*Issue No. 56* *January 2008*

# *DISTANT EKOs*

## *The Kuiper Belt Electronic Newsletter*

*Edited by: Joel Wm. Parker*

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

## CONTENTS

# NEWS & ANNOUNCEMENTS

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

2007 RM283, 2007 RT15, 2007 TC418, 2007 TD418, 2007 TZ417, 2007 VJ302, 2007 VK302

and 4 new Centaur/SDO discoveries:

2007 RG283, 2007 RH283, 2007 TA418, 2007 TB418

Reclassified objects:
2007 RW10 (NTrojan → Centaur)

Objects recently assigned numbers:
2000 GE147 = 168700
2000 GP183 = 168703
2001 FR185 = 169071
2003 MW12 = 174567
2004 PF115 = 175113

Current number of TNOs: 1074 (including Pluto)
Current number of Centaurs/SDOs: 213
Current number of Neptune Trojans: 5

Out of a total of 1292 objects:
555 have measurements from only one opposition
540 of those have had no measurements for more than a year
278 of those have arcs shorter than 10 days
(for more details, see: `http://www.boulder.swri.edu/ekonews/objects/recov_stats.gif`)

# PAPERS ACCEPTED TO JOURNALS

## Origin of the Structure of the Kuiper Belt during a Dynamical Instability in the Orbits of Uranus and Neptune

**H. Levison[1], A. Morbidelli[2], C. Van Laerhoven[3], R. Gomes[4], and K. Tsiganis[5]**

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

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[4] Observatório Nacional/MCT, Brazil

[5] Department of Physics, Aristotle University of Thessaloniki, Greece

We explore the origin and orbital evolution of the Kuiper belt in the framework of a recent model of the dynamical evolution of the giant planets, sometimes known as the *Nice* model. This model is characterized by a short, but violent, instability phase, during which the planets were on large eccentricity orbits. It successfully explains, for the first time, the current orbital architecture of the giant planets (Tsiganis et al. 2005, Nature 435, 459), the existence of the Trojans populations of Jupiter and Neptune (Morbidelli et al. 2005, Nature 435, 462), and the origin of the late heavy bombardment of the terrestrial planets (Gomes et al. 2005, Nature 435, 466). One characteristic of this model is that the proto-planetary disk must have been truncated at roughly 30 to 35 AU so that Neptune would stop migrating at its currently observed location. As a result, the Kuiper belt would have initially been empty.

In this paper we present a new dynamical mechanism which can deliver objects from the region interior to $\sim$35 AU to the Kuiper belt without excessive inclination excitation. In particular, we show that during the phase when Neptune's eccentricity is large, the region interior to its 1:2 mean motion resonance becomes unstable and disk particles can diffuse into this area. In addition, we perform numerical simulations where the planets are forced to evolve using fictitious analytic forces, in a way consistent with the direct N-body simulations of the Nice model. Assuming that the last encounter with Uranus delivered Neptune onto a low-inclination orbit with a semi-major axis of $\sim$27 AU and an eccentricity of $\sim$0.3, and that subsequently Neptune's eccentricity damped in $\sim$1 My, our simulations reproduce the main observed properties of the Kuiper belt at an unprecedented level. In particular, our results explain, at least qualitatively: 1) the so-existence of resonant and non-resonant populations, 2) the eccentricity–inclination distribution of the Plutinos, 3) the peculiar semi-major axis – eccentricity distribution in the classical belt, 4) the outer edge at the 1:2 mean motion resonance with Neptune, 5) the bi-modal inclination distribution of the classical population, 6) the correlations between inclination and physical properties in the classical Kuiper belt, the existence of the so-called extended scattered disk. Nevertheless, we observe in the simulations a deficit of nearly-circular objects in the classical Kuiper belt.

**To appear in: Icarus**

*For preprints, contact* `hal@boulder.swri.edu`
*or on the web at* `http://arxiv.org/abs/0712.0553`

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## An Outer Planet beyond Pluto and Origin of the Trans-Neptunian Belt Architecture

**Patryk Sofia Lykawka**[1] **and Tadashi Mukai**[1]

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Trans-Neptunian objects (TNOs) are remnants of a collisionally and dynamically evolved planetesimal disk in the outer solar system. This complex structure, known as the trans-Neptunian belt (or Edgeworth-Kuiper belt), can reveal important clues about disk properties, planet formation, and other evolutionary processes. In contrast to the predictions of accretion theory, TNOs exhibit surprisingly large eccentricities, $e$, and inclinations, $i$, which can be grouped into distinct dynamical classes. Several models have addressed the origin and orbital evolution of TNOs, but none have reproduced detailed observations, e.g., all dynamical classes and peculiar objects, or provided insightful predictions. Based on extensive simulations of planetesimal disks with the presence of the four giant planets and massive planetesimals, we propose that the orbital history of an outer planet with tenths of Earth's mass can explain the trans-Neptunian belt orbital structure. This massive body was likely scattered by one of the giant planets, which then stirred the primordial planetesimal disk to the levels observed at 40–50 AU and truncated it at about 48 AU before planet migration. The outer planet later acquired an inclined stable orbit (>100 AU; 20–40 deg) because of a resonant interaction with Neptune (an r:1 or r:2 resonance possibly coupled with the Kozai mechanism), guaranteeing the stability of the trans-Neptunian belt. Our model consistently reproduces the main features of each dynamical class with unprecedented detail; it also satisfies other constraints such as the current small total mass of the trans-Neptunian belt and Neptune's current orbit at 30.1 AU. We also provide observationally testable predictions.

**To appear in: The Astronomical Journal**

*For preprints, contact* `patryk@dragon.kobe-u.ac.jp`

*or on the web at* `http://harbor.scitec.kobe-u.ac.jp/~patryk/index-en.html`

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## High Precision Photometry of Extreme KBO 2003 $\mathrm{EL}_{61}$

**P. Lacerda**[1], **David Jewitt**[1], **and Nuno Peixinho**[1,2]

[1] Institute for Astronomy, University of Hawaii, USA [2] Grupo de Astrofísica, Universidade de Coimbra, Portugal

We present high precision, time-resolved visible and near infrared photometry of the large (diameter $\sim 2500$ km) Kuiper belt object (136108) 2003 $\mathrm{EL}_{61}$. The new data confirm rapid rotation at period $P = 3.9155\pm0.0001$ hr with a peak-to-peak photometric range $\Delta m_R = 0.29\pm0.02$ mag. and further show subtle but reproducible color variations with rotation. Rotational deformation of 2003 $\mathrm{EL}_{61}$ alone would give rise to a symmetric lightcurve free of color variations. The observed photometric deviations from the best-fit equilibrium model show the existence of a large surface region with an albedo and color different from the mean surface of 2003 $\mathrm{EL}_{61}$. We explore constraints on the nature of this anomalous region set by the existing data.

**To appear in: The Astrophysical Journal**

*For preprints, contact* `pedro@ifa.hawaii.edu`

*or on the web at* `http://www.ifa.hawaii.edu/~pedro/papers.html`

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## Surface Composition and Temperature of the TNO Orcus

**M.A. Barucci[1], F. Merlin[1], A. Guilbert[1], C. de Bergh [1], A. Alvarez-Candal[1], O. Hainaut[2], A. Doressoundiram [1], C. Dumas[2], T. Owen[3], and A. Coradini[4]**

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The aim of this paper is to investigate the surface composition of the Transneptunian Object (TNO) Orcus. High quality observations have been carried out with the new instrument SINFONI at the Very Large Telescope (VLT) of ESO. Crystalline water ice, and possibly ammonia ice, have been found from spectroscopic observations of the TNO Orcus between 1.4 and 2.4 $\mu$m. The existence of such ices on the surface of Orcus may indicate a renewal mechanism on the surface and geological activity. The presence of ammonia on the surface of Orcus, if confirmed, could have important implications for the composition of the primitive solar nebula and the formation of the TNO population.

**To appear in: Astronomy & Astrophysics**

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## Evidence of $N_2$-Ice On the Surface of the Icy Dwarf Planet 136472 (2005 FY9)

**S.C. Tegler[1], W.M. Grundy[2], F. Vilas[3], W. Romanishin[4], D. Cornelison[1], and G.J. Consolmagno[5]**

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We present high signal precision optical reflectance spectra of 2005 FY9 taken with the Red Channel Spectrograph and the 6.5-m MMT telescope on 2006 March 4 UT (5000–9500 Å; 6.33 Å pixel$^{-1}$) and 2007 February 12 UT (6600–8500 Å; 1.93 Å pixel$^{-1}$). From cross correlation experiments between the 2006 March 4 spectrum and a pure $CH_4$-ice Hapke model, we find the $CH_4$-ice bands in the MMT spectrum are blueshifted by 3$\pm$4 Å relative to bands in the pure $CH_4$-ice Hapke spectrum. The higher resolution MMT spectrum of 2007 February 12 UT enabled us to measure shifts of individual $CH_4$-ice bands. We find the 7296 Å, 7862 Å, and 7993 Å $CH_4$-ice bands are blueshifted by 4$\pm$2 Å, 4$\pm$4 Å, and 6$\pm$5 Å. From four measurements we report here and one of our previously published measurements, we find the $CH_4$-ice bands are shifted by 4$\pm$1 Å. This small shift is important because it suggest the presence of another ice component on the surface of 2005 FY9. Laboratory experiments show that $CH_4$-ice bands in spectra of $CH_4$ mixed with other ices are blueshifted relative to bands in spectra of pure $CH_4$-ice. A likely candidate for the other component is $N_2$-ice because its weak 2.15 $\mu$m band and blueshifted $CH_4$ bands are seen in spectra of Triton and Pluto. Assuming the shift is due to the presence of $N_2$, spectra taken on two consecutive nights show no difference in $CH_4/N_2$. In addition, we find no measurable difference in $CH_4/N_2$ at different depths into the surface of 2005 FY9.

**To appear in: Icarus**

*For preprints, contact* `Stephen.Tegler@nau.edu`

*or on the web at* `http://arxiv.org/abs/0801.3115`

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## A Search for sub-km KBOs with the Method of Serendipitous Stellar Occultations

**S.J. Bickerton[1], JJ. Kavelaars[2], and D.L. Welch[3]**

[1] McMaster University, Dept. of Physics and Astronomy, 1280 Main St. West, Hamilton, ON L8S 4M1, Canada

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[3] McMaster University, Dept. of Physics and Astronomy, 1280 Main St. West, Hamilton, ON L8S 4M1, Canada

The results of a search for sub-km Kuiper Belt Objects (KBOs) with the method of serendipitous stellar occultations are reported. Photometric time series were obtained on the 1.8m telescope at the Dominion Astrophysical Observatory (DAO) in Victoria, British Columbia, and were analyzed for the presence of occultation events. Observations were performed at 40 Hz and included a total of 5.0 star-hours for target stars in the ecliptic open cluster M35 ($\beta = 0.9°$), and 2.1 star-hours for control stars in the off-ecliptic open cluster M34 ($\beta = 25.7°$). To evaluate the recovery fraction of the analysis method, and thereby determine the limiting detectable size, artificial occultation events were added to simulated time series (1/f scintillation-like power-spectra), and to the real data. No viable candidate occultation events were detected. This limits the cumulative surface density of KBOs to $3.5 \times 10^{10}$ deg$^{-2}$ (95% confidence) for KBOs brighter than $m_R$=35.3 (larger than ∼860 m in diameter, assuming a geometric albedo of 0.04 and a distance of 40 AU). An evaluation of TNO occultations reported in the literature suggests that they are unlikely to be genuine, and an overall 95%-confidence upper limit on the surface density of $2.8 \times 10^9$ deg$^{-2}$ is obtained for KBOs brighter than $m_R$=35 (larger than ∼1 km in diameter, assuming a geometric albedo of 0.04 and a distance of 40 AU) when all existing surveys are combined.

**To appear in: The Astronomical Journal**

*For preprints, contact* `bick@astro.princeton.edu`

*or on the web at* `http://arXiv.org/abs/0801.2969`

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## Helios and Prometheus: A Solar/Nuclear Outer-Solar System Mission

**Gregory L. Matloff[1], Les Johnson[2], and Claudio Maccone[3]**

[1] New York City College of Technology, CUNY, USA

[2] Marshall Space flight Center, NASA, USA

[3] Politechnico Torino, Turin, Italy

A 2–3 decade mission is proposed with a solar-sail spacecraft approaching the Sun within 0.2 AU. After sail unfurlment at the perihelion of an initially elliptical solar orbit and the completion of acceleration, the spacecraft splits into two components. One part is a scientific payload bound for the heliopause; the second is designed to rendezvous with a Kuiper Belt Object and decelerates across the solar system using Radioisotope-Electric Propulsion.

**Published in: Journal of the British Interplanetary Society, 60, 439 (2007 Dec)**

*For preprints, contact* `GMatloff@citytech.cuny.edu`

# PAPERS RECENTLY SUBMITTED TO JOURNALS

## Masses of Nix and Hydra

**David J. Tholen[1], Marc W. Buie[2], William M. Grundy[2], and Garrett T. Elliott[3]**

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

[2] Lowell Observatory, 1400 W. Mars Hill Road, Flagstaff, AZ 86001, USA

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Submitted to: The Astronomical Journal

*Preprint available on the web at* `http://arxiv.org/abs/0712.1261`

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# OTHER PAPERS OF INTEREST

## Amorphization of Crystalline Water Ice

**Weijun Zheng[1,2,3], David Jewitt[1], and Ralf I. Kaiser[2]**

[1] Institute for Astronomy, University of Hawaii, Honolulu, HI 96822, USA

[2] Department of Chemistry, University of Hawaii, Honolulu, HI 96822, USA

[3] State Key Laboratory of Molecular Reaction Dynamics, Institute of Chemistry, Chinese Academy of Sciences, Beijing 100080, P. R. China

*Preprint available on the web at* `http://arxiv.org/abs/0801.2805`

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# CONFERENCE CONTRIBUTIONS

## Detection of Small Kuiper Belt Objects by Stellar Occultations

**R.Stevenson[1]**

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

To appear in: Proc. of the 14th Young Scientists Conference on Astronomy and Space Physics

*Preprint available on the web at* `http://arxiv.org/abs/0712.1550`

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# BOOKS

## The Solar System Beyond Neptune

Edited by
**M. Antonietta Barucci**
**Hermann Boehnhardt**
**Dale P. Cruikshank**
**Alessandro Morbidelli**

The University of Arizona Press in collaboration with the Lunar and Planetary Institute, 2008

CONTENTS

# THESES

## A Search for Kilometer-Sized Kuiper Belt Objects with the Method of Serendipitous Stellar Occultations

**S.J. Bickerton**[1]

[1] McMaster University, Dept. of Physics and Astronomy, 1280 Main St. West, Hamilton, ON L8S 4M1, Canada

The results of a search for kilometer-sized Kuiper Belt Objects (KBOs) with the method of serendipitous stellar occultations are reported. Photometric time-series were obtained at the Dominion Astrophysical Observatory (DAO) in Victoria, British Columbia, and were analyzed for the presence of occultation events. Observations were performed at 40 Hz and included a total of 5.0 star-hours for target stars in the ecliptic open cluster M35, and 2.1 star-hours for control stars in the off-ecliptic open cluster M34. To evaluate the recovery fraction of the analysis method, and thereby determine the limiting detectable size, artificial occultation events were added to the data. No viable candidate occultation events were detected. This limits the cumulative surface density of KBOs to $3.5 \times 10^{10}$ deg$^{-2}$ (95% confidence) for KBOs brighter than $m_R$=35.3 (larger than ~860 m in diameter, assuming a geometric albedo of 0.04 and a distance of 40 AU). To evaluate false-positive rates, a method of simulating scintillation effects was developed.

*Dissertation directed by D.L. Welch and J-J. Kavelaars*
*Ph.D. awarded May, 2007 from McMaster University*
*Available in postscript or PDF, contact* `bick@astro.princeton.edu`

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`

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

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## Moving ... ??

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`ekonews@boulder.swri.edu`