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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

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

CONTENTS

NEWS & ANNOUNCEMENTS

There have been a few new additions to the *Distant EKOs* website on the "Observer Support" page (`http://www.boulder.swri.edu/ekonews/observer.html`):

- A list of links to web pages provided by observers to communicate their progress in recoveries and general observations. Such information will be useful for other researchers to coordinate and plan observing runs. If you would like to add your web page to the list, please send the URL to me.
- A link to the new "Lost Objects" page. Until now, there has been no way for observers to find out about *failed* recoveries in any systemmatic way. The intention of this new page is to encourage people to report their failed recoveries so others can use that information for wider-ranging attempts to recover objects. The success of this page depends on observers regularly and accurately reporting their failed recoveries. Please let me know if you find this page useful or not.

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There were 27 new discoveries announced since the previous issue of the *Distant EKOs* Newsletter:

1999 RB215, 1999 RC215, 1999 RD215, 1999 RE215, 1999 RF215, 1999 RG215, 1999 RH215, 1999 RJ215, 1999 RK215, 1999 DL8, 1999 RN215, 1999 DM8, 1999 DN8, 1999 DO8, 1999 DP8, 1999 DQ8, 1999 DR8, 1999 RR215, 1999 RT215, 1999 RU215, 1999 RV215, 1999 RW215, 1999 RX215, 1999 RY215, 1999 RZ215, 1999 RA216, 1999 RB216

This brings the number of objects discovered in 1999 to 132, which is more than the number of TNOs discovered in all the previous year combined.

Current number of TNOs: 243 (and Pluto & Charon)
Current number of Centaurs: 17

REQUESTS FOR COLLABORATION

Call for Follow-up Astrometry

M. W. Buie[1], R. L. Millis[1], J. L. Elliot[2], and R. M. Wagner[3]

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We recently had a successful run of nights on the KPNO 4-m Mayall telescope with the Mosaic camera. These observations are designed to maximize the total number of trans-Neptunian objects discovered with this large field of view camera. We do not schedule followup time for these observations with Mosaic, preferring instead to use smaller field of view instruments and perhaps smaller telescopes once we know where to look. We are proceeding with our own followup efforts but the list of objects is quite long. We invite help from anyone in the community capable of making useful followup observations.

To request objects, contact `buie@lowell.edu`
Details are available on the web at `http://www.lowell.edu/users/buie/kbo/kbofollowup.html`

EDITORIALS & SHORT ARTICLES

Leuschner and The Kuiper Belt

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In a recent popular article, Beekman (1999) makes the case that Armin Otto Leuschner was the first to suggest the existence of what is variously called the Kuiper Belt, the Edgeworth-Kuiper Belt or the Transneptunian Belt. This assertion was on the basis of a news item (Science Service 1930) written soon after Pluto's discovery.

The important thing to appreciate about this news item is that it was inspired by the calculation at the Lowell Observatory of an orbit for Pluto that had an eccentricity of 0.9. The item then goes on:

> Dr. Slipher's report conforms to an announcement of an orbit computed by A. C. [sic] Bower and F. L. Whipple under the direction of Professor A. O. Leuschner of the University of California Observatory [sic] at Berkeley. Professor Leuschner telegraphed today [i.e., 1930 Apr. 13]:
>
> "The Lowell result confirms the possible high eccentricity announced by us on April 5. Among the possibilities are a large asteroid greatly disturbed in its orbit by close approach to a major planet such as Jupiter, or it may be one of many long-period planetary objects yet to be discovered, or a bright cometary object.
>
> "I have frequently referred to the close orbital and physical relationship of minor planets and comets. High eccentricity and small mass would seem to eliminate object [sic] as being planet X predicted by Lowell, and singly an unexpected discovery, nevertheless of highest astronomical importance and interest on account of the great distance of the object in the solar system at discovery."
>
> Dr. Harlow Shapley, director of the Harvard Observatory, wired:
>
> "The preliminary orbit indicates remarkable type of member of the solar system not comparable with known asteroids and comets, and perhaps of greater importance in cosmogony than would be another major planet beyond Neptune."

Consider now Leuschner's statement "or it may be one of many long-period planetary objects yet to be discovered". Although the additional descriptor "high-eccentricity" is not given, everything else in Leuschner's statement ("large asteroid greatly disturbed", "bright cometary object", "eliminate object as being planet X") suggests that he was thinking of orbits of high eccentricity. If that is so, what he was envisaging does not in fact bear much resemblance to the Transneptunian Belt as we now generally understand it. This is an important point, not mentioned in Beekman's article. Furthermore, the suggested similarity of Pluto in that region to 'giants' like Ceres, Pallas and Vesta among the general 'dwarfs' in the asteroid belt comes from Beekman, not Leuschner.

But one must remember that the inspiration for the news item was the *specific* Lowell high-eccentricity orbit computed for Pluto, with the author of the article (not specified but known to be James Stokely; Hoyt 1980) therefore having the specific aim of wanting to *support* the Lowell calculation with the Berkeley work. As it happens, *E. C.* Bower and Whipple (1930) had computed six different orbits, with eccentricities ranging all the way from 0.111 to a parabola. They were aware, even if the Lowell people were not, that Pluto could have had a low orbital eccentricity. Leuschner must therefore also have been aware of this, even if there is no hint of it in the article.

But, in making his enigmatic statement, also quoted by Hoyt (1980, p. 207), was he in fact considering that at least some of the "many long-period planetary objects" might have low-eccentricity orbits somewhat beyond Neptune? That is hard to say. Leuschner does not seem to have published anything else on the subject. Whipple (2000) recalls no discussion by Leuschner of such a multiplicity of objects, noting that Leuschner really did not apply much "direction" to Bower and himself; Leuschner was the one who spoke to the press.

In researching the above, however, I came across some intriguing comments by Leonard (1930), written after the 0.25-eccentricity of Pluto had been demonstrated: "Now that a body of the evident [small] dimensions and mass of Pluto has been revealed, is there any reason to suppose that there are not other, probably similarly constituted, members revolving around the Sun outside the orbit of Neptune? ... As a matter of fact, astronomers have recognized for more than a century that this system [i.e., the solar system] is composed successively of the families of the terrestrial planets, the minor planets, and the giant planets. Is it not likely that in Pluto there has come to light the *first* of a *series* of ultra-Neptunian bodies, the remaining members of which still await discovery but which are destined eventually to be detected?" Leonard was in fact the mentor of Whipple, prior to the latter's going to Berkeley. Although Whipple, Bower and Leuschner are mentioned earlier in the article, there is no indication that Leonard got these ideas from Leuschner, and Whipple (2000) thinks it unlikely that he did.

The point is that remarks such as those made by Leuschner and Leonard (and perhaps particularly the prescient comment by Shapley!) were quite reasonable for anyone to make, given the then-growing realization that Pluto was not the object predicted by Percival Lowell from its supposed perturbations on Uranus. That realization seems first to have been appreciated by Jackson (1930), who added, writing just ten days after the announcement of the Pluto discovery, "It looks as if long-exposure photographs are revealing a number of faint objects inside the solar system which would otherwise remain unknown, and possibly we may soon have better knowledge from which to judge the distribution of comets [sic] in our system".

In contrast to the rather general remarks made by the astronomers of 1930 on the basis of *observational* arguments, Kuiper (1951), and to some extent Edgeworth (1943, 1949), based their remarks on *physical* grounds, and it is perhaps for this reason that their names have more generally been quoted in connection with the now-well-known population in the outer solar system. Nevertheless, the fact that the observational arguments had been made soon after Pluto's discovery was probably not lost on Kuiper, a point that should be taken into account by those who feel he may have been less than generous in his failure to acknowledge Edgeworth's work.

This still leaves unresolved what collective term we should use for these denizens of the outer solar system. For better or for worse, "Kuiper Belt" has become rather entrenched. Much as I can sympathize with the followers of Edgeworth, I think the 1930 statements weaken the case for "EKOs". Furthermore, if Leuschner did not in fact speculate on distant objects in low-eccentricity orbits, he could clearly be credited with anticipating the "scattered-disk objects" with their highly eccentric orbits! Since these objects are understood by most researchers as being an extension of the centaurs (given in particular that we now have the object 1999 TD_{10} with its heliocentric distance ranging between 12 and 190 AU), the latter would then also be considered part of the Leuschner population... In any case, considering the objects in eccentric and/or rather unstable orbits to represent a more evolved population, we can clearly speak, in an altogether quite reasonable, correct and unemotional manner, of the stable population, whether "cubewano" ("classical") or "plutino" ("resonant"), as "Transneptunian Objects", in the "Transneptunian Belt". In a complete analogy, the "regular" asteroids or "Main Belt" minor planets, as well as the Hungarias and Hildas, would then be referred to as "Cisjovian Objects" in the "Cisjovian Belt".

I thank Tom Gehrels for drawing my attention to the Beekman article and translating relevant sections into English. I thank Dan Green for locating a copy of the 1930 item in *The New York Times*.

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PAPERS ACCEPTED TO JOURNALS

Water Ice in 2060 Chiron and its Implications for Centaurs and Kuiper Belt Objects

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We report the detection of water ice in the Centaur 2060 Chiron, based on near-infrared spectra (1.0 - 2.5 μm) taken with the 3.8-meter United Kingdom Infrared Telescope (UKIRT) and the 10-meter Keck Telescope. The appearance of this ice is correlated with the recent decline in Chiron's cometary activity: the decrease in the coma cross-section allows previously hidden solid-state surface features to be seen. We predict that water ice is ubiquitous among Centaurs and Kuiper Belt objects, but its surface coverage varies from object to object, and thus determines its detectability and the occurrence of cometary activity.

Published in: The Astrophysical Journal Letters, 531, L151 (2000 March 10)

Available at `http://www.journals.uchicago.edu/ApJ/journal/contents/ApJL/v531n2.html`

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Chiron Activity and Thermal Evolution

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In this paper we discuss the results obtained simulating the thermal evolution of the object 2060 Chiron, the largest of the Centaur objects. The study of Chiron is extremely important due to the presence of an activity in spite of its large distance from the Sun. In this paper we study the thermal evolution of a Chiron-like body under different assumptions concerning the initial composition and taking into account its evolutionary history. The composition of Centaurs and Kuiper Belt Objects is almost unknown: we can guess that Chiron's "cometary behaviour" is an indication of a composition dominated by different ices. We have therefore computed the thermal evolution of Chiron using a numerical code developed to study the thermal evolution of cometary nuclei. As in the case of comets, we assume that the ice is mixed with dust and that the body is highly porous. CO is present in the mixture both as ice and as gas trapped in the amorphous ice. Our conclusion is that Chiron's activity can be explained only assuming a composition in which CO is present not far from the object surface, as an ice or as a gas trapped in the amorphous ice.

To appear in: The Astronomical Journal

For preprints, contact `capria@ias.rm.cnr.it`

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Physical Properties of TNO 1996 TO_{66} – Lightcurves and Possible Cometary Activity

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We describe observations of the Trans-Neptunian Object (TNO) 1996 TO_{66} performed during three observing runs (August 1997, October 1997 and September 1998). They show significant brightness variations that indicate a rotation period of 6.25±0.03h. In the 1997 data, the phased lightcurve displays a nearly symmetrical double peak with a peak-to-peak amplitude of 0.12 mag, while in the data of 1998, it shows a single maximum with a full amplitude of 0.33 mag. Possible causes for this change of shape are explored, the simplest explanation being that 1996 TO_{66} experienced a phase of cometary activity during the interval between these observations. This hypothesis, if confirmed, could be of interest for the pending question of the observed color diversity of TNOs.

The average magnitude ($R = 21.15$) was converted into a mean radius of 326±7 km (assuming albedo $p = 0.04$), making 1996 TO_{66} the largest known TNO after Pluto and Charon. The object is among the bluest in the outer Solar System and the colour, as measured at different epochs, shows marginally significant changes. Deep, composite images, totaling 13,500s integration time with the NTT and 4500s with the UH 2.2m in the R filter, were searched for possible signatures of a faint coma. None were found and the photometric profile of 1996 TO_{66} perfectly matches a stellar one, down to the 29 mag/sq.arcsec level. We also present an apparently featureless 8100s NTT+EMMI spectrum (6000-9100Å) with a neutral reflectivity in the 6000–7600Å range, and with a marginally significant red gradient $S' = 30 \pm 10\%/1000$Å in the 7600–9000Å range.

To appear in: Astronomy and Astrophysics
For preprints, contact `ohainaut@eso.org`
or on the web at `http://sc6.sc.eso.org/~ohainaut/papers`

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Close Approaches of Trans-neptunian Objects to Pluto Have Left Observable Signatures on Their Orbital Distribution

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It is shown that in addition to four outer planets (Jupiter to Neptune) Pluto should be also taken into account in studies of the orbital dynamics in the trans-Neptunian region. Pluto's effect is particularly large on the orbits in the 2:3 Neptune mean motion resonance. The trajectories found stable over the age of the solar system when only the gravitational effect of four outer planets is considered are often destabilized there in the effect of close Pluto approaches. We estimate that many dynamically primordial bodies moving initially with low to moderate amplitudes in the 2:3 Neptune resonance (semimajor axis 39.45 AU) have been removed from their respective, otherwise

stable, locations, when their resonant amplitudes increased in the course of close encounters with Pluto. At large libration amplitude, the orbits became exposed to chaotic changes, and objects were ejected from the 2:3 resonance to Neptune-crossing trajectories. The process of the resonant amplitude excitation was especially efficient for orbits with moderate and large inclinations ($i > 8\,\mathrm{deg}$), where more than 50% of the population has been removed in 4×10^9 yr. We estimate that the remaining part of the primordial resonant population at these inclinations should have had its resonant amplitude excited to about 80. The effect of Pluto on low-inclination orbits is smaller. We have examined the distribution of 33 objects observed on the 2:3 resonant orbits (Plutinos) and found that there could actually exist indications of the above mechanism. The resonant amplitudes of Plutinos are unusually high for $0.15 < e < 0.3$ when compared with randomly generated distribution, and, also, there is only one object (1997 QJ4) on an orbit similar to that of Pluto. In fact, a certain gap may be noticed in the distribution of Plutinos at Pluto's inclination and eccentricity, which, if confirmed by future observations, may be the consequence of Pluto's sweeping effect.

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For preprints, contact `david@orion.iagusp.usp.br`
Available on the web at
`http://www.journals.uchicago.edu/AJ/journal/issues/v119n2/990321/990321.html`

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Four Cometary Belts Associated with the Orbits of Giant Planets: A New View of the Outer Solar System's Structure Emerges from Numerical Simulations

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Using numerical simulations, we examine the structure of a cometary population near a massive planet, such as a giant planet of the Solar system, starting with one-planet approximation (the Sun plus one planet). By studying the distributions of comets in semimajor axis, eccentricity, pericenter, and apocenter distances, we have revealed several interesting features in these distributions. The most remarkable ones include (i) spatial accumulation of comets near the planetary orbit (which we call the *'cometary belt'*) and (ii) avoidance of resonant orbits by comets. Then we abandon one-planet approximation and examine as to how a cometary belt is modified when the influence of all four giant planets is taken into consideration. To this end, we simulate a stationary distribution of comets, which results from the gravitational scattering of the Kuiper belt objects on the four giant planets and accounts for the effects of mean motion resonances. In our simulations, we deal with the stationary distributions computed, at different initial conditions, as 36 runs for the dynamical evolution of comets, which start from the Kuiper belt and are typically traced until the comets are ejected from the Solar system. Accounting for the influence of four giant planets makes the cometary belts overlapping, but nevertheless keeping almost all their basic features found in one-planet approximation. In particular, the belts maintain the gaps in the (a, e)- and (a, i)-space similar to the Kirkwood gaps in the main asteroid belt. We conclude that the large-scale structure of the Solar system is featured by the four cometary belts expected to contain 20-30 millions of

scattered comets, and only a tiny fraction of them is currently visible as Jupiter-, Saturn-, etc. family comets.

To appear in: Planetary and Space Science
For preprints, contact `ozernoy@science.gmu.edu`
or on the web at `http://xxx.lanl.gov/abs/astro-ph/0001316`

PAPERS RECENTLY SUBMITTED TO JOURNALS

Thermal Evolution and Differentiation of Kuiper Belt Objects

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Submitted to: Astronomy and Astrophysics
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CONFERENCE CONTRIBUTIONS

Below is the list of the few Kuiper Belt/Centaur/Pluto-related papers I gleaned from the program for the 31st Lunar and Planetary Science Conference (2000 March 13–17, in Houston, TX, USA):

- **Asteroids and Comets**, 13:30, Tuesday, March 14
  - *Trapping of Volatiles in Amorphous Water Ice*
    Mastrapa R. M. E., Brown R. H., Cohen B. A., Anicich V. G., Dai W., and Lunine J. I.
    (abstract #2020, `http://www.lpi.usra.edu/meetings/lpsc2000/pdf/2020.pdf`)
- **Outer Body Experiences**, 8:30, Thursday, March 16
  - *Predicted Stress Patterns on Pluto and Charon Due to Their Mutual Orbital Evolution*
    Collins G. C., and Pappalardo R. T
    (abstract #1035, `http://www.lpi.usra.edu/meetings/lpsc2000/pdf/1035.pdf`)
- **Small Body Mélange** (Poster Session II), 19:00, Thursday, March 16
  - *The Outer Edge of the Kuiper Belt*
    Hahn J. M.
    (abstract #1797, `http://www.lpi.usra.edu/meetings/lpsc2000/pdf/1797.pdf`)

CONFERENCE INFORMATION

Minor Planet Amateur/Professional Workshop 2000

2000 June 15–18
Alfred University, New York, USA

http://www.bitnik.com/mp/mpw2000/mpw2000.html

The second Minor Planet Amateur/Professional Workshop will be held June 16th through June 18th, 2000 at Alfred University, Alfred, New York. The workshop is intended to provide an outlet for discussion, collaboration and to strengthen the ties between the amateur and professional communities in this field of research. Topics include astrometry techniques, follow-up strategies and how best to organize the amateur efforts, photometry and photometric techniques as well as the latest results in software and instrumentation used in asteroid and comet research.

Contact:
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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.

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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