Issue No. 29 *May 2003*

DISTANT EKOs

The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

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CONTENTS

NEWS & ANNOUNCEMENTS

According to MPEC 2003-F07 (`http://cfa-www.harvard.edu/mpec/K03/K03F07.html`), the MPC is revising how the "Type" entries in the "Distant Minor Planets" MPECs are defined. Objects that are in a Neptunian resonance will be given a Type of the resonance designation (e.g., 1:1, 4:5, 3:4, 3:5, 4:7, or 1:2), the exception being that "plutino" will continue to be used for objects in the 2:3 resonance. The name "cubewano" will be used for classical (a.k.a., main belt) TNOs, and "SDO" (scattered disk object) for those that are not otherwise in a resonance. Types will be listed only for those objects with well-determined orbits (i.e., those with uncertainty parameters U$\leq$6).

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Also note that Neptune Trojans (1:1 resonance) are now listed on a separate page at the MPC:
`http://cfa-www.harvard.edu/iau/lists/NeptuneTrojans.html`
The *Distant EKOs* object lists now also include these objects (well, one so far) in a separate category:
`http://www.boulder.swri.edu/ekonews/objects/`

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The TNO appulse event web page was upgraded recently to include the year 2004. The authors (Marchis and Berthier) plan to soon include calculations for Pluto and additional details about possible occultation events in 2003 and 2004. The page is available at:
`http://astron.berkeley.edu/~fmarchis/Science/TNOs_Appulse/`

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W. Romanishin provides several lists, updated monthly, available at:
`http://observatory.ou.edu`
These lists include: (1) Observable objects sorted from bright to faint apparent magnitude for each dynamical class, which is useful to help pick out objects bright enough to be observable with given instrumental limitations; (2) Cross references of numbered objects listing original designation, number, and name; and (3) Observatory codes and names of observatories that have submitted astrometry of these objects. Most of information in these lists comes from monthly Distant Minor Planet MPECs.

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There were 11 new TNO discoveries announced since the previous issue of *Distant EKOs*:
2003 FH127, 2003 FJ127, 2003 FK127, 2003 FL127, 2003 FM127, 2003 FB128,
2003 FC128, 2003 FD128, 2003 FE128, 2003 FF128, 2003 FY128
and 2 new Centaur/SDO discoveries:
2003 CO1, 2003 FX128

Reclassified objects:
2002 GY32 (SDO $\rightarrow$ TNO)

Current number of TNOs: 676 (and Pluto & Charon, and 8 other TNO binary companions)
Current number of Centaurs/SDOs: 126
Current number of Neptune Trojans: 1

Out of a total of 803] objects:
402 have measurements from only one opposition
277 of those have had no measurements for more than a year
144 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

Resolution of the Kuiper Belt Object Color Controversy: Two Distinct Color Populations

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Four years ago, we reported that the surface colors of ancient, icy bodies at and beyond the orbit of Neptune—Kuiper belt objects—divide into two distinct color populations. Our report has proven quite controversial. Specifically, every other research group looking with large telescopes at Kuiper belt objects finds a continuous range of colors rather than two distinct populations. Here we report new color measurements of 18 objects, primarily from the Keck I 10-m telescope, that confirm the existence of two populations. We have combined the color measurements of the other groups to create a data set comparable in size to our data set. We have carried out a Monte Carlo statistical analysis and found that both data sets are consistent with two color populations and our data set, which has smaller uncertainties, rules out a continuum of colors. In addition, our new observations and those in the literature confirm our earlier report that classical KBOs with perihelion distances beyond 40 AU exhibit extremely red surface colors. Our results rule out a continuous color distribution for both our complete sample and subsamples with perihelion distances greater than or less than 40 AU. We suspect the color patterns will result in a better understanding of the formation and evolution of the outer Solar System.

Published in: Icarus, 161, 181 (2003 January)
For preprints, contact `tegler@proto.phy.nau.edu`

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Colors and Collision Rates within the Kuiper Belt. Problems with the Collisional Resurfacing Scenario

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We present a numerical check of the collisional resurfacing (CR) hypothesis proposed to explain the observed color diversity within the Kuiper Belt (where surface reddening due to space weathering is counteracted by regular resurfacing of neutral material after mutual collisions). Deterministic simulations are performed in order to estimate the *relative* spatial distribution of kinetic energy received by collisions, ΣE_{cin}, for a population of target Kuiper Belt Objects (KBOs) imbedded in a swarm of impactors distributed within the belt. Four different impactor disks have been considered, depending on the excitation and the external limit of the belt and the density of the Scattered KBOs (SKBOs) population. The obtained results are compared to the *relative* color index distribution within the observed Kuiper Belt, in order to derive possible similarities between the high vs. low ΣE_{cin} objects spatial distribution in our simulations and the bluer vs. redder KBOs distribution in the "real" Kuiper Belt. Such similarities are found for several important features, in particular the general correlations between highly impacted objects and high rms excitation and low perihelion q values, that are in good agreement with equivalent correlations found for the bluest objects of the observed belt. Nevertheless, simulations disagree with observations on two crucial points. 1) The

plutinos are significantly more collisionally affected than the rest of our test KBO population, whereas there is no observed tendency towards bluer plutinos. 2) There is always a much stronger correlation between ΣE_{cin} and eccentricities than inclinations, whereas observations show just the opposite feature. The presence of numerous SKBO impactors could significantly damp these problematic features, but cannot erase them. Whether these contradictions invalidate the whole CR scenario or not remains yet uncertain, since the physical processes at play are still far from being fully understood and the sample of available observational data is still relatively limited. But it seems nevertheless that the scenario might not hold in its simple present form.

Published in: Icarus, 162, 27 (2003 March)
For preprints, contact philippe.thebault@obspm.fr
or on the web at http://despa.obspm.fr/~tno

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ESO Large Programme on Physical Studies of Trans-Neptunian Objects and Centaurs: Visible Spectroscopy

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We present the first results from a visible spectroscopic investigation of trans-Neptunian objects (TNOs) and Centaurs, performed within an ESO Large Programme started in 2001 April to spectrophotometrically study these pristine objects in the visible and near-infrared. So far, spectra of 12 TNOs and Centaurs have been obtained using the FORS1 instrument at the Very Large Telescope. The principal preliminary results are differences in the spectral gradient-the gradients obtained indicate the existence of a range of values from moderately red to very red-and the presence of absorption features on two of the observed objects of as yet unexplained origin. The spectral gradients of the objects are also compared with photometric slopes obtained from quasi-simultaneous *BVRI* magnitudes of the objects (where available). An analysis of the spectral gradients with respect to the perihelion distance of the objects suggests that Centaurs (with the possible exception of 1999 OX_3) occupy a zone of lower reflectance slope compared with the TNOs, probably indicating stronger resurfacing effects from cometary activity and, though less likely, collisions.

Published in: The Astronomical Journal, 125, 1554 (2003 March)
For preprints, contact lazzarin@pd.astro.it

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ESO Large Program on Trans-neptunian Objects and Centaurs: Spectroscopic Investigation of Centaur 2001 BL41 and TNOs (26181) 1996 GQ21 and (26375) 1999 DE9.

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The observational results presented in this paper are part of an ESO Large program dedicated to the characterization of the physical properties of TNOs and Centaurs. In this paper we report observations related to the Centaur 2001 BL41 and two trans-Neptunian objects, (26181) 1996 GQ21, and (26375) 1999 DE9. We present results from broadband photometry (*JHK* filters) and low-dispersion infrared spectroscopy performed with ISAAC at the Very Large Telescope (VLT-ESO) in Chile. None of the spectra show evidence of absorption features, in particular water ice features. We used a radiative transfer model to investigate the surface composition of these icy and primitive outer solar system bodies. We suggest models composed of geographical mixtures of organics compounds and minerals.

Published in: The Astronomical Journal, 125, 2721 (2003 May)

For preprints, contact `Alain.Doressoundiram@obspm.fr`

or on the web at `http://despa.obspm.fr/~tno`

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0.8-2.5 Micron Reflectance Spectroscopy of Pluto

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[4] Earth and Space Science Support Office, M/S 160, NASA Langley Research Center, Hampton, VA 23681, USA

Near-infrared (0.8–2.5 μm) spectrophotometry, acquired on 2002 July 18.25, is presented for the Pluto-Charon system. The sub-Earth longitude and latitude of Pluto at the time of the observations were 80° and 28.5°, with a phase angle of 1.25°. The data span wavelength segments that are typically covered by different instruments and includes the seldom-observed 1–1.3 μm region. The geometric albedo is compared to previous observations that were close to this longitude, and no significant differences are seen. Wavelength shifts, relative to laboratory values for pure methane ice and methane immersed in N_2 ice, are reported for a number of methane features in Pluto's spectrum.

Published in: The Publications of the Astronomical Society of the Pacific, 115, 484 (2003 April)

For preprints, contact `richard.j.rudy@aero.org`

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The Resonance Region of Plutinos Under the Perturbation of Outer Planets

X.-S. Wan[1], Z.-F. Dai[1], and T.-Y. Huang[1]

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Three resonances, the 3:2 exterior mean motion resonance with Neptune, Kozai resonance and 1:1 super resonance, are known to govern concurrently the stability of the motion of Pluto. We explore numerically the resonance zones in which the three resonance coexist. There might exist plutinos with relatively large masses in these zones. Considering that Pluto's perturbation is important to the long term evolution of plutinos, the resonance zone is mainly explored in the mirror region of Pluto, which is a mirror image of the region around Pluto with respect to the invariant plane of the solar system. We find six resonance zones in the mirror region. The orbit elements at the centers of the six zones and the corresponding heliocentric distances, longitudes and latitudes on July 1 of 2003 have been computed and listed for the reference of observation.

To appear in: Celestial Mechanics and Dynamical Astronomy
For preprints, contact `xswan@nju.edu.cn`

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Delayed Gratification Habitable Zones (DGHZs): When Deep Outer Solar System Regions Become Balmy During Post-Main Sequence Stellar Evolution

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Like all low and moderate mass stars, during the Sun's later evolution, it will burn as a red giant, generating 1000s of solar luminosities for some tens of millions of years. During this post-main sequence phase, the habitable (i.e., liquid water) thermal zone of our solar system will lie in the region where Triton, Pluto-Charon, and KBOs orbit. Compared to the 1 AU habitable zone where Earth resides, this "Delayed Gratification Habitable Zone" (DGHZ) will enjoy a far less biologically hazardous environment—with far lower harmful UV radiation levels from the Sun, and a far less destructive collisional environment. Objects like Triton, Pluto-Charon, and KBOs, which are known to be rich in both water and organics, will then become possible sites for biochemical and perhaps even biological evolution. The Kuiper Belt, with $> 10^5$ objects 50 km or more in size and more than three times the combined surface area of the four terrestrial planets, provides numerous sites for possible evolution once the Sun's DGHZ reaches it. The Sun's DGHZ might be thought to only be of academic interest owing to its great separation from us in time. However, $\sim 10^9$ Milky Way stars burn as luminous red giants today. Thus, if icy-organic objects are common in the 20–50 AU zones of these stars, as they are in our solar system (and as inferred in numerous main sequence stellar disk systems), then DGHZs may form a niche type of habitable zone that is likely to be numerically common in the Galaxy.

To appear in: Astrobiology
For preprints, contact `astern@swri.edu`

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Occultation Searches for Kuiper Belt Objects

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The occultation of background stellar sources by foreground Kuiper belt objects (KBOs) can be used to survey physical properties of the KBO population. We discuss statistics related to a KBO occultation survey, such as the event duration distribution, and suggest that occultation searches can be effectively used to probe the KBO size distribution below 10 km. In particular, we suggest that occultation surveys may be best suited to search for a turnover radius in the KBO size distribution because of collisions between small-size objects. For occultation surveys that monitor stellar sources near the ecliptic over a few square degrees, with time sampling intervals of the order of 0.1 s and sensitivity to flux variations of a few percent or more, a turnover radius between 0.1 and 1.0 km can be probed. While occultation surveys will probe the low-radius limit and imaging surveys will detect KBOs of size 100 km or more, statistics of objects with sizes in the intermediate range of around 1–100 km will likely remain unattainable.

Published in: The Astrophysical Journal Letters, 587, L125 (2003 April 20)
For preprints, contact asante@tapir.caltech.edu

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Kuiper Belt Object Sizes and Distances from Occultation Observations

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There are several observational campaigns under way to detect kilometer size foreground Kuiper Belt Objects (KBOs) through their occultation of background stars. The interpretation of an occultation light curve, unfortunately, is affected by a geometric degeneracy such that one is unable to determine the KBO size independent of its distance. This degeneracy can be broken through a precise measurement of the relative velocity obtained from simultaneous observations of individual events. While an array of telescopes spread over an area of few square kilometers can be employed, it is unlikely that the relative velocity can be measured to the required accuracy to help break this geometric degeneracy. The presence of diffraction fringes in KBO occultation light curves, when projected sizes of occulted stars are smaller than the Fresnel scale, improves determination of size and distance significantly. In this regard, we discuss the potential role of a dedicated satellite mission for KBO occultation observations. If dwarf stars at the V-band magnitudes of 14th and fainter can be monitored at time intervals of 0.1 seconds with normalized flux errors at the level of 1%, the occultation observations will allow individual KBO sizes and distances to be determined at the level of a few percent or better.

To appear in: The Astrophysical Journal Letters
For preprints, contact asante@tapir.caltech.edu

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The Populations of Comet-Like Bodies in the Solar System

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A new classification scheme is introduced for comet-like bodies in the Solar system. It covers the traditional comets as well as the Centaurs and Edgeworth-Kuiper belt objects. At low inclinations, close encounters with planets often result in near-constant perihelion or aphelion distances, or in perihelion-aphelion interchanges, so the minor bodies can be labelled according to the planets predominantly controlling them at perihelion and aphelion. For example, a JN object has a perihelion under the control of Jupiter and aphelion under the control of Neptune, and so on. This provides 20 dynamically distinct categories of outer Solar system objects in the Jovian and trans-Jovian regions. The Tisserand parameter with respect to the planet controlling perihelion is also often roughly constant under orbital evolution. So, each category can be further sub-divided according to the Tisserand parameter.

The dynamical evolution of comets, however, is dominated not by the planets nearest at perihelion or aphelion, but by the more massive Jupiter. The comets are separated into four categories — Encke-type, short-period, intermediate, and long-period — according to aphelion distance. The Tisserand parameter categories now roughly correspond to the well-known Jupiter-family comets, transition-types and Halley-types. In this way, the nomenclature for the Centaurs and Edgeworth-Kuiper belt objects is based on, and consistent with, that for comets. Given the perihelion and aphelion distances together with the Tisserand parameter, our classification scheme provides a description for any comet-like body in the Solar system. The usefulness of the scheme is illustrated with examples drawn from numerical simulations and from the present-day Solar system.

To appear in: Monthly Notices of the Royal Astronomical Society

For preprints, contact `horner@thphys.ox.ac.uk`

or on the web at `http://www-thphys.physics.ox.ac.uk/users/WynEvans/preprints.pdf`

and `http://www.arxiv.org/abs/astro-ph/0304319`

PAPERS RECENTLY SUBMITTED TO JOURNALS

The Color of Scattered Kuiper Belt Objects

R. Gil-Hutton[1]

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Submitted to: Icarus

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Kuiper-belt Binary Formation through Exchange Reactions

Yoko Funato[1], **Junichiro Makino**[2], **Piet Hut**[3], **Eiichiro Kokubo**[4], **and Daisuke Kinoshita**[4]

[1] General System Studies, University of Tokyo, Tokyo 153, Japan

[2] Department of Astronomy, University of Tokyo, Tokyo 113, Japan

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[4] National Astronomical Observatory, Tokyo 180, Japan

A shortened version of this paper has been submitted to Nature

For preprints, contact funato@chianti.c.u-tokyo.ac.jp

or on the web at http://www.arxiv.org/abs/astro-ph/0303113

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Long-term Evolution of the Neptune Trojan 2001 QR322

R. Brasser[1], **S. Mikkola**[1], **T.-Y. Huang**[2], **P. Wiegert**[3], **and K. Innanen**[4]

[1] Tuorla Observatory, University of Turku, Piikkiö, Finland

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[4] Dept of Physics and Astronomy, York University, Toronto, ON, Canada

Submitted to: Monthly Notices of the Royal Astronomical Society

For preprints, contact brasser@astro.utu.fi

OTHER PAPERS OF INTEREST

Kuiper Belt Interlopers

A. Morbidelli[1] and H.F. Levison[2,1]

[1] OCA, B.P. 4229, 06304 Nice Cedex 4, France

[2] SWRI, 1050 Walnut St., Boulder, CO. 80302, USA

Published in: Nature, 422, 30 (2003 March 6)

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Infrared Study of Ion-irradiated N2-dominated Ices Relevant to Triton and Pluto: Formation of HCN and HNC

M.H. Moore[1] and R.L. Hudson[2]

[1] Code 691, NASA/Goddard Space Flight Center, Greenbelt, MD 20771, USA

[2] Department of Chemistry, Eckerd College, St. Petersburg, FL 33733, USA

Published in: Icarus, 161, 486 (2003 February)

For preprints, contact ummhm@lepvax.gsfc.nasa.gov

CONFERENCE CONTRIBUTIONS

Dynamical Evolution of Dust Particles in the Kuiper Disk

E.K. Holmes[1], S.F. Dermott[2], and B.Å.S. Gustafson[2]

[1] National Research Council Resident Research Associate, Jet Propulsion Laboratory, California Institute of Technology, M/S 169-506, 4800 Oak Grove Drive, Pasadena, CA 91109, USA

[2] Department of Astronomy, University of Florida, Gainesville, FL 32611, USA

To appear in: Proceedings of the Conference Asteroids, Comets, Meteors ACM 2002

For preprints, contact elizabeth.holmes@jpl.nasa.gov

CONFERENCE INFORMATION

The 35th Annual DPS meeting

2003 September 2–6
Monterey, California, USA

http://dps03.arc.nasa.gov/

The 35th meeting of the DPS will be held Tuesday, September 2 through Saturday, September 6, 2003 at the Double Tree Hotel and the Monterey Conference Center in Monterey, California. Abstract submission deadline is July 1, 2003.

Contact Information:
Ted Roush (LOC, main meeting and affiliated workshops): ted.l.roush@nasa.gov
Jeffrey Moore (SOC): jeffrey.m.moore@nasa.gov

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 ... ??

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`