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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

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CONTENTS

NEWS & ANNOUNCEMENTS

The biggest news is about the biggest new TNOs.

On February 20, Brown, Rabinowitz, and Trujillo announced their team's discovery of a new TNO, 2004 DW, that with an absolute magnitude of $H = 2.2$ may be larger than Quaoar (also discovered by their team), and second only to Pluto. It has been located in Sky Survey images going back to 1951. IAUC 8295 reports that it's reflectance appears to be neutral.
MPEC 2004-D13: `http://cfa-www.harvard.edu/mpec/K04/K04D13.html`
MPEC 2004-D15: MPEC `http://cfa-www.harvard.edu/mpec/K04/K04D15.html`
IAUC 08291: `http://cfa-www.harvard.edu/iauc/08200/08291.html`

But, 2004 DW's reign was short-lived and ended, appropriately, on the ides of March. Brown's team announced the discovery of the scattered disk object 2003 VB12. At $H = 1.7$, its initial size was estimated to be roughly 2000 km in diameter (making the usual albedo assumptions), compared to Pluto at 2300 km. However, a non-detection by the Spitzer Space Telescope places an upper limit at 1700 km. Another interesting aspect of this object is its record perihelion distance of 76 AU. The team also suspects it may have a satellite based on its measured slow rotation of 40 days. 2003 VB12 has been located in images going back to 2001.
MPEC 2004-E45: `http://cfa-www.harvard.edu/mpec/K04/K04E45.html`
IAUC 08304: `http://cfa-www.harvard.edu/iauc/08300/08304.html`
Press release: `http://www.spitzer.caltech.edu/Media/releases/ssc2004-05/release.shtml`

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The discovery that 2000 CQ114 is a binary TNO was announced in IAUC 8289 by Stephens et al.. The primary and secondary were resolved in four HST/NICMOS images with a separation of 0.178 ± 0.005 arcsec (5880 ± 200 km).
IAUC 08289: `http://cfa-www.harvard.edu/iauc/08200/08289.html`

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There were 14 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2003 UK293, 2003 WU188, 2003 WV188, 2003 WW188, 2004 DW, 2003 FM129, 2003 GH55, 2004 DG64, 2004 DH64, 2004 DJ64, 2004 DK64, 2004 DL64, 2004 DM64, 2004 DN64

and 2 new Centaur/SDO discoveries:

2004 CJ39, 2003 VB12

Objects recently assigned numbers:

2000 PK30 = (76803)
2002 XW93 = (78799)

Objects recently assigned names:

2000 QC243 = Bienor

Deleted/Re-identified objects:

2003 WT42 was removed from the SDO list and is now C/2003 WT42 (LINEAR)

Current number of TNOs: 774 (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 924 objects:
461 have measurements from only one opposition
337 of those have had no measurements for more than a year
190 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

Direct Measurement of the Size of the Large Kuiper Belt Object (50000) Quaoar

M.E. Brown[1] **and C.A. Trujillo**[1]

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We imaged the recently discovered bright Kuiper belt object (50000) Quaoar with the Hubble Space Telescope High Resolution Camera to directly determine its size. The PSF of each of 16 images was carefully measured from a field star 13 arcseconds from Quaoar, and the expected PSF at the location of Quaoar was convolved with Quaoar's motion vector and a model resolved disk. A least-squares analysis was performed to find the best-fit disk size. The apparent diameter of Quaoar was resolved as 40.4 ± 1.8 milliarcseconds. Accounting for the uncertainty due to an unknown limb darkening function, the size of Quaoar is 1260 ± 190 km with a red and blue albedos of $0.092^{+0.036}_{-0.023}$ and $0.101^{+0.039}_{-0.024}$, respectively. These albedos are significantly higher than the canonically assumed value of 4%. Quaoar is the largest currently known minor planet.

To appear in: The Astronomical Journal (2004 April)
Preprints on the web at `www.gps.caltech.edu/~mbrown/papers`

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Two Regions Where Plutinos with Larger Masses Might Exist

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Up to now nearly 1000 small objects have been found in the solar system beyond Neptune. They are called Kuiper Belt Objects (KBOs) or Edgeworth-Kuiper Belt Objects. A group of KBOs named plutinos are in the 3:2 mean motion resonance with Neptune, and Pluto is one of them. Since the discovery of the first KBO in 1992, several small-scale surveys have been carried out and a few large KBOs are discovered. By numerical calculations we have found two regions in the space of orbital elements, where, just as Pluto, objects are trapped in three resonances. These resonances protect Pluto and plutinos from the strong perturbation of Neptune. Furthermore, objects in these two regions will avoid close encounters with Pluto as well. Consequently, in these two regions astronomers might discover some plutinos with larger masses.

Published in: Chinese Astronomy and Astrophysics, 27, 315 (2003 July-September)
(translated from: Acta Astronomica Sinica, 44, 166)

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Extreme Kuiper Belt Object 2001 QG_{298} and the Fraction of Contact Binaries

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Extensive time-resolved observations of Kuiper Belt object 2001 QG_{298} show a lightcurve with a peak-to-peak variation of 1.14 ± 0.04 magnitudes and single-peaked period of 6.8872 ± 0.0002 hr. The mean absolute magnitude is 6.85 magnitudes which corresponds to a mean effective radius of 122 (77) km if an albedo of 0.04 (0.10) is assumed. This is the first known Kuiper Belt object and only the third minor planet with a radius >25 km to display a lightcurve with a range in excess of 1 magnitude. We find the colors to be typical for a Kuiper Belt object ($B - V = 1.00 \pm 0.04$, $V - R = 0.60 \pm 0.02$) with no variation in color between minimum and maximum light. The large light variation, relatively long double-peaked period and absence of rotational color change argue against explanations due to albedo markings or elongation due to high angular momentum. Instead, we suggest that 2001 QG_{298} may be a very close or contact binary similar in structure to what has been independently proposed for the Trojan asteroid 624 Hektor. If so, its rotational period would be twice the lightcurve period or 13.7744 ± 0.0004 hr. By correcting for the effects of projection, we estimate that the fraction of similar objects in the Kuiper Belt is at least ~10% to 20% with the true fraction probably much higher. A high abundance of close and contact binaries is expected in some scenarios for the evolution of binary Kuiper Belt objects.

To appear in: The Astronomical Journal (2004 May)
For preprints, contact `sheppard@ifa.hawaii.edu`
or on the web at `http://www.ifa.hawaii.edu/~sheppard/2001qg298.html`
and `http://arxiv.org/abs/astro-ph/0402277`

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The Formation of Kuiper-belt Binaries through Exchange Reactions

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Recent observations have revealed an unexpectedly high fraction — a few per cent — of the trans-Neptunian objects (TNOs) that inhabit the Kuiper belt are binaries. The components have roughly equal masses, with very eccentric orbits that are wider than a hundred times the radius of the primary. Standard theories of binary asteroid formation tend to produce close binaries with circular orbits, so two models have been proposed to explain the unique characteristics of the TNOs. Both models, however, require extreme assumptions regarding the size distribution of the TNOs. Here we report a mechanism that is capable of producing binary TNOs with the observed properties during the early stages of their formation and growth. The only required assumption is that the TNOs were initially formed through gravitational instabilities in the protoplanetary dust disk. The basis of the mechanism is an exchange reaction in which a binary whose primary component is much more massive than the secondary interacts with a third body, whose mass is comparable to that of

the primary. The low-mass secondary component is ejected and replaced by the third body in a wide but eccentric orbit.

Published in: Nature, 427, 518 (2004 February 5)
For preprints, contact funato@chianti.c.u-tokyo.ac.jp

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Color Patterns In The Kuiper Belt: A Possible Primordial Origin

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As a result of our continuing photometric survey, we report here optical colors for 36 Kuiper belt objects, increasing our sample size to 91 objects. We find that certain dynamical classes of objects exhibit distinctive colors — 21 out of 21 objects on small-inclination and small-eccentricity orbits with perihelion distances larger than 40 AU exhibit red surface colors ($B - R > 1.5$) while 17 out of 20 objects on large-inclination and large-eccentricity orbits with aphelion distances larger than 70 AU exhibit gray surface colors ($B - R < 1.5$). Our observations are consistent with a primordial origin for Kuiper belt surface colors, if we assume that gray objects formed closer to the Sun than red objects, and as Neptune migrated outward it scattered gray objects onto dynamically hot orbits. By this model, the contrasting dynamically cold and red objects beyond 40 AU remained far enough away from Neptune that they were never perturbed by the planet.

Published in: Astrophysical Journal Letters, 599, L49 (2003 Dec 10)
For preprints, contact Stephen.Tegler@nau.edu
or on the web at http://www.physics.nau.edu/~tegler/apjl.pdf

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ESO Large Program on Centaurs and TNOs: Visible Colors — Final Results

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We report 43 new visible colors of Centaurs and TNOs, obtained at NTT and VLT telescopes under the "ESO Large Program on Physical Properties of Centaurs and TNOs". Merging these new measurements with those obtained during the first part of the program (Boehnhardt et al., 2002) and the "Meudon Multicolor Survey" (Doressoundiram et al., 2002) we have a unique dataset of 109 objects. We checked for correlations and trends between colors, physical and orbital parameters, carrying out an analysis based on Monte Carlo simulation to account for observational error bars.

Centaurs show no evidence for correlation between $V - R$ *vs.* $R - I$ colors which raises the hypothesis that more than one single coloring process might be acting on their surfaces. Classical objects seem to be composed of two different color populations: objects with $i < 4.5°$ display only

red colors while those with $i > 4.5°$ display the whole range of colors from blue to very red. The possibility that the low inclined population is misguiding global conclusions is analyzed. Classical objects also show a stronger color–perihelion correlation for intrinsically brighter objects, corresponding to critical estimated sizes of different formation histories. Scattered disk objects show color resemblances with the Classical objects at $i > 12°$, hence surface reflectivities resemblances, pointing to a common origin. No color–aphelion trend is found for SDOs, as expected from the intense irradiation by galactic cosmic–rays beyond the solar wind termination shock. Plutinos show a color–absolute magnitude trend, in which all the intrinsically faintest objects are blue. We see many red Plutinos in highly inclined and highly eccentric orbits, that should have originated in a primordial inner disk under Gomes (2003) migration scenario. This seems to invalidate the assumption that objects originated in this inner disk are mainly blue. Finally, we also find six candidates for light-curve studies: four objects (1998 WU_{31}, 1999 OE_4, 1999 OX_3 and 2001 KP_{77}) present significant short term R-magnitude variability, and two objects (1999 XX_{143} and 2000 GP_{183}) evidence possible color variations with rotation.

To appear in: Icarus
For preprints, contact Nuno.Peixinho@obspm.fr

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Simultaneous Visible-near IR Photometric Study of Kuiper Belt Object Surfaces with the ESO/Very Large Telescopes

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We present simultaneous visible-near-IR ($BVRIJHK$) photometry of 8 Kuiper belt objects (KBOs) and 4 Centaurs. The observations were carried out using two 8m-units of the ESO/Very Large Telescope operated simultaneously on November 29 and 30, 2000. The KBOs displayed linear reflectivity spectra in the optical with a wide range of slopes from neutral (solar) to very red. In most cases, the reflectivity spectra are linear from B to J bands. We notice a change of regime in the spectra which flatten toward the H and K bandpasses. (33128) 1998 BU_{48} even has a significantly negative $H-K$ value. Only (54598) 2000 QC_{243} does not flatten in the infra-red. (24835) 1995 SM_{55} has a noticeably blue spectrum in the near-IR which might be indicative of water ice absorption features. We also present an empirical model for KBO surface evolution, based on models from Luu & Jewitt (1996, AJ, 112, 2310) and Stern (1995, AJ, 110, 856), in which surface colors evolve because of collisions. In the model presented here we propose that cometary activity can refresh the surface. This model predicts that (1) small (*e.g.* <<80 km in radius) KBOs should have color variations with rotation, (2) the larger objects should display uniform colors, (3) there should be no color dependence with inclination for objects >100 km in radius, and (4) very distant KBOs are fully irradiated.

To appear in: Astronomy & Astrophysics
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The Plane of the Kuiper Belt

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We present a robust method for measuring the effective plane of the Kuiper belt. The derived plane has an inclination with respect to the ecliptic of 1.86 degrees and an ascending node of 81.6 degrees, with a 1σ error in pole position of the plane of 0.37 degrees. The plane of the Kuiper belt is inconsistent with the invariable plane, the plane of Jupiter, and the plane of Neptune at the greater than 3σ level. Using linear secular perturbation theory, we show that the plane of the Kuiper belt is expected to oscillate about the position of the invariable plane with a period of 1.9 million years and an amplitude of 1.2 degrees. The present predicted position of the plane of the Kuiper belt has an inclination with respect to the ecliptic of 1.74 degrees and an ascending node of 86.7 degrees, within 0.20 degrees of our measured position.

To appear in: The Astronomical Journal (2004 April)
Preprints on the web at `www.gps.caltech.edu/~mbrown/papers`

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Other Kuiper Belts

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When a main sequence star evolves into a red giant and its Kuiper Belt objects (KBOs) reach a temperature of $\sim$170 K, the dust released during the rapid ice sublimation of these cometary bodies may lead to a detectable infrared excess at 25 μm, depending on the mass of the KBOs. Analysis of *IRAS* data for 66 first-ascent red giants with $200L_{\odot} < L < 300L_{\odot}$ within 150 pc of the Sun provides an upper limit to the mass in KBOs at 45 AU orbital radius that is usually less than 0.1 $\mathcal{M}_{\oplus}$. With improved infrared data, we may detect systems of KBOs around first-ascent red giants that are analogs to our solar system.

Published in: The Astrophysical Journal, 603, 729 (2004 March 10)
For preprints, contact `jura@clotho.astro.ucla.edu`
or on the web at `http://arxiv.org/abs/astro-ph/0311629`

PAPERS RECENTLY SUBMITTED TO JOURNALS

Occultations of HIP and UCAC2 stars down to 15 mag by large TNO in 2004–2014

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Submitted to: Astronomy Letters
Preprints available on the web at `http://arxiv.org/abs/astro-ph/0403002`

OTHER PAPERS OF INTEREST

Reflectance Spectra of Hydrated Titan Tholins at Cryogenic Temperatures and Implications for Compositional Interpretation of Red Objects in the Outer Solar System

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Published in: Icarus, 168, 158 (2004 March)

For preprints, contact troush@mail.arc.nasa.gov

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A Search for Debris Discs around Stars with Giant Planets

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Published in: Monthly Notices of the Royal Astronomical Society, 348, 1097

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The Absence of CO from the Dust Peak around epsilon Eri

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Published in: Monthly Notices of the Royal Astronomical Society, 348, L39

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Double Trouble

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Published in: Nature, 427, 494 (2004 February 5)

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Survival of Trojan-type Companions of Neptune during Primordial Planet Migration

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Icarus, 167, 347 (2004 February)

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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`