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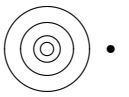
DISTANT EKOs



The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

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

CONTENTS

NEWS & ANNOUNCEMENTS

Knoll and colleagues report in IAUC 9075 and 9076 the discovery of five TNO binaries using the WFPC2 on HST: 1999 XY143, 1999 RY214, 2000 WT169, 2002 VT130, 2003 YU179. Separations of the components range from 0.056 to 0.085 arcsec.
IAUC 9075: `http://cfa-www.harvard.edu/iauc/09000/09075.html`
IAUC 9076: `http://cfa-www.harvard.edu/iauc/09000/09076.html`

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There were 4 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2009 KL30, 2009 KM30, 2009 KO30, 2009 KJ30

and 5 new Centaur/SDO discoveries:

2009 KK30, 2009 KN30, 2006 XQ51, 2009 QV38, 2009 MS9

Current number of TNOs: 1097 (including Pluto)
Current number of Centaurs/SDOs: 248
Current number of Neptune Trojans: 6

Out of a total of 1351 objects:
554 have measurements from only one opposition
538 of those have had no measurements for more than a year
288 of those have arcs shorter than 10 days
(for more details, see: `http://www.boulder.swri.edu/ekonews/objects/recov_stats.jpg`)

PAPERS ACCEPTED TO JOURNALS

Visible Spectroscopy of the New ESO Large Program on Trans-Neptunian Objects and Centaurs: Final Results

S. Fornasier[1,2], M.A. Barucci[1], C. de Bergh[1], A. Alvarez-Candal[1,3], F. DeMeo[1], F. Merlin[1,4], D. Perna[1,5,6], A. Guilbert[1], A. Delsanti[1], E. Dotto[6], and A. Doressoundiram[1]

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A second Large Program (LP) on the physical studies of TNOs and Centaurs, started at ESO Cerro Paranal on October 2006 to obtain high quality data, has recently been concluded. In this paper we present the spectra of these pristine bodies obtained in the visible range during the last two semesters (November 2007–November 2008) of the LP. We investigate the spectral behaviour of the TNOs and Centaurs observed, and we analyse the spectral slopes distribution of the full data set coming from this LP and from the literature. Spectroscopic observations in the visible range were carried out at the UT1 (Antu) telescope using the instrument FORS2. We computed the spectral slope for each observed object, and we searched for the possible existence of weak absorption features. A statistical analysis was performed on a total sample of 73 TNOs and Centaurs to look for possible correlations between dynamical classes, orbital parameters and spectral gradient. We obtained new spectra for 28 bodies (10 Centaurs, 6 classical, 5 resonant, 5 scattered disk and 2 detached objects), 15 of which were observed for the first time. All the new spectra presented are featureless, including 2003 AZ84, for which a faint and broad absorption band possibly attributed to the presence of hydrated silicates on its surface was reported in the literature (Fornasier et al. 2004a, and Alvarez-Candal et al. 2008). The data confirm a large variety of spectral behaviours, with neutral–gray to very red gradients. An analysis of the spectral slopes available from this LP and in the literature on a total sample of 73 Centaurs and TNOs shows that there is a lack of very red objects in the classical population. We present the results of the statistical analysis on spectral slope distribution versus orbital parameters. In particular, we confirm a strong anticorrelation between spectral slope and orbital inclination for the classical population. Nevertheless, we do not observe a change in the slope distribution at $i \sim 5^o$, the boundary between the dynamically hot and cold populations, but we find that objects with $i < 12^o$ show no correlation between spectral slope and inclination, as already noticed by Peixinho et al. (2008) on the color –inclination relation for classical TNOs. A strong correlation is also found between the spectral slope and orbital eccentricity for resonant TNOs, with objects having higher spectral slope values with increasing eccentricity.

To appear in: Astronomy & Astrophysics
For preprints, contact `sonia.fornasier@obspm.fr`
or on the web at `http://arxiv.org/abs/0910.0450`

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TNOs and Centaurs from Light Curves

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We compile and analyze an extended database of light curve parameters scattered in the literature to search for correlations and study physical properties, including internal structure constraints. We analyze a vast light curve database by obtaining mean rotational properties of the entire sample, determining the spin frequency distribution and comparing those data with a simple model based on hydrostatic equilibrium. For the rotation periods, the mean value obtained is 6.95 h for the whole sample, 6.88 h for the Trans-neptunian objects (TNOs) alone and 6.75 h for the Centaurs. From Maxwellian fits to the rotational frequencies distribution the mean rotation rates are 7.35 h for the entire sample, 7.71 h for the TNOs alone and 8.95 h for the Centaurs. These results are obtained by taking into account the criteria of considering a single-peak light curve for objects with amplitudes lower than 0.15 mag and a double-peak light curve for objects with variability >0.15 mag. We investigate the effect of using different values other than 0.15 mag for the transition threshold from albedo-caused light curves to shape-caused light curves. The best Maxwellian fits were obtained with the threshold between 0.10 and 0.15 mag. The mean light-curve amplitude for the entire sample is 0.26 mag, 0.25 mag for TNOs only, and 0.26 mag for the Centaurs. The Period versus $B-V$ color shows a correlation that suggests that objects with shorter rotation periods may have suffered more collisions than objects with larger ones. The amplitude versus H_v correlation clearly indicates that the smaller (and collisionally evolved) objects are more elongated than the bigger ones. From the model results, it appears that hydrostatic equilibrium can explain the statistical results of almost the entire sample, which means hydrostatic equilibrium is probably reached by almost all TNOs in the H range [-1,7]. This implies that for plausible albedos of 0.04 to 0.20, objects with diameters from 300 km to even 100 km would likely be in equilibrium. Thus, the great majority of objects would qualify as being dwarf planets because they would meet the hydrostatic equilibrium condition. The best model density corresponds to 1100 kg/m^3.

To appear in: Astronomy & Astrophysics
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From KBOs to Centaurs: The Thermal Connection

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We present results of thermal evolution calculations for objects originating in the Kuiper belt and transferring inwards, to the region of the outer planets. Kuiper belt objects (KBOs) are considered to be part of a reservoir that supplies the flux of small icy bodies, mainly Centaurs and Jupiter-family comets, to regions interior to the orbit of Neptune. We study the internal thermal evolution, for $\sim 10^8$ yr, of three typical KBOs and use the end state of the simulation as initial conditions for evolutionary calculations of two typical Centaurs. Some evolutionary trends can be identified for the KBOs, depending on key physical parameters, such as size and composition. The subsequent evolution in the Centaur region results in both specific features for each modeled object (mainly surface and sub-surface composition) and common characteristics of thermally evolved Centaurs.

To appear in: Meteoritics and Planetary Sciences (ACM 2008 Special Issue)
For preprints, contact galahead@post.tau.ac.il

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The Neptune Trojans - A New Source for The Centaurs?

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The fact that the Centaurs are the primary source of the Short Period Comets is well established. However, the origin of the Centaurs themselves is still under some debate, with a variety of different source reservoirs being proposed in the last decade. In this work, we suggest that the Neptune Trojans (together with the Jovian Trojans) could represent an additional significant source of Centaurs. Using dynamical simulations of the first Neptune Trojan discovered (2001 QR322), together with integrations following the evolution of clouds of theoretical Neptune Trojans obtained during simulations of planetary migration, we show that the Neptune Trojan population contains a great number of objects which are unstable on both Myr and Gyr timescales. Using individual examples, we show how objects that leave the Neptunian Trojan cloud evolve onto orbits indistinguishable from those of the known Centaurs, before providing a range of estimates of the flux from this region to the Centaur population. With only moderate assumptions, it is shown that the Trojans can contribute a significant proportion of the Centaur population, and may even be the dominant source reservoir. This result is supported by past work on the colours of the Trojans and the Centaurs, but it will take future observations to determine the full scale of the contribution of the escaped Trojans to the Centaur population.

To appear in: Monthly Notices of the Royal Astronomical Society

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or on the web at `http://sites.google.com/site/patryksofialykawka/`

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Jupiter - Friend or Foe? II: the Centaurs

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It has long been assumed that the planet Jupiter acts as a giant shield, significantly lowering the impact rate of minor bodies upon the Earth, and thus enabling the development and evolution of life in a collisional environment which is not overly hostile. In other words, it is thought that, thanks to Jupiter, mass extinctions have been sufficiently infrequent that the biosphere has been able to diversify and prosper. However, in the past, little work has been carried out to examine the validity of this idea. In the second of a series of papers, we examine the degree to which the impact risk resulting from objects on Centaur-like orbits is affected by the presence of a giant planet, in an attempt to fully understand the impact regime under which life on Earth has developed. The Centaurs are a population of ice-rich bodies which move on dynamically unstable orbits in the outer Solar system. The largest Centaurs known are several hundred kilometres in diameter, and it is certain that a great number of kilometre or sub-kilometre sized Centaurs still await discovery. These objects move on orbits which bring them closer to the Sun than Neptune, although they remain beyond the orbit of Jupiter at all times, and have their origins in the vast reservoir of debris known as the Edgeworth-Kuiper belt that extends beyond Neptune. Over time, the giant planets perturb the Centaurs, sending a significant fraction into the inner Solar System where they become visible as short-period comets. In this work, we obtain results which show that the presence of a giant planet

can act to significantly change the impact rate of short-period comets on the Earth, and that such planets often actually increase the impact flux greatly over that which would be expected were a giant planet not present.

Published in: International Journal of Astrobiology, 8, 75 (2009 August)
Preprints available on the web at `http://jontihorner.com/index.php?p=1_10_Publications`

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A Portrait of Centaur 10199 Chariklo

A. Guilbert[1], M.A. Barucci[1], R. Brunetto[2], A. Delsanti[1], F. Merlin[1,3], A. Alvarez-Candal[1], S. Fornasier[1,4], C. de Bergh[1], and G. Sarid[5]

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An ESO Large Program was undertaken in October 2006 (P.I.: M.A. Barucci) to provide as complete observations as possible of about 40 Trans-Neptunian Objects and Centaurs, to investigate their surface properties. Hence, new visible and near-infrared observations of Centaur 10199 Chariklo (1997 CU_{26}) were performed.

We investigate Chariklo's surface composition. It has already been suspected of being inhomogeneous. We try to confirm this assumption by comparing our results with previously published works, and find an explanation related the observed variations.

A spectral modeling is applied to the spectra, using different types of mixtures, to place constraints on the amount of water ice present in our new spectrum. Several spectra, obtained at different moments by different groups, are compared by studying the variations in the depth of absorption bands attributable to water ice. The irradiation doses received by Chariklo's surface are also considered to interpret the observed variations.

The presence of water ice is not confirmed by our featureless near-infrared spectra. The main component on the surface, identified by our spectral modeling, is amorphous carbon, which may have been produced by irradiation if Chariklo originated in the transneptunian region. The suspected surface heterogeneity is also confirmed. We show that the variations in Chariklo's spectral behaviour could be explained by a variation in the number of craters across the surface. Comet-like activity is not detected in our data, though it cannot be excluded.

Published in: Astronomy and Astrophysics, 501, 777 (2009 July)

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The Collisional Divot in the Kuiper belt Size Distribution

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This paper presents the results of collisional evolution calculations for the Kuiper belt starting from an initial size distribution similar to that produced by accretion simulations of that region – a steep power-law large object size distribution that breaks to a shallower slope at $r \sim 1-2$ km, with collisional equilibrium achieved for objects $r \lesssim 0.5$ km. We find that the break from the steep large object power-law causes a divot, or depletion of objects at $r \sim 10-20$ km, which in-turn greatly reduces the disruption rate of objects with $r \gtrsim 25-50$ km, preserving the steep power-law behavior for objects at this size. Our calculations demonstrate that the roll-over observed in the Kuiper belt size distribution is naturally explained as an edge of a divot in the size distribution; the radius at which the size distribution transitions away from the power-law, and the shape of the divot from our simulations are consistent with the size of the observed roll-over, and size distribution for smaller bodies. Both the kink radius and the radius of the divot center depend on the strength scaling law in the gravity regime for Kuiper belt objects. These simulations suggest that the sky density of $r \sim 1$ km objects is $\sim 10^6 - 10^7$ objects per square degree. A detection of the divot in the size distribution would provide a measure of the strength of large Kuiper belt objects, and constrain the shape of the size distribution at the end of accretion in the Kuiper belt.

To appear in: The Astrophysical Journal

For preprints, contact `fraserw@gps.caltech.edu`

or on the web at `http://arxiv.org/abs/0910.0246`

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Chaotic Diffusion of Resonant Kuiper Belt Objects

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We carried out extensive numerical orbit integrations to probe the long-term chaotic dynamics of the two strongest mean motion resonances of Neptune in the Kuiper belt, the 3:2 (Plutinos) and 2:1 (Twotinos). Our primary results include a computation of the relative volumes of phase space characterized by large- and small-resonance libration amplitudes, and maps of resonance stability measured by mean chaotic diffusion rate. We find that Neptune's 2:1 resonance has weaker overall long-term stability than the 3:2—only $\sim 15\%$ of Twotinos are projected to survive for 4 Gyr, compared to $\sim 27\%$ of Plutinos, based on an extrapolation from our 1-Gyr integrations. We find that Pluto has only a modest effect, causing a $\sim 4\%$ decrease in the Plutino population that survives to 4 Gyr. Given current observational estimates, and assuming an initial distribution of particles proportional to the local phase space volume in the resonance, we conclude that the primordial populations of Plutinos and Twotinos formerly made up more than half the population of the classical and resonant Kuiper Belt. We also conclude that Twotinos were originally nearly as numerous as Plutinos; this is consistent with predictions from early models of smooth giant planet migration and resonance sweeping of the Kuiper Belt, and provides a useful constraint for more detailed models.

Published in: The Astronomical Journal, 138, 827 (2009 August)

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The Contamination of the Asteroid Belt by Primordial Trans-Neptunian Objects

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The main asteroid belt, which inhabits a relatively narrow annulus 2.1–3.3 AU from the Sun, contains a surprising diversity of objects ranging from primitive ice/rock mixtures to igneous rocks. The standard model used to explain this assumes that most asteroids formed in situ from a primordial disk that experienced radical chemical changes within this zone. Here we show that the violent dynamical evolution of the giant planet orbits required by the so-called Nice model leads to the insertion of primitive trans-Neptunian objects into the outer belt. This result implies that the observed diversity of the asteroid belt is not a direct reflection of the intrinsic compositional variation of the proto-planetary disk. The dark captured bodies, composed of organic-rich materials, would have been more susceptible to collisional evolution than typical main belt asteroids. Their weak nature makes them a prodigious source of micrometeorites — sufficient to explain why most are primitive in composition and are isotopically different from most macroscopic meteorites.

Published in: Nature, 2009, 460, 364 (2009 July 16)
For preprints, contact hal@boulder.swri.edu

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Detailed Survey of the Phase Space around Nix and Hydra

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We present a detailed survey of the dynamical structure of the phase space around the new moons of the Pluto-Charon system. The spatial elliptic restricted three-body problem was used as model and stability maps were created by chaos indicators. The orbital elements of the moons are in the stable domain both on the semimajor axis - eccentricity and - inclination spaces. The structures related to the 4:1 and 6:1 mean motion resonances are clearly visible on the maps. They do not contain the positions of the moons, confirming previous studies.We showed the possibility that Nix might be in the 4:1 resonance if its argument of pericenter or longitude of node falls in a certain range. The results strongly suggest that Hydra is not in the 6:1 resonance for arbitrary values of the argument of pericenter or longitude of node.

Published in: Monthly Notices of the Royal Astronomical Society, 398, 2199
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Corona-like Atmospheric Escape from KBOs. I. Gas Dynamics

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We show that for low temperatures ($T \sim 30$ K) and small, but non-negligible, gravitational fields the hydrodynamic escape of gas can be treated by Parker's theory of coronal expansion [Parker, E.N., 1963. Interplanetary Dynamical Processes. Interscience Publishers, New York]. We apply this theory to gas escape from Kuiper belt objects. We derive limits on the density and radius of the bodies for which this theory is applicable, and show how the flow depends on the mean molecular weight and internal degrees of freedom of the gas molecules. We use these results to explain the CH4 dichotomy seen on KBOs [Schaller, E.L., Brown, M.E., 2007. Astrophys. J., 659, L61-L64].

Published in: Icarus, 202, 681 (2009 August)

OTHER PAPERS OF INTEREST

Jupiter - Friend or Foe? III: The Oort Cloud Comets

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International Journal of Astrobiology

Preprints available on the web at `http://jontihorner.com/index.php?p=1_10_Publications`

THESES

Albedos in the Kuiper Belt

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I have focused my research on the visual geometric albedos of transneptunian objects (TNOs), how the albedo varies with dynamical class, and whether or not it is correlated to orbital parameters. TNOs are among the least-processed objects in the solar system. By studying them, we can learn about the conditions in the solar system: the density of matter in the protoplanetary disk, the composition of different primordial regions, planetary migration, stirring of the disk, stellar close encounters, collision histories, binary capture, and space weathering. What we learn about how our solar system evolved also can be applied to debris disks surrounding other stars.

Using infrared images from the Multiband Imaging Photometer for Spitzer (MIPS) on the Spitzer Space Telescope (SST), I measured the thermal flux in two different wavelength bands for sixteen transneptunian objects with point-spread function (PSF) fitting photometry. I converted the measurements to monochromatic flux densities at 23.68 microns and 71.42 microns. Next, I fit the Standard Thermal Model (STM), employing a linear function for the phase integral and Monte Carlo simulations, to the flux measurements and the absolute visual magnitude for each object in order to constrain its albedo and radius. Fitting a thermal model to infrared thermal radiation measurements resolves the ambiguity found with visual reflected radiation between a small object with a high albedo and a large object with a low albedo as they would have different temperatures. Once accurate albedos and radii are determined, they can be applied to size and mass distributions of the Kuiper belt.

The sample was constructed from new targets and those previously published in the work of Stansberry et al. (2008), Grundy et al. (2005), and Grundy et al. (2009). A correlation was found between albedo and inclination for Classical Kuiper belt objects (KBOs) not including inner Classicals. The dynamically cold Classicals have higher albedos than hot Classicals. The albedos of the two populations are drawn from different parent distributions if one assumes an inclination break between them of 2.4 degrees to 8.8 degrees. It has already been shown that cold Classicals and hot Classicals differ in color, magnitude, and binary fraction. The high albedos of cold Classicals extend support for orbital dynamic theories that involve different formation regions, methods of transport, or surface alterations for the hot and cold Classical KBO populations. In addition, the high albedos found for cold Classical KBOs reduce the estimate for the total mass in this region by almost an order of magnitude.

Dissertation directed by W. Grundy and W. Romanishin
Ph.D. awarded July 2009 from University of Oklahoma

Address as of September 2009: University of Nebraska - Lincoln, Dept. of Physics and Astronomy, 116 Brace Lab, Lincoln, NE 68588-0111

For preprints, contact `mjulianneb@yahoo.com`

JOB ANNOUNCEMENTS

Postdoctoral position in Kuiper Belt Studies

Northern Arizona University, Flagstaff, AZ, USA

The Department of Physics and Astronomy at Northern Arizona University (NAU) seeks an outstanding postdoctoral scholar to work with Professor David Trilling in studies of small bodies in the Solar System, and in particular of the Kuiper Belt. Candidates should have a Ph.D. in astronomy, physics, planetary science, or related field. Desired skills include familiarity with optical and/or infrared observations, large observational datasets, and/or the Kuiper Belt and Kuiper Belt Objects. The successful candidate will work on projects of mutual interest with Professor Trilling and will also lead independent research projects. NAU has full competitive access to all University of Arizona Observatories facilities, including the 6.5-meter MMT and Magellan telescopes, the 2x8.4-meter LBT telescopes, and numerous smaller telescopes.

The appointment is expected to be two years with a third year possible. NAU offers an excellent benefits package to postdoctoral scholars. Flagstaff is a beautiful town of 60,000 people nestled at the base of the San Francisco Peaks in northern Arizona and features four seasons of outdoor activities. The Department of Physics and Astronomy is a small, friendly group.

To apply, please visit the NAU HR web page `http://hr.nau.edu/m/content/view/797/550/` and search for position #558129.

Northern Arizona University is a committed Equal Opportunity/Affirmative Action Institution. Women, minorities, veterans and individuals with disabilities are encouraged to apply. NAU is responsive to the needs of dual career couples.

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`