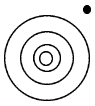
Issue No. 4 *March 1999*

DISTANT EKOs



The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

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

CONTENTS

NEWS & ANNOUNCEMENTS

In the previous issue of *Distant EKOs*, it was reported that 1997 SZ10 may be the first confirmed EKO in the 1:2 mean mean-motion resonance with Neptune. Within a few days, it was announced that it now has company: new observations of 1996 TR66 show that this object is also in the 1:2.

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Only 20 years ago, Pluto moved within Neptune's orbit. On February 11, 1999, Pluto once again claimed the title of "farthest planet" and the order of things will remain that way for the next 232 years.

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The *Distant EKOs* web site (`http://www.boulder.swri.edu/ekonews`) has some changes:

- `http://www.boulder.swri.edu/ekonews/software.html` is new page that provides information about existing software that is useful for Kuiper belt observations and studies. I know many of us are re-inventing the wheel writing code to detect moving objects in CCD images, perform astrometry and photometry, etc., and it would be useful to provide information and software for others. If you have any software you would like to let people use, let me know and I'll add the information to the web page. This does *not* imply that those who wrote the software will be responsible for lots of user support. The benefit for the users is that they don't have to write code from scratch. The benefit to those who wrote and provide the code is that other users may find bugs you were not aware of, and, hopefully, the users would acknowledge your contribution in any publications that made use of your programs.
- `http://www.boulder.swri.edu/ekonews/collaboration.html` is a new "Requests for Collaboration" page that provides a site for people to coordinate observations, obtain assistance in analysis and modeling, etc.. Collaboration requests are also published in the Newsletter.
- The "Objects and Observations" pages (`http://www.boulder.swri.edu/ekonews/objects`) have been improved to give updated RA and Dec positions of objects, which is useful for observation planning. The list of objects and their positions are updated daily.

Please come visit, let me know what you find useful (or not), and send me any information on contributions you may have for software, collaboration requests, or articles that have not been included in the table of published observations.

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There were 17 new EKO discoveries announced since the previous issue of the *Distant EKOs* Newsletter:

1998 UU43, 1998 WS31, 1998 WT31, 1998 WU31, 1998 WV31, 1998 WW31, 1998 WX31, 1998 WY31, 1998 WZ31, 1998 XY95, 1999 CV118, 1999 CW118, 1999 CX118, 1999 CY118, 1999 CZ118, 1999 CA119, 1999 DA

That makes over 100 EKOs! 30 were EKOs discovered in 1998, a third of the total number of objects at the time. 18 were discovered in 1997, and 14 in 1996. This increasing discovery rate adds considerably more pressure to the challenge of obtaining sufficient recovery observations.

Also, two of these new objects, 1999 CY118 and 1999 CZ118, have the highest inclinations seen to date: 41 and 39 degrees, respectively.

Current number of EKOs: 101 (and Pluto and Charon)
Current number of Centaurs: 9

REQUESTS FOR COLLABORATION

Request for Assistance with Retrieval of Faint KBOs

G. Bernstein[1], L. Allen[1], R. Malhotra[2]

[1] University of Michigan Astronomy Department

[2] Lunar & Planetary Institute

As the floodgates open on KBO detections from mosaic cameras and the concomitant need for retrieval observations becomes acute, we wish to attract your attention toward the discoveries of very faint KBOs that we plan to make this May. Our particular goal is characterize the population beyond 50 AU, where perturbations by the giant planets should have been too weak to disturb the primordial dynamical state. Extensive surveys to $R < 24$ mag have failed to find any KBOs beyond 50 AU, suggesting that we must seek fainter objects to probe the primordial Kuiper Belt. Followup observations of these very faint objects will be particularly difficult, so we are soliciting your efforts or collaboration if you have access to large telescopes.

In May, 1999, we will conduct a survey using the BTC camera at the CTIO 4-meter telescope, which should be complete to $R = 26$ over roughly one square degree of the ecliptic. To date, only a very small area (~ 0.01 square degree, the Luu & Jewitt Keck data) has been surveyed to this depth. Current N(m) estimates suggest we will detect 30–50 new KBOs at this time, and an unknown number beyond 50 AU.

Retrieval observations and better orbit determinations are as critical to our study of the Kuiper Belt as new object discoveries. Their faintness requires use of either an 8m-class telescope, or a 4m-class telescope with a large enough field of view to facilitate simultaneous retrieval of large numbers of objects. In practice this means access to the Keck, VLT, or Subaru imagers, or the CFHT, KPNO, and CTIO 4m telescopes with mosaic cameras. While we will pursue several avenues toward retrieval resources, it seems prudent to set forth redundant proposals in order to improve our odds of being granted time and getting good weather.

We are able to detect very faint KBOs with the 4-meter CTIO telescope by using the "digital tracking" technique to combine many hours' worth of data (taken over more than one night) into a single image. The large FOV of the BTC mosaic camera permits coverage of large areas of sky in a single run. In May, 1998, we were able to detect 8 KBOs to a limiting magnitude of $R = 25.4$ over 0.5 square degrees of sky, with only 2 nights of observing. All 8 objects were retrieved on images taken 10 nights earlier; the 10-day baseline permits extrapolation of the KBO position to an accuracy of a few arcminutes for most of the following year, sufficient for retrieval with most imagers. The 1998 BTC run was a complete success in that our software was able to find KBOs to the limits predicted by calculations of the Poisson noise limits. We thus have strong faith that our 1999 observations - with more fields, longer integration times, and a broader filter - will reach the goals stated above, if the weather cooperates. The contents of a colloquium describing our method and results may be viewed on my home page (`http://www.astro.lsa.umich.edu/users/garyb`).

Determinations of useful orbits for the 1999 objects will require a few half-nights per semester on 8m-class telescopes for a year or so, particularly in August 1999 (or earlier) and January 2000. If you are interested in helping fill this potential gap in our own followup capabilities, please contact us for details about field locations, etc. While we will post our discoveries to the MPC promptly, a strong effort toward detection of KBOs at $R \sim 26$ probably calls for advance coordination of our efforts.

Thank you,

Gary Bernstein, Renu Malhotra, Lynne Allen

For further information, contact `garyb@astro.lsa.umich.edu`

PAPERS ACCEPTED TO REFEREED PUBLICATIONS

Kuiper Belt Objects

David Jewitt[1]

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

The region of the solar system immediately beyond Neptune's orbit is densely populated with small bodies. This region, known as the Kuiper Belt, consists of objects that may pre-date Neptune, the orbits of which provide a fossil record of processes operating in the young solar system. The Kuiper Belt contains some of the solar system's most primitive, least thermally processed matter. It is probably the source of the short-period comets and Centaurs, and may also supply collisionally generated interplanetary dust. We discuss the properties of the Kuiper Belt and provide an overview of the outstanding scientific issues.

To appear in: Annual Reviews of Earth and Planetary Science
Available on the web at `http://www.ifa.hawaii.edu/~jewitt/papers/AREPS`

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Dynamics of the Kuiper Belt

Renu Malhotra[1], **Martin Duncan**[2], **and Harold F. Levison**[3]

[1] Lunar and Planetary Institute, Houston, TX 77058, USA
[2] Queens University, Department of Physics, Kingston, ON K7L 3N6, Canada
[3] Southwest Research Institute, Boulder, CO 80302, USA

Our current knowledge of the dynamical structure of the Kuiper Belt is reviewed here. Numerical results on long term orbital evolution and dynamical mechanisms underlying the transport of objects out of the Kuiper Belt are discussed. Scenarios about the origin of the highly non-uniform orbital distribution of Kuiper Belt objects are described, as well as the constraints these provide on the formation and long term dynamical evolution of the outer Solar system. Possible mechanisms include an early history of orbital migration of the outer planets, a mass loss phase in the outer Solar system and scattering by large planetesimals. The origin and dynamics of the scattered component of the Kuiper Belt is discussed. Inferences about the primordial mass distribution in the trans-Neptune region are reviewed. Outstanding questions about Kuiper Belt dynamics are listed.

To appear in: Protostars and Planets IV
For preprints contact `renu@lpis39.jsc.nasa.gov`
or on the web at `http://www.boulder.swri.edu/~hal/ppiv.html`

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Orbital Evolution of Planets Embedded in a Planetesimal Disk

J. Hahn[1], and R. Malhotra[1]

[1] Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77062

The existence of the Oort Comet Cloud, the Kuiper Belt, and plausible inefficiencies in planetary core formation, all suggest that there was once a residual planetesimal disk of mass $\sim$ 10–100 $M_\oplus$ in the vicinity of the giant planets following their formation. Since removal of this disk requires an exchange of orbital energy and angular momentum with the planets, significant planetary migration can ensue. The planet migration phenomenon is examined numerically by evolving the orbits of the giant planets while they are embedded in a planetesimal disk having a mass of M_D = 10 to 200 $M_\oplus$. We find that Saturn, Uranus, and Neptune evolve radially outwards as they scatter the planetesimals, while Jupiter's orbit shrinks as it ejects mass. Higher–mass disks result in more rapid and extensive planet migration. If orbit expansion and resonance trapping by Neptune is invoked to explain the eccentricities of Pluto and its cohort of Kuiper Belt Objects at Neptune's 3:2 mean–motion resonance, then our simulations suggest that a disk mass of order $M_D \sim 50$ $M_\oplus$ is required to expand Neptune's orbit by $\Delta a \sim 7$ AU in order to pump up Plutino eccentricities to $e \sim 0.3$. Such planet migration implies that the initial Solar System was more compact in the past, with the Jupiter–Neptune separation having been smaller by about 30%.

We discuss the fate of the remnants of the primordial planetesimal disk. We point out that most of the planetesimal disk beyond Neptune's 2:1 resonance should reside in nearly circular, low–inclination orbits, unless there are (or were) additional unseen, distant perturbers. The planetesimal disk is also the source of the Oort Cloud of comets. Using the results of our simulations together with a simple treatment of Oort Cloud dynamics, we estimate that $\sim$ 12 $M_\oplus$ of disk material was initially deposited in the Oort Cloud, of which $\sim$ 4 $M_\oplus$ will persist over the age of the Solar System. The majority of these comets originated from the Saturn–Neptune region of the solar nebula.

To appear in: The Astronomical Journal
For preprints on the web `http://cass.jsc.nasa.gov/science/hahn/public/joe_hahn.html`

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IR Kuiper Belt Constraints

Vigdor L. Teplitz[1], S. Alan Stern[2], John D. Anderson[3], Doris Rosenbaum[1], Randall J. Scalise[1], and Paul Wentzler[1]

[1] Physics Department, Southern Methodist University, Dallas, TX 75275

[2] Southwest Research Institute, Boulder, CO 80302

[3] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109

[This is a corrected version of an abstract that appeared in the previous issue of the *Distant EKOs* Newsletter — *Ed.*]

We compute the temperature and IR signal of particles of radius a and albedo α at heliocentric distance R, taking into account the emissivity effect, and give an interpolating formula for the result. We compare with analyses of COBE DIRBE data by others (including recent detection of the cosmic IR background) for various values of heliocentric distance, R, particle radius, a, and particle albedo, α. We then apply these results to a recently-developed picture of the Kuiper belt as a two-sector disk with a nearby, low-density sector ($40 < R < 50-90$ AU) and a more distant sector

with a higher density. We consider the case in which passage through a molecular cloud essentially cleans the Solar System of dust. We apply a simple model of dust production by comet collisions and removal by the Poynting-Robertson effect to find limits on total and dust masses in the near and far sectors as a function of time since such a passage. Finally we compare Kuiper belt IR spectra for various parameter values. Results of this work include: (1) numerical limits on Kuiper belt dust as a function of (R, a, α) on the basis of 4 alternative sets of constraints including those following from recent discovery of the cosmic IR background by Hauser et al. (1998); (2) application to the two-sector Kuiper belt model finding mass limits and spectrum shape for different values of relevant parameters including dependence on time elapsed since last passage through a molecular cloud cleared the outer Solar System of dust; and (3) potential use of spectral information to determine time since last passage of the Sun through a giant molecular cloud.

To appear in: The Astrophysical Journal, Vol. 516 #1 (1999)
For preprints contact `teplitz@phyvms.physics.smu.edu`
or on the web at `http://xxx.lanl.gov/abs/astro-ph/9807207`

CONFERENCE CONTRIBUTIONS

Poynting-Robertson Enhancement of Kuiper Belt IR Signal

Vigdor L. Teplitz[1], Doris Rosenbaum[1], Randall J. Scalise[1], Dana Backman[2], and S. Alan Stern[3]

[1] Physics Department, Southern Methodist University, Dallas, TX 75275

[2] Department of Physics and Astronomy, Franklin and Marshall College, Lancaster, PA 17604

[3] Southwest Research Institute, Boulder, CO 80302

To appear in: APS Centennial - April Conference Proceedings
For preprints contact `teplitz@phyvms.physics.smu.edu`

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The annual Lunar and Planetary Science Conference (LPSC) is being held on March 15–19 in Houston, Texas. Information is available at: `http://cass.jsc.nasa.gov/meetings/LPSC99/` and the program is available at: `http://cass.jsc.nasa.gov/meetings/LPSC99/pdf/program.pdf`. Below I list the Kuiper belt-related abstracts that I found after a brief perusal of the program. (In the HTML-version of the *Distant EKOs* newsletter, you can link directly to the abstracts.)

- **Future Planetary Missions** (Poster Session I), 12:15, Tuesday, March 16
  - *Exploring Comets, Asteroids, and Related Bodies: A Report from the Campaign Strategy Working Group on Building Blocks and Chemical Origins of the SSES*, J. Veverka et al. (abstract #1739, `http://cass.jsc.nasa.gov/meetings/LPSC99/pdf/1739.pdf`)
- **Future Missions: Science and Technology** (Poster Session I), 19:00, Tuesday, March 16
  - *Outer Planets/Solar Probe Project: Pluto Kuiper Express*, Terrile, R.J., Klaasen, K.P., Lunine, J., & Johnson, T.V. (abstract #1988, `http://cass.jsc.nasa.gov/meetings/LPSC99/pdf/1988.pdf`)
- **Origins of Planetary Systems**, 8:30, Wednesday, March 19
  - *Signatures of Giant Planets on the Solar System Kuiper Belt Dust Disk and Implications for Extrasolar Planet in Epsilon Eridani*, Liou, J.-C., & Zook, H.A. (abstract #1698, `http://cass.jsc.nasa.gov/meetings/LPSC99/pdf/1698.pdf`)

- *Accretion of a Massive Edgeworth-Kuiper Belt*, Davis, D.R., Farinella, P., & Weidenschilling, S.J.
  (abstract #1883, `http://cass.jsc.nasa.gov/meetings/LPSC99/pdf/1883.pdf`)

- **Small Bodies**, 13:30, Wednesday, March 19
  - *Neptune's 2:1 Orbital Resonance in the Kuiper Belt*, Malhotra, R.
    (abstract #1998, `http://cass.jsc.nasa.gov/meetings/LPSC99/pdf/1998.pdf`)

- **Small Icy Bodies** (Poster Session II), 19:00, Thursday, March 18
  - *Interpreting the Kuiper Belt Luminosity Function*, Hahn, J.M., & Brown, L.
    (abstract #1888, `http://cass.jsc.nasa.gov/meetings/LPSC99/pdf/1888.pdf`)
  - *VRI Photometry of Kuiper Belt Objects and Centaurs* Ekholm, A.G., et al.
    (abstract #1714, `http://cass.jsc.nasa.gov/meetings/LPSC99/pdf/1714.pdf`)

- **Outer Planets and Satellites** (Print Only Presentations)
  - *Pluto's Family: Debris from the Binary-forming Collision in the 2:3 Resonance?*, Stern, S.A., Canup, R., & Durda, D.D.
    (abstract #1213, `http://cass.jsc.nasa.gov/meetings/LPSC99/pdf/1213.pdf`)

- **Small Bodies** (Print Only Presentations)
  - *Albedo Dependence of Asteroid Opposition Effect* Belskaya, I.N., & Shevchenko, V.G.
    (abstract #1374, `http://cass.jsc.nasa.gov/meetings/LPSC99/pdf/1374.pdf`)
  - *Kuiper Belt Objects 1997 SZ10 and 1996 TR66* Malhotra, R.
    (abstract # 1810, `http://cass.jsc.nasa.gov/meetings/LPSC99/pdf/1810.pdf`)

CONFERENCE INFORMATION

AAS Division on Dynamical Astronomy

28 April – 1 May, 1999
Estes Park, Colorado, USA

`http://dda.harvard.edu/meetings/estespark/`

The DDA includes all aspects of dynamical astronomy, including celestial mechanics, solar system dynamics, stellar dynamics, the dynamics of the interstellar medium and galactic dynamics, and coordination of such research with other branches of science. Invited talks at this meeting will cover topics such as dynamical chaos in the solar system, planetesimal dynamics and the formation of Uranus and Neptune, and other non-solar system topics.

Registration Deadline: 12 March 1999

Abstract Submission Deadline: 19 March 1999

Contact Hal Levison (`hal@gort.boulder.swri.edu`) for more information about this meeting.

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Pluto and Triton: Comparison and Evolution Over Time

23–25 September 1999
Lowell Observatory, Flagstaff, Arizona, USA

`http://www.lowell.edu/workshop`

A decade after the Voyager flyby of Triton and the end of the Pluto/Charon mutual event season, this meeting will provide an opportunity to synthesize recent investigations of these two bodies and to explore and compare processes affecting them over time scales ranging from diurnal to cosmological. Themes to be addressed include:

- Recent Data
  - Spectroscopy (ISO, HST, ground-based...)
  - Occultations
  - Photometry (UV to thermal)
- Interpretations and Models
  - Atmosphere and surface interactions
  - Cratering in the trans-Neptunian environment
  - Surface and interior composition and structure
  - Radiation chemistry
  - Tidal and dynamical inputs
- Additional Data Needed
  - Future Observations (HST, SIRTF, NGST, SOFIA, ground-based...)
  - Laboratory experiments
- Spacecraft missions

Persons considering attending are requested to send e-mail expressions of interest to Will Grundy (`grundy@lowell.edu`), including approximate presentation topic(s) and likelihood of attending, for planning purposes. Those who express interest will receive further e-mail announcements and reminders directly, as appropriate.

Visit `http://www.lowell.edu/workshop` for more information about the meeting as well as (eventually) electronic registration and submission of abstracts. The abstract deadline is August 13 and the registration deadline is July 30. If there is sufficient interest, workshop papers submitted to Icarus by November 15 will be considered for publication in a special "Pluto and Triton" section.

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Disks, Planetesimals & Planets

24–28 January 2000
Puerto de la Cruz, Tenerife

`http://www.iac.es/MEETINGS.html`

A conference organized by EXPORT (EXoPlanetary Observational Research Team)

The recent discoveries of extrasolar planets and the progress in studies of disks around pre-main sequence and main sequence stars highlight the need of better understanding the formation and evolution of planetary systems. Many groups and observatories are dedicating important efforts towards these goals. The 1998 international time of the Canary Islands Observatories is fully devoted to studies related to these topics, making use of spectroscopic, polarimetric and photometric techniques in the optical, as well as near-IR photometry.

The conference is the frame where the large amount of data collected with the facilities in the Canary Islands will be presented. In addition, contributions from participants addressing theoretical models and observations in all wavelength ranges will provide an updated overview of the field.

The conference will last five days (including a free afternoon) and will consist of sessions with invited and contributed talks and poster. Sessions will devoted to:

- PMS objects: circumstellar (protoplanetary) disks around protostellar objects, PMS stars and Vega-type stars
- Planetesimals in PMS and MS stellar systems
- Planets around stars
- Searches for planets
- Impact on planetary system studies of future space and ground-based facilities

The first Announcement of the meeting will be issued March 1, 1999. It will include a preliminary scientific programme, membership of the SOC, invited speakers, registration forms and instructions for abstracts, hotel reservation and travel information, social events, etc.

Information on the meeting will regularly be updated at the Conference Web page that can be found from January 1999 on: `http://www.iac.es/MEETINGS.html`

Inquiries about the meeting can be e-mailed to the address: `planet@ll.iac.es`
or post to:
Monica Murphy
(Disks, Planetesimals & Planets Meeting)
Instituto de Astrofisica de Canarias
c/ Via Lactea s/n
38200 La Laguna
Tenerife. Spain

Information on EXPORT can be obtained at: `http://pollux.ft.uam.es/export`

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`