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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

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NEWS & ANNOUNCEMENTS

Subsequent issues of the Distant EKOs newsletter no longer will be mailed out in LaTeX format. Starting with the January 2009 issue, future mailings of issues will consist of a brief, plain-text format table of contents and a link to the webpage where the newsletter is available in several formats: HTML, PDF, PostScript, and LaTeX. I hope this change will not cause problems for any subscribers, since all formats will still be easily available via a URL in the e-mail.

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In an experiment that I hope will catch on for many more astronomical meetings, presentations at this year's DPS meeting in Ithaca were streamed live on the web. Also, the AAS plans to permanently archive (online) the webstreamed presentations. Details on how to access the archived presentations will be provided on the DPS web site in the near future.

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Benecchi et al. report in IAUC 8998 that TNO 1998 WV24 is a binary. Observations with HST show a separation of 0.051 arcsec (∼1400 km), with the secondary being 0.3 mag fainter than the primary.
IAUC: `http://cfa-www.harvard.edu/iauc/08900/08998.html`

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

2007 TQ436, 2007 BO81, 2007 CJ66, 2007 CK66, 2008 AP118, 2008 AQ118

and 4 new Centaur/SDO discoveries:

2007 TR436, 2008 QD4, 2008 SJ236, 2008 UZ6

Objects recently assigned names:
2003 EL61 = Haumea

Current number of TNOs: 1090 (including Pluto)
Current number of Centaurs/SDOs: 237
Current number of Neptune Trojans: 6

Out of a total of 1333 objects:
564 have measurements from only one opposition
543 of those have had no measurements for more than a year
287 of those have arcs shorter than 10 days
(for more details, see: `http://www.boulder.swri.edu/ekonews/objects/recov_stats.gif`)

PAPERS ACCEPTED TO JOURNALS

The Extreme Kuiper Belt Binary 2001 QW_{322}

J-M. Petit[1,3], J.J. Kavelaars[2], B.J. Gladman[3], J.L. Margot[4], P.D. Nicholson[4], R.L. Jones[5], J.Wm. Parker[6], M.L.N. Ashby[7], A. Campo Bagatin[8], P. Benavidez[8], J. Coffey[3], P. Rousselot[1], O. Mousis[1], and P.A. Taylor[4]

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The study of binary Kuiper Belt objects help probe the dynamic conditions present during planet formation in the Solar System. We report on the mutual-orbit determination of 2001 QW_{322}, a Kuiper Belt binary with a very large separation whose properties challenge binary-formation and evolution theories. Six years of tracking indicate that the binary's mutual orbit period is ≈25–30 years, that the orbit pole is retrograde and inclined 50–62° from the ecliptic plane, and, most surprisingly, that the mutual orbital eccentricity is < 0.4. The semimajor axis of 105,000–135,000 km is 10 times that of other near-equal mass binaries. Because this weakly bound binary is prone to orbital disruption by interlopers, its lifetime in its present state is likely less than 1 Gy.

Published in: Science, 322, 432 (2008 October 17)

For preprints, contact `petit@obs-besancon.fr`

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The Correlated Colors of Transneptunian Binaries

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We report resolved photometry of the primary and secondary components of 23 transneptunian binaries obtained with the Hubble Space Telescope. $V - I$ colors of the components range from 0.7 to 1.5 with a median uncertainty of 0.06 magnitudes. The colors of the primaries and secondaries are correlated with a Spearman rank correlation probability of 99.99991%, 5 sigma for a normal distribution. Fits to the primary vs. secondary colors are identical to within measurement uncertainties. The color range of binaries as a group is indistinguishable from that of the larger population of apparently single transneptunian objects. Whatever mechanism produced the colors of apparently single TNOs acted equally on binary systems. The most likely explanation is that the colors of transneptunian objects and binaries alike are primordial and indicative of their origin in a locally homogeneous, globally heterogeneous protoplanetary disk.

To appear in: Icarus

Preprints on the web at `http://arxiv.org/abs/0811.2104`

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The Youthful Appearance of the 2003 EL61 Collisional Family

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We present new solar phase curve observations of the 2003 EL61 collisional family showing that all the members have light-scattering properties similar to the bright icy satellites of the giant planets and dwarf planets. Compared with other Kuiper Belt objects (KBOs), the five family members we observe (2003 EL61, 2002 TX300, 2003 OP32, 2005 RR43, and 1995 SM55) have conspicuously neutral color ($V-I = 0.6-0.8$ mag) and flat phase curves at small phase angles (phase coefficients of 0.0–0.1 mag deg^{-1}). Comparing the phase curves we observe for other icy KBOs with the phase curves of icy satellites, we find that the flat phase curves of the 2003 EL61 family are an indication that they have high albedo surfaces coated with fresh ice in the last $\sim$100 Myr. We examine possible resurfacing processes and find none that are plausible. To avoid the influence of cosmic radiation that darkens and reddens most icy surfaces on times scales 100 Myr, the family members must be unusually depleted in carbon, or the collision that created the family occurred so recently that the parent body and fragments have not had time to darken. We also find a rotation period of 4.854 (+/-0.003) h with amplitude 0.26 (+/-0.04) mag for 2003 OP32.

Published in: The Astronomical Journal, 136, 1502 (2008 October)

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Full Numerical Simulations of Catastrophic Small Body Collisions

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The outcome of collisions between small icy bodies, such as Kuiper belt objects, is poorly understood and yet a critical component of the evolution of the trans-Neptunian region. The expected physical properties of outer solar system materials (high porosity, mixed ice-rock composition, and low material strength) pose significant computational challenges. We present results from catastrophic small body collisions using a new hybrid hydrocode to N-body code computational technique. This method allows detailed modeling of shock propagation and material modification as well as gravitational reaccumulation. Here, we consider a wide range of material strengths to span the possible range of Kuiper belt objects. We find that the shear strength of the target is important in determining the collision outcome for 2 to 50-km radius bodies, which are traditionally thought to be in a pure gravity regime. The catastrophic disruption and dispersal criteria, Q^*_D, can vary by up to a factor of three between strong crystalline and weak aggregate materials. The material within the largest reaccumulated remnants experiences a wide range of shock pressures. The dispersal and reaccumulation process results in the material on the surfaces of the largest remnants having experienced a wider range of shock pressures compared to material in the interior. Hence, depending on the initial structure and composition, the surface materials on large, reaccumulated bodies in the outer solar system may exhibit complex spectral and albedo variations. Finally, we present revised catastrophic disruption criteria for a range of impact velocities and material strengths for outer solar system bodies.

To appear in: Icarus

For preprints, contact `z.m.leinhardt@damtp.cam.ac.uk`

or on the web at `http://www.shock.eps.harvard.edu/preprints/`

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Ejecta Exchange and Satellite Color Evolution in the Pluto System, with Implications for KBOs and Asteroids with Satellites

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In this Note, I present first-order scaling calculations to examine the efficacy of impacts by Kuiper Belt debris in causing regolith exchange between objects in the Pluto system. It is found that ejecta can escape Nix and Hydra with sufficient velocity to reach one another, as well as Charon, and even Pluto. The degree of ejecta exchanged between Nix and Hydra is sufficient to cover these bodies with much more material than is required for photometrically change. In specific, Nix and Hydra may have exchanged as up to 10s of meters of regolith, and may have covered Charon to depths up to 14 centimeters with their ejecta. Pluto is likely unaffected by most Nix and Hydra ejecta by virtue of a combination of dynamical shielding from Charon and Pluto's own annual atmospheric frost deposition cycle. As a result of ejecta exchange between Nix, Hydra, and Charon, these bodies are expected to evolve their colors, albedos, and other photometric properties to be self similar. These are testable predictions of this model, as is the prediction that Nix and Hydra will have diameters near 50 km, owing to having a Charon-like albedo induced by ejecta exchange. As I discuss, this ejecta exchange process can also be effective in many KBOs and asteroids with satellites, and may be the reason that very many KBO and asteroid satellite systems have like colors.

To appear in: Icarus

For preprints, contact `alan@boulder.swri.edu`

or on the web at `http://dx.doi.org/10.1016/j.icarus.2008.10.006`

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The Size Distribution of Kuiper belt objects for $D \gtrsim 10$ km

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We have performed a survey of the Kuiper covering $\sim 1/3$ a square degree of the sky using Suprime-cam on the Subaru telescope, to a limiting magnitude of $m_{50}(R) \sim 26.8$ and have found 36 new KBOs. We have confirmed that the luminosity function of the Kuiper belt must break as previously observed (Bernstein et al. 2004; Fuentes & Holman 2008). We find that the luminosity function is consistent with that observed from a size distribution with large object power-law slope $q_1 \sim 4.8$ that breaks to a slope $q_2 \sim 1.9$ at object diameter $D_b \sim 60$ km assuming 6% albedos. We have found no conclusive evidence that the size distribution of KBOs with inclinations $i < 5$ is different than that of those with $i > 5$. We discuss implications of this measurement for early accretion in the outer solar system and Neptune migration scenarios.

To appear in: The Astronomical Journal

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

or on the web at `http://arxiv.org/abs/0810.2296`

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First Results From The Taiwanese-American Occultation Survey (TAOS)

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Results from the first two years of data from the Taiwanese-American Occultation Survey (TAOS) are presented. Stars have been monitored photometrically at 4 Hz or 5 Hz to search for occultations by small ($\sim$3 km) Kuiper Belt Objects (KBOs). No statistically significant events were found, allowing us to present an upper bound to the size distribution of KBOs with diameters 0.5 km $< D <$ 28 km.

Published in: The Astrophysical Journal Letters, 685, L157 (2008 October 1)
For preprints, contact s1249001@cc.ncu.edu.tw
or on the web at http://arxiv.org/abs/0808.2051

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Rotational Properties of Centaurs and Trans-Neptunian Objects. Lightcurves and Densities.

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The knowledge of the rotational periods of the small bodies in the outer Solar System is a useful tool for retrieving information on the internal structure of the observed objects and for having hints on the collisional evolution state of the whole population.
In order to investigate the physical nature of Centaurs and TNOs, we analysed the rotational properties of a selected sample. Photometric observations of 2 Centaurs (12929 1999 TZ_1 and 95626 2002 GZ_{32}), and 5 Trans-Neptunian Objects (42355 Typhon, 47932 2000 GN_{171}, 65489 Ceto, 90568 2004 GV_9, and

120132 2003 FY_{128}) were carried out with the New Technology Telescope (NTT) at the European Southern Observatory La Silla (Chile) in the framework of the ESO Large Programme 178.C-0036 (PI. M.A. Barucci).
These observations allow us to estimate the rotational rate of three objects, to confirm previously published periods of two bodies, and to have the first single night lightcurves of 42355 Typhon and 120132 2003 FY_{128}. These data allow us to improve the available sample of determined rotational periods of TNOs and Centaurs. For 5 out of the 7 observed objects we have estimated the axis ratio a/b, hence the density. Our new results seem to confirm the density/dimension trend, found by Sheppard et al. (2008), with larger (brighter) objects having higher densities.

Published in: Astronomy and Astrophysics, 490, 829 (2008 November)
For preprints, contact dotto@mporzio.astro.it

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The Diverse Solar Phase Curves of Distant Icy Bodies. II. The Cause of the Opposition Surges and Their Correlations

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We collect well-measured opposition surge properties for many icy bodies orbiting the Sun (mostly from our own observations) plus for many icy moons, resulting in a data base of surface and orbital properties for 52 icy bodies. (1) We put forward four criteria for determining whether the surge is being dominated by shadow hiding (SH) or coherent backscattering (CB) based on readily measured quantities. The CB surge mechanism dominates if the surge is color dependent, the phase curve is steeper than 0.04 mag $\deg^{-1}$, the phase curve shape matches the CB model of Hapke, or if the albedo is higher than roughly 40%. (2) We find that virtually all of our sample have their phase curves dominated by CB at low phase angles. (3) We present a graphical method to determine the Hapke surge parameters B_{C0} and h_C. (4) The Kuiper Belt Objects (KBOs) and Centaurs have relatively high surge amplitudes, $B_{C0} >\sim 0.5$ and widths with $h_C \sim 3$ degrees. (5) We find highly significant but loose correlations between surge properties and the colors, albedos, and inclinations. We interpret this as young surfaces tending to have low surge slopes, high albedo, and gray colors. (6) Nereid has its surface properties similar to other icy moons and greatly different from KBOs and Centaurs, so we conclude that Nereid is likely a nearly-ejected inner Neptunian moon rather than a captured KBO.

To appear in: The Astronomical Journal
For preprints, contact schaefer@lsu.edu
or on the web at http://arxiv.org/abs/0810.0965

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Discovery of Two Distinct Polarimetric Behaviours of Trans-Neptunian Objects

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Trans-Neptunian objects (TNOs) contain the most primitive and thermally least-processed materials from the early accretional phase of the solar system. They allow us to study interrelations between various classes of small bodies, their origin and evolution.

Using FORS1 of the ESO VLT, we have obtained linear-polarization measurements in the Bessell R filter for five TNOs at different values of their phase angle (i.e., the angle between the Sun, the object, and the Earth). Due to the large distance of the targets (> 30 AU), the observed range of phase angles is limited to about $0^\circ - 2^\circ$.

We have analyzed our new observations of five TNOs, and those of another four TNOs obtained in previous works, and discovered that there exist two classes of objects that exhibit different polarimetric behaviour. Objects with a diameter > 1000 km, such as, e.g., Pluto and Eris, show a small polarization in the scattering plane ($\sim 0.5\,\%$) which slowly changes in the observed phase angle range. In smaller objects such as, e.g., Ixion and Varuna, linear polarization changes rapidly with the phase angle, and reaches $\sim 1\,\%$ (in the scattering plane) at phase angle 1°. The larger objects have a higher albedo than the smaller ones, and have the capability of retaining volatiles such as CO, N_2 and CH_4. Both of these facts can be linked to their different polarimetric behaviour compared to smaller objects.

In spite of the very limited range of observable phase angles, ground-based polarimetric observations are a powerful tool to identify different properties of the surfaces of TNOs. We suggest that a single polarimetric observation at phase angle $\sim 1^\circ$ allows one to determine whether the target albedo is low or high.

To appear in: Astronomy & Astrophysics
For preprints, contact sba@arm.ac.uk
or on the web at http://star.arm.ac.uk/preprints/

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Digging Into the Surface of the Icy Dwarf Planet Eris

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We describe optical spectroscopic observations of the icy dwarf planet Eris with the 6.5 meter MMT telescope and the Red Channel Spectrograph. We report a correlation, that is at the edge of statistical significance, between blue shift and albedo at maximum absorption for five methane ice bands. We interpret the correlation as an increasing dilution of methane ice with another ice component, probably nitrogen, with increasing depth into the surface.

We suggest a mechanism to explain the apparent increase in nitrogen with depth. Specifically, if we are seeing Eris 50 degrees from pole-on (Brown and Schaller, 2008), the pole we are seeing now at aphelion was in winter darkness at perihelion. Near perihelion, sublimation could have built up atmospheric pressure on the sunlit (summer) hemisphere sufficient to drive winds toward the dark (winter) hemisphere, where the winds would condense. Because nitrogen is more volatile and scarcer than methane, it sublimated from the sunlit hemisphere relatively early in the season, so the early summer atmosphere was nitrogen rich, and so was the ice deposited on the winter pole. Later in the season, much of the nitrogen was exhausted

from the summer pole, but there was plenty of methane, which continued to sublimate. At this point, the atmosphere was more depleted in nitrogen, as was the ice freezing out on top of the earlier deposited nitrogen rich ice.

Our increasing nitrogen abundance with depth apparently contradicts the Licandro et al. (2006) result of a decreasing nitrogen abundance with depth. A comparison of observational, data reduction, and analysis techniques between the two works, suggests the difference between the two works is real. If so, we may be witnessing the signature of weather on Eris. The work reported here is intended to trigger further observational effort by the community.

To appear in: Icarus
For preprints, contact Stephen.Tegler@nau.edu
or on the web at http://arxiv.org/abs/0811.0825

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Vertical Structure in Pluto's Atmosphere from the 2006 June 12 Stellar Occultation

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Pluto occultations are historically rare events, having been observed in 1988, 2002, 2006, and, as Pluto moves into the crowded Galactic plane, on several occasions in 2007. Here we present six results from our observations of the 2006 June 12 event from several sites in Australia and New Zealand. First, we show that Pluto's 2006 bulk atmospheric column abundance, as in 2002, is over twice the value measured in 1988, implying that nitrogen frost on Pluto's surface is 1.2–1.7 K warmer in 2006 than 1988 despite a 9% drop in incident solar flux. We measure a half-light shadow radius of 1216±8.6 km in 2006, nominally larger than published values of 1213±16 km measured in 2002. Given the current error bars, this latest half-light radius cannot discriminate between continued atmospheric growth or shrinkage, but it rules out several of the volatile transport scenarios modeled by Hansen & Paige. Second, we resolve spikes in the occultation light curve that are similar to those seen in 2002 and model the vertical temperature fluctuations that cause them. Third, we show that Pluto's upper atmosphere appears to hold a steady temperature of ∼100 K, as predicted from the methane thermostat model, even at latitudes where the methane thermostat is inoperative. This implies that energy transport rates are faster than radiational cooling rates. Fourth, this occultation has provided the first significant detection of a non-isothermal temperature gradient in Pluto's upper atmosphere also reported by Elliot et al., possibly the result of CO gas in Pluto's upper atmosphere. Fifth, we show that a haze-only explanation for Pluto's light curve is extremely unlikely; a thermal inversion is necessary to explain the observed light curve. And sixth, we derive an upper limit for the haze optical depth of 0.0023 in the zenith direction at average CCD wavelengths.

Published in: The Astronomical Journal, 136, 1757 (2008 November)

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Waves in Pluto's Upper Atmosphere

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Observations of the 2007 March 18 occultation of the star P445.3 (2UCAC 25823784; $R = 15.3$) by Pluto were obtained at high time resolution at five sites across the western United States and reduced to produce light curves for each station using standard aperture photometry. Global models of Pluto's upper atmosphere are fit simultaneously to all resulting light curves. The results of these model fits indicate that the structure of Pluto's upper atmosphere is essentially unchanged since the previous occultation observed in 2006, leading to a well constrained measurement of the atmospheric half-light radius at 1291 ± 5 km, and confirm that the significant increase in atmospheric pressure detected between 1988 and 2002 has ceased (Elliot et al. 2007). Inversion of the MMTO light curves with unprecedented signal-to-noise ratios reveals significant oscillations in the number density, pressure, and temperature profiles of Pluto's atmosphere. Detailed analysis of this highest resolution light curve indicates that these variations in Pluto's upper atmospheric structure exhibit a previously unseen oscillatory structure with strong correlations of features among locations separated by almost 1200 km in Pluto's atmosphere. Thus, we conclude that these variations are caused by some form of large-scale atmospheric waves. Interpreting these oscillations as Rossby (planetary) waves allows us to establish lower and upper limits of 2 and 30 m/s respectively for horizontal wind speeds in the sampled region (radius 1340–1460 km) of Pluto's upper atmosphere.

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Surface Characterization of Pluto and Charon by L and M Band Spectra

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Context. One of the main scientific objectives of NASA's New Horizons mission is to map the icy surface compositions of Pluto and its moon Charon. The encounter will be in 2015. Meanwhile remote observations from earth and space are the most suitable means to enhance further our knowledge of the Pluto/Charon system.

Aims. We intend to assist the New Horizons mission by improving our knowledge of Pluto's and Charon's surface compositions. Specifically, we extend the wavelength coverage of the surface spectroscopy beyond the K band, with the goal to detect further surface ice absorption bands predicted from the models that are based on the available JHK spectra, and to search for signatures of yet unknown ices. In particular we aim to resolve the binary system Pluto/Charon and to obtain, for the first time, spectra up to 5 μm of the two objects resolved.

Methods. Spectroscopic measurements of Pluto/Charon taken with the adaptive optics instrument NACO at the ESO VLT in the interval 3–7 August 2005 were obtained. The nature and properties of the compounds present on the surface of Pluto and Charon are investigated by applying a Hapke radiative transfer model to the measured spectra.

Results. We present Pluto's reflectance spectrum in the wavelength range (1–5) μm. Apart from known and expected absorption bands of methane ice, our Pluto spectrum reveals a new absorption band centered near 4.6 μm, not previously detected. This absorption band could be related to the presence of CO and nitriles (compounds of C and N connected with a triple bond). A geographic mixture of pure methane ice with two different grain sizes, methane and CO ice diluted in nitrogen, CH_2CHCN and titan tholin gives the best fit to Pluto's spectrum, although not in all details. Differences compared to published Pluto spectra from 2001 taken at similar longitude could be due to a different surface coverage in latitude or to a possible resurfacing process on Pluto. Charon's spectrum is measured in the wavelength range (1–4) μm. The surface of Charon can be modeled by pure water ice darkened by a spectrally neutral continuum absorber.

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Is the Missing Ultra-Red Material Colorless Ice?

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The extremely red colors of some transneptunian objects and Centaurs are not seen among the Jupiter family comets which supposedly derive from them. Could this mismatch result from sublimation loss of colorless ice? Radiative transfer models show that mixtures of volatile ice and nonvolatile organics could be extremely red, but become progressively darker and less red as the ice sublimates away.

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Preprints at `http://arxiv.org/abs/0811.2433`

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Integrated NIR Band Strengths of Solid CH_4 and its Mixtures with N_2

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We studied icy CH_4 and its mixtures with N_2 (temperature 16–40 K), using near-IR transmittance spectroscopy (1.0–3.6 μm), and monitoring the film growth using interference patterns of two lasers. We measured peak position, full width at half maximum, and strengths of the methane bands, and density and real refractive index of the icy films. Results confirm and extend but also partially contradict previous studies on similar mixtures. Experimental data can be applied to interpret observations of Solar System (trans-Neptunian objects) and interstellar ices, where methane and nitrogen are believed to be present. We predict the optical depths of two methane NIR bands in the line of sight of some dense molecular clouds.

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Impact of Irradiated Methane Ice Crusts on Compositional Interpretations of TNOs

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Context. Minor bodies in the outer solar system show a wide variety of spectral colors related to both composition and surface processing, e.g. cosmic ion irradiation.
Aims. We investigate the effect of an irradiation mantle on the reflectance spectrum in the V-NIR (visible-near-infrared) range. In particular we investigate the condition needed for a weathering crust to mask the presence of water ice.
Methods. We start from laboratory experiments of ion irradiated methane ice to study the optical properties of the hydrocarbon residue by-product of the space weathering process. We compare the real and imaginary index of refraction with those of Titan and ice tholins and with those of amorphous carbon. We use the estimated optical constants to model a layered configuration using the Hapke theory, varying the thickness and grain size of the modeled crust.
Results. We find that a relatively thin (tens of microns) crust of irradiated methane by-products can mask the presence of water ice bands in the spectrum, while a much larger layer of tholins would be required to produce a similar effect. We also estimate the conditions for the detection of water ice on trans-Neptunian objects (TNOs). We discuss the results in view of the astrophysical timescale.

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For preprints, contact rosario.brunetto@ias.u-psud.fr

PAPERS RECENTLY SUBMITTED TO JOURNALS

A Subaru Pencil-beam Search for $m_R \sim 27$ Trans-neptunian Bodies

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or on the web at http://arxiv.org/abs/0809.4166

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Velocity-dependent Catastrophic Disruption Criteria for Planetesimals

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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 the Kuiper Belt. The ideal candidate will have a Ph.D. in astronomy, physics, planetary science, or related field, and be familiar with optical and/or infrared surveys of the Kuiper Belt and/or large observational datasets. The successful candidate will use both archival datasets and acquire new observations of the Kuiper Belt, and may also execute independent research. NAU has full competitive access to all University of Arizona Observatories (UAO) facilities, including the 6.5-meter MMT and Magellan telescopes, the 2x8.4-meter Large Binocular Telescope, and numerous smaller telescopes. Ample research and travel funds will be available.

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To apply, please visit the NAU HR web page at http://hr.nau.edu/m/content/view/797/550/ and reference job #557928.

Applicants should submit a CV, list of publications, a brief statement of research interests and experience, and the names and contact information of three recommenders. Applications will be considered beginning on January 15, 2009.

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:
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