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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 45 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2004 HC79, 2004 HD79, 2004 HE79, 2004 HF79, 2004 HG79, 2004 HH79, 2004 HJ79, 2004 HK79, 2004 HL79, 2004 HM79, 2004 KD19, 2004 KE19, 2004 KF19, 2004 KG19, 2004 KH19, 2004 KJ19, 2004 MT8, 2004 MU8, 2004 MV8, 2004 OP15, 2004 PT117, 2004 PU117, 2004 PV117, 2004 PW117, 2004 PX117, 2004 QD29, 2004 QE29, 2004 QF29, 2004 VA131, 2004 VB131, 2004 VC131, 2004 VD131, 2005 BV49, 2005 BW49, 2005 CE81, 2005 CF81, 2005 GH228, 2005 JJ186, 2005 LA54, 2005 LB54, 2006 WF206, 2007 DS101, 2011 FW62, 2011 GM27, 2011 GY61

and 5 new Centaur/SDO discoveries:

2011 FS53, 2011 FX62, 2011 GN27, 2007 BP102, 2011 KT19

Reclassified objects:

2003 UY413 (SDO → TNO)
2010 KZ39 (SDO → TNO)

Objects recently assigned numbers:

2001 QY297 = (275809)
2007 JJ43 = (278361)
2008 FC76 = (281371)

Current number of TNOs: 1222 (including Pluto)
Current number of Centaurs/SDOs: 296
Current number of Neptune Trojans: 7

Out of a total of 1525 objects:
- 620 have measurements from only one opposition
  - 581 of those have had no measurements for more than a year
    - 317 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

High Resolution Spectroscopy of Pluto's Atmosphere: Detection of the 2.3 μm CH_4 Bands and Evidence for Carbon Monoxide

E. Lellouch[1], C. de Bergh[1], B. Sicardy[1,2], H.U. Käufl[3], and A. Smette[4]

[1] LESIA, Observatoire de Paris, 5 place Jules Janssen, 92195 Meudon, France

[2] Université Pierre et Marie Curie, 4 place Jussieu, 75005 Paris, France

[3] European Space Observatory, Karl-Schwarzschild-Strasse 2, 85748 Garching bei München, Germany

[4] European Space Observatory, Alonso de Córdova 3107, Casilla 19001, Vitacura, Chile

The goal is to determine the composition of Pluto's atmosphere and to constrain the nature of surface-atmosphere interactions. We perform high-resolution spectroscopic observations in the 2.33–2.36 μm range, using CRIRES at the VLT. We obtain (i) the first detection of gaseous methane in this spectral range, through lines of the $\nu_3 + \nu_4$ and $\nu_1 + \nu_4$ bands (ii) strong evidence (6-σ confidence) for gaseous CO in Pluto. For an isothermal atmosphere at 90 K, the CH_4 and CO column densities are 0.75 and 0.07 cm-am, within factors of 2 and 3, respectively. Using a physically–based thermal structure model of Pluto's atmosphere also satisfying constraints from stellar occultations, we infer CH_4 and CO mixing ratios $q_{CH_4} = 0.6^{+0.6}_{-0.3}$% (consistent with results from the 1.66 μm range) and $q_{CO} = 0.5^{+1}_{-0.25} \times 10^{-3}$. The CO atmospheric abundance is consistent with its surface abundance. As for Triton, it is probably controlled by a thin, CO-rich, detailed balancing layer resulting from seasonal transport and/or atmospheric escape.

Published in: Astronomy & Astrophysics, 530, L4 (2011 June)

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Retention of a Primordial Cold Classical Kuiper Belt in an Instability-Driven Model of Solar System Formation

Konstantin Batygin[1], Michael E. Brown[1], and Wesley C. Fraser[1]

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

The cold classical population of the Kuiper belt exhibits a wide variety of unique physical characteristics, which collectively suggest that its dynamical coherence has been maintained through out the solar system's lifetime. Simultaneously, the retention of the cold population's relatively unexcited orbital state has remained a mystery, especially in the context of a solar system formation model, that is driven by a transient period of instability, where Neptune is temporarily eccentric. Here, we show that the cold belt can survive the instability, and its dynamical structure can be reproduced. We develop a simple analytical model for secular excitation of cold KBOs and show that comparatively fast apsidal precession and nodal recession of Neptune, during the eccentric phase, are essential for preservation of an unexcited state in the cold classical region. Subsequently, we confirm our results with self-consistent N-body simulations. We further show that contamination of the hot classical and scattered populations by objects of similar nature to that of cold classicals has been instrumental in shaping the vast physical diversity inherent to the Kuiper belt.

To appear in: The Astrophysical Journal

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

or on the web at `http://arxiv.org/abs/1106.0937`

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Inclination Mixing in the Classical Kuiper Belt

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

[1] Department of Planetary Sciences, University of Arizona, 1629 East University Boulevard, Tucson, AZ 85721, USA

We investigate the long-term evolution of the inclinations of the known classical and resonant Kuiper belt objects (KBOs). This is partially motivated by the observed bimodal inclination distribution and by the putative physical differences between the low- and high-inclination populations. We find that some classical KBOs undergo large changes in inclination over gigayear timescales, which means that a current member of the low-inclination population may have been in the high-inclination population in the past, and vice versa. The dynamical mechanisms responsible for the time-variability of inclinations are predominantly distant encounters with Neptune and chaotic diffusion near the boundaries of mean motion resonances. We reassess the correlations between inclination and physical properties including inclination time-variability. We find that the size-inclination and color-inclination correlations are less statistically significant than previously reported (mostly due to the increased size of the data set since previous works with some contribution from inclination variability). The time-variability of inclinations does not change the previous finding that binary classical KBOs have lower inclinations than non-binary objects. Our study of resonant objects in the classical Kuiper belt region includes objects in the 3:2, 7:4, 2:1, and eight higher-order mean motion resonances. We find that these objects (some of which were previously classified as non-resonant) undergo larger changes in inclination compared to the non-resonant population, indicating that their current inclinations are not generally representative of their original inclinations. They are also less stable on gigayear timescales.

To appear in: The Astrophysical Journal

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

or on the web at `http://arxiv.org/abs/1104.4967`

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Estimating the Density of Intermediate Size KBOs from Considerations of Volatile Retention

A. Levi[1] and M. Podolak[1]

[1]Tel Aviv University, Tel Aviv, 69978 Israel

By using a hydrodynamic atmospheric escape mechanism we show how the unusually high mass density of Quaoar could have been predicted (constrained), without any knowledge of a binary companion. We suggest an explanation of the recent spectroscopic observations of Orcus and Charon. We present a simple relation between the detection of certain volatile ices and the body mass density and diameter. As a test case we implement the relations on the KBO 2003 AZ_{84} and give constraints on its mass density. We also present a method of relating the latitude-dependence of hydrodynamic gas escape to the internal structure of a rapidly rotating body and apply it to Haumea.

To appear in: Icarus

For preprints, contact `morris@post.tau.ac.il`

or on the web at `http://arxiv.org/abs/1008.1105`

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Identifying Collisional Families in the Kuiper Belt

Robert A. Marcus[1], Darin Ragozzine[1], Ruth A. Murray-Clay[1], and Matthew J. Holman[1]

[1] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, USA

The identification and characterization of numerous collisional families – clusters of bodies with a common collisional origin – in the asteroid belt has added greatly to the understanding of asteroid belt formation and evolution. More recent study has also led to an appreciation of physical processes that had previously been neglected (e.g., the Yarkovsky effect). Collisions have certainly played an important role in the evolution of the Kuiper Belt as well, though only one collisional family has been identified in that region to date, around the dwarf planet Haumea. In this paper, we combine insights into collisional families from numerical simulations with the current observational constraints on the dynamical structure of the Kuiper Belt to investigate the ideal sizes and locations for identifying collisional families. We find that larger progenitors (r $\sim$ 500 km) result in more easily identifiable families, given the difficulty in identifying fragments of smaller progenitors in magnitude-limited surveys, despite their larger spread and less frequent occurrence. However, even these families do not stand out well from the background. Identifying families as statistical overdensities is much easier than characterizing families by distinguishing individual members from interlopers. Such identification seems promising, provided the background population is well known. In either case, families will also be much easier to study where the background population is small, i.e., at high inclinations. Overall, our results indicate that entirely different techniques for identifying families will be needed for the Kuiper Belt, and we provide some suggestions.

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The Hill Stability of Binary Asteroid and Binary Kuiper Belt Systems

J.R. Donnison[1]

[1] Astronomy Unit, School of Mathematical Sciences, Queen Mary, University of London,Mile End Road, London, E1 4NS, UK

The dynamical stability of a bound triple system composed of a binary asteroid system or Kuiper Belt binary system moving on a orbit inclined to a central third body, the Sun, is discussed in terms of Hill stability for the full three-body problem. The regions of Hill stability of these triple systems, where the binary mass is very small compared with that of the third body, can be determined against the possibility of disruption, component exchange and capture. The critical Hill stability curves for the binary mass range of these types of system are determined for different secondary/primary mass ratios as a function of their orbital eccentricity. The regions of stability are found to increase with increasing binary mass. The regions however decrease in size substantially with increasing orbital eccentricity and also decrease slightly as the secondary/primary mass ratio of the binary is decreased.

The currently observed binary and multiple asteroid systems are discussed generally. In the majority of systems, the primary component is very much larger than the secondary component forming an asteroid-satellite system. It was found that those systems where the binary mass is well determined would lie in stable regions if they moved on circular orbits, but when their eccentricity is taken into account, it is less clear that the systems are stable. The same is likely to be true for the systems where the masses are not well established. Upper mass limits could be placed on these systems that would ensure they are Hill stable. The currently observed Kuiper Belt binaries were

also discussed generally. The majority of these binary systems have secondary components which are often comparable to the diameter of the primary component forming a true binary system. Similar to the asteroid binaries, it was found that binary systems where the mass was well determined were stable if they moved on circular orbits relative to the Sun. When the eccentricity was taken into account it is less clear that the systems are stable. The same conclusions are also likely to be true for the systems with unknown masses. Upper mass limits again can be placed on these systems that would ensure they are Hill stable.

To appear in: **Monthly Notices of the Royal Astronomical Society**

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Dynamical Effects of Stellar Mass Loss on a Kuiper-like Belt

A. Bonsor[1], A. J. Mustill[1], and M.C. Wyatt[1]

[1] Institute of Astronomy, Madingely Rise, Madingley Road, Cambridge CB30HA, UK

A quarter of DA white dwarfs are metal polluted, yet elements heavier than helium sink down through the stellar atmosphere on timescales of days. Hence, these white dwarfs must be currently accreting material containing heavy elements. Here, we consider whether the scattering of comets or asteroids from an outer planetary system, following stellar mass loss on the asymptotic giant branch, can reproduce these observations. We use N-body simulations to investigate the effects of stellar mass loss on a simple system consisting of a planetesimal belt whose inner edge is truncated by a planet. Our simulations find that, starting with a planetesimal belt population fitted to the observed main sequence evolution, sufficient mass is scattered into the inner planetary system to explain the inferred heavy element accretion rates. This assumes that some fraction of the mass scattered into the inner planetary system ends up on star-grazing orbits, is tidally disrupted and accreted onto the white dwarf. The simulations also reproduce the observed decrease in accretion rate with cooling age and predict accretion rates in old (>1 Gyr) white dwarfs, in line with observations. The efficiency we assumed for material scattered into the inner planetary system to end up on star-grazing orbits is based on a Solar-like planetary system, since the simulations show that a single planet is not sufficient. Although the correct level of accretion is reproduced, the simulations predict a higher fraction of accreting white dwarfs than observed. This could indicate that evolved planetary systems are less efficient at scattering bodies onto star-grazing orbits or that dynamical instabilities post-stellar mass loss cause rapid planetesimal belt depletion for a significant fraction of systems.

To appear in: **Monthly Notices of the Royal Astronomical Society**
For preprints, contact `abonsor@ast.cam.ac.uk`
or on the web at `http://arxiv.org/abs/1102.3185`

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 accepted papers
⋆ Titles of submitted (but not yet accepted) papers and conference articles
⋆ 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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