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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

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CONTENTS

NEWS & ANNOUNCEMENTS

2003 VB12 (Sedna) has a long lightcurve of 20–50 days, making it the slowest rotating object in the solar system after Mercury and Venus. One explanation is that it is a binary, and the rotation has been regulated by a companion. However, recent HST observations did not detect a satellite.
`http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/14/`

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There were 15 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2003 WS184, 2004 DJ71, 2004 DK71, 2004 DL71, 2004 DM71, 2004 EQ95, 2004 ER95, 2004 ES95, 2004 ET95, 2004 EU95, 2004 EV95, 2004 EW95, 2004 EO95, 2004 EP95, 2004 GV9

and *no* new Centaur/SDO discoveries.

Objects recently assigned numbers:

1997 CS29 = (79360)
1999 CP133 = (79969)
1999 DF9 = (79983)
1999 CC158 = (79978)
2000 CM105 = (80806)
2000 YW134 = (82075)
2001 FM185 = (82157)
2001 FP185 = (82158)
2001 FZ173 = (82155)
2002 GO9 = (83982)
2002 TC302 = (84522)
2002 VR128 = (84719)
2003 VS2 = (84922)

Current number of TNOs: 789 (and Pluto & Charon, and 12 other TNO binary companions)
Current number of Centaurs/SDOs: 149
Current number of Neptune Trojans: 1

Out of a total of 939 objects:
471 have measurements from only one opposition
339 of those have had no measurements for more than a year
191 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

Discovery of a Candidate Inner Oort Cloud Planetoid

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We report the discovery of the minor planet 2003 VB12 (popularly named Sedna), the most distant object ever seen in the solar system. Pre-discovery images from 2001, 2002, and 2003 have allowed us to refine the orbit sufficiently to conclude that 2003 VB12 is on a highly eccentric orbit which permanently resides well beyond the Kuiper belt with a semimajor axis of 480±40 AU and a perihelion of 76±4 AU. Such an orbit is unexpected in our current understanding of the solar system, but could be the result of scattering by a yet-to-be-discovered planet, perturbation by an anomalously close stellar encounter, or formation of the solar system within a cluster of stars. In all of these cases a significant additional population is likely present, and in the two most likely cases 2003 VB12 is best considered a member of the inner Oort cloud, which then extends to much smaller semimajor axes than previously expected. Continued discovery and orbital characterization of objects in this inner Oort cloud will verify the genesis of this unexpected population.

To appear in: The Astrophysical Journal Letters (2004 August 10)

Preprints on the web at: `www.gps.caltech.edu/~mbrown/papers`

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KBO Binaries: How Numerous Were They?

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Given the large orbital separation and high satellite-to-primary mass ratio of all known Kuiper Belt Object (KBO) binaries, it is important to reassess their stability as bound pairs with respect to several disruptive mechanisms. Besides the classical shattering and dispersing of the secondary due to a high-velocity impact, we consider the possibility that the secondary is kicked off its orbit by a direct collision of a small impactor, or that it is gravitationally perturbed due to the close approach of a somewhat larger TNO.

Depending on the values for the size/mass/separation of the binaries that we used, 2 or 3 of the 9 pairs can be dispersed in a timescale shorter than the age of the solar system in the current rarefied environment. A contemporary formation scenario could explain why we still observe these binaries, but no convincing mechanism has been proposed to date. The primordial formation scenarios, which seem to be the only viable ones, must be revised to increase the formation efficiency in order to account for this high dispersal rate. For the reference current KBO population, objects like the large-separation KBO binaries 1998 WW_{31} or 2001 QW_{322} must have been initially an order of magnitude more numerous.

If the KBO binaries are indeed primordial, then we show that the mass depletion of the Kuiper belt cannot result from collisional grinding, but must rather be due to dynamical ejection.

Published in: Icarus, 168, 409 (2004 April)

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Kepler and the Kuiper Belt

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The proposed field-of-view of the Kepler mission is at an ecliptic latitude of $\sim 55°$, where the surface density of scattered Kuiper Belt Objects (KBOs) is a few percent that in the ecliptic plane. The rate of occultations of Kepler target stars by scattered KBOs with radii $r > 10$ km is $\sim 10^{-6}$ to 10^{-4} per star per year, where the uncertainty reflects the current ignorance of the thickness of the scattered KBO disk and the faint-end slope of their magnitude distribution. These occultation events will last only ~0.1% of the planned $t_{exp} = 15$ minute integration time, and thus will appear as single data points that deviate by tiny amounts. However, given the target photometric accuracy of Kepler, these deviations will nevertheless be highly significant, with typical signal-to-noise ratios of ~10. I estimate that 1–20 of the 10^5 main-sequence stars in Kepler's field-of-view will exhibit detectable occultations during its four-year mission. For unresolved events, the signal-to-noise of individual occultations scales as $t_{exp}^{-1/2}$, and the minimum detectable radius could be decreased by an order of magnitude to ~1 km by searching the individual 3-second readouts for occultations. I propose a number of methods by which occultation events may be differentiated from systematic effects. Kepler should measure or significantly constrain the frequency of highly-inclined, ~10 km-sized KBOs.

To appear in: The Astrophysical Journal

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Planetary Migration in a Planetesimal Disk: Why did Neptune Stop at 30 AU?

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We study planetary migration in a gas-free disk of planetesimals. In the case of our Solar System we show that Neptune could have had either a damped migration, limited to a few AUs, or a forced migration up to the disk's edge, depending on the disk's mass density. We also study the possibility of runaway migration of isolated planets in very massive disk, which might be relevant for extra-solar systems. We investigate the problem of the mass depletion of the Kuiper belt in the light of planetary migration and conclude that the belt lost its pristine mass well before that Neptune reached its current position. Therefore, Neptune effectively hit the outer edge of the proto-planetary disk. We also investigate the dynamics of massive planetary embryos embedded in the planetesimal disk. We conclude that the elimination of Earth-mass or Mars-mass embryos originally placed outside the initial location of Neptune also requires the existence of a disk edge near 30 AU.

To appear in: Icarus

For preprints, contact `rodney@ov.ufrj.br`

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Comparative Study of the 2:3 and 3:4 Resonant Motion with Neptune: An Application of Symplectic Mappings and Low Frequency Analysis

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The 2:3 and 3:4 exterior mean motion resonances with Neptune are studied by applying symplectic mapping models. The mappings represent efficiently Poincaré maps for the 3D elliptic restricted three body problem in the neighbourhood of the particular resonances. A large number of trajectories is studied showing the coexistence of regular and chaotic orbits. Generally, chaotic motion depletes the small bodies of the effective resonant region in both the 2:3 and 3:4 resonances. Applying a low frequency spectral analysis of trajectories, we determined the phase space regions that correspond to either regular or chaotic motion. It is found that the phase space of the 3:4 resonant motion is more chaotic than the 2:3 one.

Published in: Celestial Mechanics and Dynamical Astronomy, 88, 343 (2004 April)
For preprints, contact `voyatzis@auth.gr`

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A Study of Trans-Neptunian Object 55636 (2002 TX_{300})

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We report on physical properties of the bright Trans-Neptunian Object 2003 TX_{300} based on a large set of observations taken in different wavelength ranges. Broad band CCD observations aimed at studying the short-term rotational variability show a low amplitude periodic signal of 7.89 ± 0.03 hours. We cannot yet determine whether the lightcurve is single-peaked (i.e. the rotation period would be 7.89 hr) or double-peaked (i.e. the actual spin period would be 15.78 hr). From a sinusoidal fit, the peak to peak amplitude of the brightness changes is 0.09 ± 0.08 mag. If the brightness changes are due to irregular shape, this amplitude implies a minimum axial ratio of 1.09. $BVRI$ photometry indicates similar colors as other large Kuiper Belt members, with $B - V = 0.64 \pm 0.04$, $V - R = 0.40 \pm 0.07$, and $R - I = 0.22 \pm 0.05$. Thermal observations at 250 GHz (1.2 mm) result in no confident detection of the body, with a measured flux of 0.22 ± 0.51 mJy.

Combining all the data and using the same thermophysical model as in Lellouch et al. (A&A, 391, 1133) we find (at a 3σ confidence level) a lower limit for the geometric albedo ($p_v > 0.06$) and an upper limit for the size of this object ($D < 1110$ km). A more relaxed 2σ confidence level implies a diameter $D < 907$ km and an albedo $p_v > 0.08$, which is significantly higher than the typical 0.04 cometary value and also higher than that of Varuna.

To appear in: Astronomy and Astrophysics
For preprints, contact `ortiz@iaa.es`

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Initial Orbit Determination for Distant Objects

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Initial orbit determination for distant objects can be made a simple linear problem with explicit solutions. This is similar to stellar parallax work, with very difficult observations but simple computations. A very simple procedure for computing ephemerides for distant objects is proposed. The optimum distribution of observations in time and regions is investigated. The problem of double solutions, linking, elongation, and latitude, and accuracy of elements are also discussed.

Published in: The Astronomical Journal, 127, 2424 (2004 April)

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A Highly-automated Moving Object Detection Package

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With the deployment of large CCD mosaic cameras and their use in large-scale surveys to discover Solar System objects, there is a need for a fast detection algorithms that can handle large data loads in a nearly automatic way. We present here an algorithm that we have developed. Our approach, by using two independent detection algorithms and combining the results, maintains high efficiency while producing low false detection rates. These properties are crucial to in order to reduce the operator time associated with searching these huge data sets. We have used this algorithm on two different mosaic data sets obtained using the CFH12K camera at CFHT. Comparing the detection efficiency and false-detection rate of each individual algorithm with the combination of both, we show that our approach decreases the false detection rate by a factor of a few hundred to a thousand, while decreasing the 'limiting magnitude' (where the detection rate drops to 50%) by only 0.1–0.3 magnitudes. The limiting magnitude is similar to that of a human operator blinking the images. Our full pipeline also characterizes the magnitude efficiency of the entire system by implanting artificial objects in the data set. The detection portion of the package is publicly available.

Published in: MNRAS, 347, 471 (2004 January)

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High-eccentricity Trans-Neptunian Objects as a Source of Jupiter-family Comets

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The dynamical evolution of trans-Neptunian objects (TNOs) to the inner Solar system is investigated. The study is based on the observed sample of high-eccentricity TNOs with perihelia in the near-Neptune region, using a procedure to take account of observational biases. It is shown that observations favour TNOs in high-eccentricity orbits as the main source of Jupiter-family (JF) comets. The relative fraction of objects captured per year from the near-Neptune region to JF comets with perihelion distances $q < 1.5\,\mathrm{AU}$ is estimated as 0.2×10^{-10}. The maximum lifetime of typical JF comets with $q < 1.5\,\mathrm{AU}$ is approximately 200 revolutions. Based on the observed population of JF comets, there should be $\sim 10^{10}$ TNOs of cometary size in high-eccentricity orbits with $28 < q < 35.5$ au. If this population originated 4.5 Gyr ago, the primordial number must have been at least 20 times as large as the present one.

To appear in: Monthly Notices of the Royal Astronomical Society, 350, 161

Preprints available on the web at `http://star.arm.ac.uk/preprints/`

PAPERS RECENTLY SUBMITTED TO JOURNALS

Regarding the Accretion of 2003 VB12 (Sedna) and Like Bodies in Distant Heliocentric Orbits

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Submitted to: The Astronomical Journal

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or on the web at `http://arxiv.org/abs/astro-ph/0404525`

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The Size Distribution of Kuiper Belt Objects

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Submitted to: The Astronomical Journal

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Internal Properties of Kuiper Belt Objects Derived from Hubble Space Telescope Lightcurve Observations

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Submitted to: The Astronomical Journal

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OTHER PAPERS OF INTEREST

The Kuiper Belt

Michael E. Brown[1]

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Published in: Physics Today, 57, 49 (2004 April)

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The Formation of the Solar System by Gravitational Instability: Prediction of a New Planet or Another Kuiper-type Belt

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[1] Department of Physics, Ben-Gurion University of the Negev, P.O. Box 653, Beer-Sheva 84105, Israel

Available on the web at `http://arxiv.org/abs/astro-ph/0403376`

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Dynamical Effects of the Radial Galactic Tide on an Oort Cloud of Comets for Stars with Different Masses and Varying Distances from the Galactic Center

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or on the web at `http://arxiv.org/abs/astro-ph/0403599`

CONFERENCE CONTRIBUTIONS

There were several Kuiper belt presentations at the recent 35th Meeting of the AAS Division on Dynamical Astronomy, which was held on 2004 April 20–23 in Canes, France. The following are the papers that I gleaned from the online abstracts, though there some others may be relevant to aspects of Kuiper belt research: `http://www.aas.org/publications/baas/v36n2/dda04/SL.htm`

Planetary Migration in a Planetesimal Disk: Why did Neptune Stop at 30 AU?
A. Morbidelli (OCA- Nice), R. Gomes (ON- Rio de Janeiro), H. Levison (SWRI- Boulder)
`http://www.aas.org/publications/baas/v36n2/dda04/14.htm`

Could 2003 VB12 (Sedna) Have Formed In Situ Within A Massive, Disk-Like Extension of the Kuiper Belt?
S. A. Stern (SwRI)
`http://www.aas.org/publications/baas/v36n2/dda04/13.htm`

An Impact Formation of Pluto-Charon
R.M. Canup (Southwest Research Institute)
`http://www.aas.org/publications/baas/v36n2/dda04/37.htm`

Dynamical Evolution and End States of Scattered Disk Objects
J.A. Fernandez, T. Gallardo (Depto. Astronomia, Facultad de Ciencias, Montevideo, Uruguay), A. Brunini (Facultad de Ciencias Astronomicas y Geofisicas, La Plata, Argentina - CONICET)
`http://www.aas.org/publications/baas/v36n2/dda04/23.htm`

The Formation of High Inclination Trans-Neptunian Objects
R.S. Gomes (GEA/OV/MCT & ON/MCT)
`http://www.aas.org/publications/baas/v36n2/dda04/29.htm`

The Scattered Disk as a Source of Halley-Type Comets
H.F. Levison (SwRI), M.J. Duncan (Queen's U), L Dones (SwRI)
`http://www.aas.org/publications/baas/v36n2/dda04/44.htm`

Neptune's Smooth Migration into a Hot Kuiper Belt
J.M. Hahn (Saint Mary's University), R. Malhotra (University of Arizona)
`http://www.aas.org/publications/baas/v36n2/dda04/41.htm`

Periodic Orbits in the Exterior Resonances 1/2,1/3 and 1/4 with Neptune
T. Kotoulas, G. Voyatzis (University of Thessaloniki)
`http://www.aas.org/publications/baas/v36n2/dda04/57.htm`

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.

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 ... ??

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`ekonews@boulder.swri.edu`