting, Knoxville, TN
Tuesday, October 23, 2018. 10:30-1:30 pm

The James Webb Space Telescope (JWST) is an infrared-optimized telescope that will now be launched to its orbit around the Earth-Sun L2 point in early 2021. JWST has a robust suite of astronomical instrumentation (imaging and spectroscopy) operating from 0.6-28.5 microns. The call for General Observer (GO) proposals is expected to be re-issued in late 2019, with the deadline about 3 months later. At this town hall we will provide a brief overview of JWST instrumentation; a status report on observatory integration and preparations at the science operations center (Space Telescope Science Institute); an overview of the currently planned Guaranteed Time Observer proposals; a summary of observation planning tools; and an overview of use documentation. More details about expected proposal dates and future solar system observer planning workshops will be provided. Our goal is to support the DPS community in preparing and submitting a robust set of observing proposals so that we can all benefit from the capabilities of JWST.

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LSST and the Solar System Workshop

50th DPS meeting, Knoxville, TN
Wednesday October 24, 2018. 4:30-6:00 pm

Over its 10 year lifespan, the Large Synoptic Survey Telescope (LSST) will catalog over 5 million Main Belt asteroids, almost 300,000 Jupiter Trojans, over 100,000 NEOs, over 40,000 KBOs, tens of interstellar objects, and over 10,000 comets. Many of these objects will receive hundreds of observations in multiple bandpasses. The LSST Solar System Science Collaboration (SSSC) is preparing methods and tools to analyze this data, as well as understand optimum survey strategies for discovering moving objects throughout the Solar System.

This workshop serves as the annual meeting of the LSST SSSC, and is open to everyone. We will provide updates on current and future activities within the SSSC. The emphasis will not be on general LSST background but on details relevant to Solar System science topics. In particular, this year discussions and presentations will focus on the development of the LSST Moving Object Processing System (MOPS), the SSSC's feedback/input on upcoming LSST survey cadence decisions, and future community follow-up opportunities. There will be time set aside for open discussion for both members of the SSSC and the broader planetary community.

Contact Meg Schwamb (`mschwamb.astro@gmail.com`) and David Trilling (`David.Trilling@nau.edu`) with any questions

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A Combined Mission Strategy for Ice Giant and Kuiper Belt Exploration

50th DPS meeting, Knoxville, TN
Thursday, October 25, 2018. 12:00-1:30 pm

This workshop provides an opportunity to discuss and refine ideas for a two-spacecraft mission to explore the Uranus and Neptune systems, a Centaur, a Dwarf Planet in the Kuiper Belt, and at least one other small KBO. Under this plan, an orbiter with atmospheric probe is sent to Neptune, flying by a Centaur on the way. A separate flyby spacecraft explores the Uranus system, a dwarf planet, and at least one other KBO. Building on the completed NASA ice giant mission study and a recently announced ESA study, this dual-spacecraft mission would address priority science objectives across the deep outer solar system. After short presentations on the NASA and ESA studies and the two-spacecraft mission, there will be time for group discussion.

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Future Pluto and Kuiper Belt Missions: The View from 2018

50th DPS meeting, Knoxville, TN
Friday, October 26, 2018. 12:00-1:30 pm

The Kuiper Belt (KB) is a scientific treasure trove consisting of comets, planetesimals, and small planets like Pluto. Since its discovery in the early 1990s, the KB has yielded fundamental insights into planetary accretion, the migration of planets, and the population structure of our solar system—including the discovery that dwarf planets like Pluto are common there.

The exploration of Pluto by New Horizons in 2015, the first KB dwarf planet to be explored, revealed a richness of geological, atmospheric, satellite, and compositional diversity at Pluto that rivals planets like Mars. The flyby also revealed evidence for Pluto being an actively evolving world over many spatial and temporal scales including evidence for an interior ocean, active glaciers, dunes, tectonics, a wide variety of terrain ages, and a complex atmosphere. Those results, combined with the heterogeneous colors, surface compositions, and satellite systems of other KB dwarf planets beg for an ongoing future in Kuiper Belt exploration.

In this workshop we will survey 2018 work on (i) a return to Pluto with an orbiter, (ii) Centaur missions to study KBOs, and (iii) flyby missions to other KB dwarf planets. We will review community and individual scientist work to motivate NASA to fund future studies leading to the next Decadal Survey.

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The 8th East-Asia Numerical Astrophysics Meeting

2018 October 22-26
National Cheng-Kung University, Tainan, Taiwan

Numerical simulations have become even more important as detailed comparisons between theories and observations are now possible at a deeper level in most fields of astrophysics. The aim of this series of meetings is to bring (but not limited to) East-Asian numerical astrophysicists together and provide chances to learn each other's work and explore possible collaborations among them. The scope of the meeting will encompass all major astronomical research fields that involve numerical simulations, including (but not limited to) cosmology, astronomical hydrodynamics, magnetohydrodynamics, radiative transfer, particle acceleration, and planetary / stellar / galactic dynamics. In addition, there will also be a focus on computer science applications directed toward astrophysics including numerical methods, simulation data analysis, high performance computing, and optimization for use on large scale computer clusters. Participants from outside of the East Asia are warmly welcome as well.

For more information, visit the meeting website at `http://eanam8.gsroc.tw`

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The Pluto System After New Horizons

2019 July 14-18
The Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA

The dates for the Pluto System After New Horizons (PSANH), an international science conference on the Pluto system and the Kuiper Belt, have shifted by two days to July 14–18, 2019 (Sunday through Thursday). Please mark your calendars accordingly!

The 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 (Ultima Thule). Contributions spanning all relevant research on the Kuiper belt, including both observations and theory, are being solicited.

The conference will also serve as the nucleus for a forthcoming volume, The Pluto System 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.

For further information regarding the conference, please contact `hal.weaver@jhuapl.edu`.

Important: To be added to the mailing list to receive reminders and other pertinent information related to the conference, including registration and the call for abstracts, submit an Indication of Interest at your earliest convenience, but no later than March 14, 2019.

For more information: `https://www.hou.usra.edu/meetings/plutosystem2019/`

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`

Recent and back issues of the newsletter are archived there in various formats. The web pages also contain other related information and links.

Distant EKOs is not a refereed publication, but is a tool for furthering communication among people interested in Kuiper belt research. Publication or listing of an article in the newsletter or the web page does not constitute an endorsement of the article's results or imply validity of its contents. When referencing an article, please reference the original source; *Distant EKOs* is not a substitute for peer-reviewed journals.

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the newsletter bounces back from an address for three consecutive issues, the address will be deleted from the mailing list. All address changes, submissions, and other correspondence should be sent to:

`ekonews@boulder.swri.edu`