Issue No. 21 *January 2002*

DISTANT EKOs

The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

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

CONTENTS

NEWS & ANNOUNCEMENTS

NASA has selected New Horizons led by Southwest Research Institute to proceed with the design (Phase B) of a mission to the Pluto and the Kuiper belt. The mission will launch in January 2006, fly by Jupiter in March 2007, nominally fly by Pluto-Charon in July, 2016, and visit up to three TNOs in the following five years (about 1 every 20 months, on average). New Horizons will hold a public 2.5-day workshop in Boulder in May regarding mission science and participation by community members (details will be available in the next issue of the Newsletter). More information about the project can be found at:

`http://www.boulder.swri.edu/pkb/`

`http://pluto.jhuapl.edu/`

Researchers interested in collaboration can contact the project PI, Alan Stern.

. . . .

The discovery that 1999 TC36 is a binary TNO was announced in IAUC 7787 by Trujillo and Brown. The components differ in brightness by 2.21 mag, with a separation of 0.37 arcsec.
IAUC: `http://cfa-www.harvard.edu/iauc/07700/07787.html`
More information at: `http://www.gps.caltech.edu/~chad/1999TC36.html`

. . . .

The Kuiper belt community panel for the Solar System Decadal Survey has produced their white paper report. It is available online at: `http://www.aas.org/~dps/decadal/community_panels.html`
The report discusses the current status of the field and lists the key science questions to be answered in the next decade, regarding: the dynamical structure of the Kuiper belt, the different types/classes, their physical composition and structure, and implications about formation of the outer solar system. The paper makes recommendations for programs to answer these questions that include support for: dedicated ground-based observatories to obtain a well-measured and unbiased sample of ∼5000 TNOs and measure physical properties of many of them, prompt development and launch of a space mission for direct exploration of Pluto and the Kuiper belt, and increased theoretical and laboratory studies.

. . . .

There were 6 new TNO discovery announced since the previous issue of the *Distant EKOs* Newsletter:

2001 DQ108, 2001 XR254, 2001 XU254, 2001 XV254, 2001 XW254, 2001 XX254

and 5 new Centaur/SDO discoveries:

2001 XP254, 2001 XQ254, 2001 XS254, 2001 XT254, 2001 XA255

Reclassified objects:
2000 SY370 (TNO → SDO)
2000 WM183 (TNO → SDO)
2000 YY1 (TNO → SDO)
2000 YW134 (TNO → SDO)

Objects recently assigned numbers:
1999 UG5 = 31824
2001 PT13 = 32532

Re-identified objects:
2000 YW134 = 2001 XG201

Current number of TNOs: 489 (and Pluto & Charon, and four other TNO binary companions)
Current number of Centaurs/SDOs: 92

EDITORIALS & SHORT ARTICLES

Notes from the DPS Kuiper Belt Workshop

A Kuiper belt observer workshop was held at the DPS meeting on November 26. Much of the discussion centered on current survey projects, their status and expected discovery and recovery rates, and the need for a much larger scale of recovery efforts. It was pointed out repeatedly that follow-up observations necessary to obtain sufficiently well-determined orbital elements require significantly (roughly 5–6 times) more observing time than used for the discoveries. At least 25% of all Kuiper belt related objects are effectively lost or should be considered "endangered."

There was general agreement that more effort should be put into recoveries, and that it would be helpful to somehow coordinate recovery observations by improving communcation between groups, sharing online tools, etc., so that effort is not needlessly duplicated. Some observers are developing web sites that provide information complementary to that avaiable at the MPC (e.g., at `http://www.lowell.edu/users/buie/kbo/kbofollowup.html` one can find lists of TNOs that are prioritized by current uncertainty or "need" for astrometric observation), but there is still no centralized facility for observers to share their target lists during observing runs or communicate details of recent successful and failed recovery observations.

Some groups have object-finding software that they will make publically available. It is requested that if you have such software that you would like to make avaiable to other observers, please send the information to `EKOnews@boulder.swri.edu` (along with a URL of the associated web page if available), and it will be advertised in a subsequent issue of the newsletter and posted on the *Distant EKOs* software web page (`http://www.boulder.swri.edu/ekonews/software.html`)

It was also mentioned that, since the number of binary TNOs has suddenly blossomed, there is a strong motivation for observers to examine objects by eye to look for extended structure that may indicate binarity.

PAPERS ACCEPTED TO JOURNALS

A Correlation Between Inclination and Color in the Classical Kuiper Belt

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

[1] California Institute of Technology, Division of Geological and Planetary Sciences, MS 150-21, Pasadena, CA 91125

We have measured broadband optical BVR photometry of 24 Classical and Scattered Kuiper belt objects (KBOs), approximately doubling the published sample of colors for these classes of objects. We find a statistically significant correlation between object color and inclination in the Classical Kuiper belt using our data. The color and inclination correlation increases in significance after the inclusion of additional data points culled from all published works. Apparently, this color and inclination correlation has not been more widely reported because the Plutinos show no such correlation, and thus have been a major contaminant in previous samples. The color and inclination correlation excludes simple origins of color diversity, such as the presence of a coloring agent without regard to dynamical effects. Unfortunately, our current knowledge of the Kuiper belt precludes us from understanding whether the color and inclination trend is due to environmental factors, such as collisional resurfacing, or primordial population effects. A perihelion and color correlation is also evident, although this appears to be a spurious correlation induced by sampling bias, as perihelion and inclination are correlated in the observed sample of KBOs.

To appear in: The Astrophysical Journal Letters

For preprints, contact `chad@gps.caltech.edu`
or by anonymous ftp to `ftp://ftp.gps.caltech.edu/pub/chad/colorincl.ps`
or on the web at `http://xxx.lanl.gov/abs/astro-ph/0201040`

. . . .

Physical Properties of Trans-Neptunian Object (20000) Varuna

David Jewitt[1] **and Scott Sheppard**[1]

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

We present new time-resolved photometric observations of the bright trans-Neptunian object (20000) Varuna and use them to study the rotation period, shape, and color. In observations from 2001 February and April, we find a best-fit two-peaked lightcurve with period 6.3442 ± 0.0002 hr. The peak-to-peak photometric range in the R-band is 0.42 ± 0.02 mag. We find no rotational variation in colors over the $0.45 \leq \lambda \leq 0.85 \mu$m wavelength range. From the short double-peaked period and large amplitude we suggest that Varuna is an elongated, prolate body perhaps close in shape to one of the Jacobi ellipsoids. If so, the ratio of the axes projected into the plane of the sky is 1.5:1 and the density is near 1000 kg m^{-3}. (20000) Varuna may be a rotationally distorted rubble pile, with a weak internal constitution due to fracturing by past impacts. The high specific angular momentum implied by our observations and recent detections of binary Trans-Neptunian Objects both point to an early, intense collisional epoch in which large Trans-Neptunian Objects were $\sim$100 times more abundant than now. In order to maintain a cosmochemically plausible rock:ice mass ratio $\sim$0.5, Varuna must be internally porous.

To appear in: The Astronomical Journal

For preprints, contact jewitt@IfA.Hawaii.Edu
or on the web at http://www.ifa.hawaii.edu/faculty/jewitt/papers/VARUNA2/

....

Planet Formation in the Outer Solar System

Scott J. Kenyon[1]
[1] Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA, 02138, USA

This paper reviews coagulation models for planet formation in the Kuiper Belt, emphasizing links to recent observations of our and other solar systems. At heliocentric distances of 35–50 AU, single annulus and multiannulus planetesimal accretion calculations produce several 1000 km or larger planets and many 50–500 km objects on timescales of 10–30 Myr in a Minimum Mass Solar Nebula. Planets form more rapidly in more massive nebulae. All models yield two power law cumulative size distributions, $N_C \propto r^{-q}$ with $q = 3.0$–3.5 for radii $r \gtrsim 10$ km and $N_C \propto r^{-2.5}$ for radii $r \lesssim 1$ km. These size distributions are consistent with observations of Kuiper Belt objects acquired during the past decade. Once large objects form at 35–50 AU, gravitational stirring leads to a collisional cascade where 0.1–10 km objects are ground to dust. The collisional cascade removes 80% to 90% of the initial mass in the nebula in ~1 Gyr. This dust production rate is comparable to rates inferred for α Lyr, β Pic, and other extrasolar debris disk systems.

To appear in: Publications of the Astronomical Society of the Pacific (2002 March)
For preprints, contact skenyon@cfa.harvard.edu
or on the web at http://arXiv.org/abs/astro-ph/0112120

....

Planetary Embryos Never Formed in the Kuiper Belt

A. Morbidelli[1]**, C. Jacob**[1]**, and J.-M. Petit**[2]
[1] Observatoire de la Côte d'Azur, B.P. 4229, 06304 Nice cedex 4, France
[2] Observatoire de Besançon, B.P. 1615, 25010 Besançon cedex, France

We study the orbital evolutions of various systems of planetary embryos in the trans-Neptunian region, undergoing mutual scattering and perturbations from the giant planets. We show that about 15–20% of the original embryos should survive in the trans-Neptunian region at the current epoch. The orbital dispersion of the surviving embryos depends on their individual mass, so that only Lunar mass embryos could survive with semimajor axis smaller than 50 AU. In all cases we show by a Monte Carlo model that at least one of the surviving embryos should have been already discovered by one of the most effective Kuiper belt surveys. This implies that planetary embryos did not form in the trans-Neptunian region (or have been removed by some external and unknown mechanism). Therefore, we conclude that the Kuiper belt did not undergo self-excitation, unlike the asteroid belt. We also compute with the Monte Carlo model that a significant number (order 10) of Pluto-size bodies could exist only on very eccentric and long-periodic orbits, typical of the scattered disk, while the existence of about 30 bodies brighter than absolute magnitude 4 in the classical belt is compatible with the discovery of Varuna by the Spacewatch survey.

To appear in: Icarus
For preprints, contact A. Morbidelli morby@obs-nice.fr
or on the web at http://www.obs-nice.fr/morby/Ref_list.html

....

Chaos in the Solar System

Myron Lecar[1], Fred A. Franklin[1], Matthew J. Holman[1], and Norman W. Murray[2]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

[2] Canadian Institute for Theoretical Astrophysics, McLennan Physical Labs, University of Toronto, 60 St. George Street, Toronto, ON M5S 1A7, Canada

The physical basis of chaos in the solar system is now better understood: in all cases investigated so far, chaotic orbits result from overlapping resonances. Perhaps the clearest examples are found in the asteroid belt. Overlapping resonances account for its Kirkwood gaps and were used to predict and find evidence for very narrow gaps in the outer belt. Further afield, about one new "short-period" comet is discovered each year. They are believed to come from the "Kuiper Belt" (at 40 AU or more) via chaotic orbits produced by mean-motion and secular resonances with Neptune. Finally, the planetary system itself is not immune from chaos. In the inner solar system, overlapping secular resonances have been identified as the possible source of chaos. For example, Mercury, in 10^{12} years, may suffer a close encounter with Venus or plunge into the Sun. In the outer solar system, three-body resonances have been identified as a source of chaos, but on an even longer time scale of 10^9 times the age of the solar system. On the human time scale, the planets do follow their orbits in a stately procession, and we can predict their trajectories for hundreds of thousands of years. That is because the mavericks, with shorter instability times, have long since been ejected. The solar system is not stable; it is just old!

Published in: Annual Review of Astronomy and Astrophysics, 39, 581 (2001)

For preprints, contact `mlecar@cfa.harvard.edu`

or on the web at `http://arXiv.org/abs/astro-ph/0111600`

. . . .

Bifurcation for Dynamical Systems of Planet-Belt Interaction

Ing-Guey Jiang[1] and Li-Chin Yeh[2]

[1] Institute of Astronomy, National Central University, Chung-Li, Taiwan

[2] Department of Mathematics, National Hsinchu Teachers College, Hsin-Chu, Taiwan

The dynamical systems of planet-belt interaction are studied by the fixed-point analysis and the bifurcation of solutions on the parameter space is discussed. For most cases, our analytical and numerical results show that the locations of fixed points are determined by the parameters and these fixed points are either structurally stable or unstable. In addition to that, there are two special fixed points: the one on the inner edge of the belt is asymptotically stable and the one on the outer edge of the belt is unstable. This is consistent with the observational picture of Asteroid Belt between the Mars and Jupiter: the Mars is moving stablely close to the inner edge but the Jupiter is quite far from the outer edge.

To appear in: International Journal of Bifurcation and Chaos

For preprints, contact `jiang@astro.ncu.edu.tw`

or on the web at `http://arXiv.org/abs/astro-ph/0201022`

. . . .

Collisional Cascades in Planetesimal Disks. I: Stellar Flybys

Scott J. Kenyon[1] **and Benjamin C. Bromley**[2]

[1] Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138 USA

[2] Department of Physics, University of Utah, 201 JFB, Salt Lake City, UT 84112 USA

We use a new multiannulus planetesimal accretion code to investigate the evolution of a planetesimal disk following a moderately close encounter with a passing star. The calculations include fragmentation, gas and Poynting-Robertson drag, and velocity evolution from dynamical friction and viscous stirring. We assume that the stellar encounter increases planetesimal velocities to the shattering velocity, initiating a collisional cascade in the disk. During the early stages of our calculations, erosive collisions damp particle velocities and produce substantial amounts of dust. For a wide range of initial conditions and input parameters, the time evolution of the dust luminosity follows a simple relation, $L_d/L_\star = L_0/[\alpha + (t/t_d)^\beta]$. The maximum dust luminosity L_0 and the damping time t_d depend on the disk mass, with $L_0 \propto M_d$ and $t_d \propto M_d^{-1}$. For disks with dust masses of 1% to 100% of the 'minimum mass solar nebula' (1–100 $M_\oplus$ at 30–150 AU), our calculations yield $t_d \sim$ 1–10 Myr, $\alpha \approx$ 1–2, $\beta = 1$, and dust luminosities similar to the range observed in known 'debris disk' systems, $L_0 \sim 10^{-3}$ to 10^{-5}. Less massive disks produce smaller dust luminosities and damp on longer timescales. Because encounters with field stars are rare, these results imply that moderately close stellar flybys cannot explain collisional cascades in debris disk systems with stellar ages of $\sim$ 100 Myr or longer.

To appear in: The Astronomical Journal (2002 March)

For preprints, contact `skenyon@cfa.harvard.edu`

or on the web at `http://xxx.lanl.gov/abs/astro-ph/0111384`

To view an animation on the web, see `http://cfa-www.harvard.edu/~kenyon/pf/flyby/ani.html`

CONFERENCE INFORMATION

[This announcement appeared in the previous issue of *Distant EKOs*, with a typo in an e-mail address and without the meeting's web page address, which is given here. — Ed.]

Debris Disks and the Formation of Planets: A Symposium in Memory of Fred Gillett

April 11–13, 2002
University Park Marriott, Tucson, Arizona, USA

`http://www.noao.edu/meetings/gillett/`

Symposium agenda outline:

I. History of the discovery
II. Progenitors
- A. Protostellar disks: review w/emphasis on massive (Ae, Be) disks
- B. Dynamics and lifetimes of protostellar disks and massive stars
- C. Evidence and cautions re. "falling evaporating bodies"

III. Debris disks
- A. Overview/Review
- B. Latest observations of debris disks
- C. Stellar ages (and how dicey it still is to determine them)
- D. Young debris disks (¡ few x 10 Myr) and their gas content
- E. Old debris disks (few x 100's M yrs) and their dust content

IV. Descendants and connection to the Solar System
- A. Characteristics of other planetary systems
- B. Evidence in debris disk morphologies for planetary masses
- C. Evolution of the Kuiper Belt and connection to Vega-like systems
- D. Caution: history of our solar system may be quite untypical

V. Where do we go from here?
- A. Observatories and observations
- B. Theory/modeling required for making progress

VI. Summary/retrospective

Chairs of the scientific organizing committee:
Dana Backman: `backman@ssa1.arc.nasa.gov`, `dana@maunakea.fandm.edu`
Larry Caroff: `lcaroff@home.com`

Chair of the local organizing committee:
Steve Strom: `sstrom@noao.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.

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`