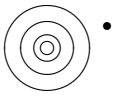
*Issue No. 70* *August 2010*

# *DISTANT EKOs*



*The Kuiper Belt Electronic Newsletter*

*Edited by: Joel Wm. Parker*

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## CONTENTS

# NEWS & ANNOUNCEMENTS

There were 20 new TNO discoveries announced since the March issue of *Distant EKOs* (the list wasn't updated in the June issue):

2005 NU125, 2005 NV125, 2006 TO130, 2006 TP130, 2009 MF10, 2009 MG10,
2010 EL139, 2010 EP65, 2010 FC49, 2010 FX86, 2010 HD112, 2010 HE79, 2010 HG109,
2010 JK124, 2010 LK109, 2010 LP68, 2010 LQ68, 2010 PU75, 2010 PK66, 2010 PT66

27 new Centaur/SDO discoveries:

2009 ME10, 2010 EN65, 2010 EO65, 2010 ES65, 2010 EU65, 2010 FB49, 2010 FH92,
2010 GX34, 2010 HM23, 2010 JB80, 2010 KR59, 2010 LJ109, 2010 LN68, 2010 LO33,
2010 EK139, 2010 EQ65, 2010 ER65, 2010 ET65, 2010 FD49, 2010 FE49, 2010 GF65,
2010 GW147, 2010 JC80, 2010 JJ124, 2010 KZ39, 2010 NV1, 2010 PL66

and 1 Neptune Trojan discovery:

2008 LC18

Reclassified objects:

2009 YE7 (TNO → SDO)

Objects recently assigned numbers:

2007 DU112 = (241097)
2006 SX368 = (248835)

Current number of TNOs: 1149 (including Pluto)
Current number of Centaurs/SDOs: 284
Current number of Neptune Trojans: 7

Out of a total of 1440 objects:

625 have measurements from only one opposition
582 of those have had no measurements for more than a year
325 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

## Formation of Kuiper Belt Binaries by Gravitational Collapse

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A large fraction of ∼100-km-class low-inclination objects in the classical Kuiper Belt (KB) are binaries with comparable mass and wide separation of components. A favored model for their formation was capture during the coagulation growth of bodies in the early KB. Instead, recent studies suggested that large, ∼100-km objects can rapidly form in the protoplanetary disks when swarms of locally concentrated solids collapse under their own gravity. Here we examine the possibility that KB binaries formed during gravitational collapse when the excess of angular momentum prevented the agglomeration of available mass into a solitary object. We find that this new mechanism provides a robust path toward the formation of KB binaries with observed properties, and can explain wide systems such as 2001 $QW_{322}$ and multiples such as (47171) 1999 $TC_{36}$. Notably, the gravitational collapse is capable of producing ∼100% binary fraction for a wide range of the swarm's initial angular momentum values. The binary components have similar masses (∼80% have the secondary-over-primary radius ratio >0.7) and their separation ranges from ∼1,000 to ∼100,000 km. The binary orbits have eccentricities from $e = 0$ to ∼1, with the majority having $e < 0.6$. The binary orbit inclinations with respect to the initial angular momentum of the swarm range from $i = 0$ to ∼90°, with most cases having $i < 50°$. The total binary mass represents a characteristic fraction of the collapsing swarm's total initial mass, $M_{\rm tot}$, suggesting $M_{\rm tot}$ equivalent to that of a radius ∼100 to 250-km compact object. Our binary formation mechanism also implies that the primary and secondary components in each binary pair should have identical bulk composition, which is consistent with the current photometric data. We discuss the applicability of our results to the Pluto-Charon, Orcus-Vanth, (617) Patroclus-Menoetius and (90) Antiope binary systems.

**Published in: The Astronomical Journal, 140, 785 (2010 September)**

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## On the Detection of Two New Transneptunian Binaries from the CFEPS Kuiper Belt Survey

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We report here the discovery of a new near-equal-mass trans-Neptunian Binary (TNB) L5c02 and the the putative detection of a second TNB (L4k12) among the detections in the second and third years of the Canada-France Ecliptic Plane Survey (CFEPS). These new binaries (internal designations L4k12 and L5c02) have moderate separations of 0.4" and 0.6", respectively. The follow-up observation

confirmed the binarity of L5c02, but L4k12 still lacks follow-up observations. L4k12 has a heliocentric orbital inclination of 35°, marking this system as having the highest heliocentric orbital inclination among known near-equal-mass binaries. Both systems are members of the classical main Kuiper belt population. Based on the sample of objects searched, we determine that the fraction of near-equal-mass wide binaries with separations $> 0.4$" is 1.5% to 20% in the cold main classical Kuiper belt, and if our detection of the binarity L4k12 holds, 3% to 43% in the hot main classical objects are binary. In this article we describe our detection process, the sample of objects surveyed, and our confirmation observations.

**To appear in: Publications of the Astronomical Society of the Pacific (2010 September)**
*For preprints, contact* sevenlin123@gmail.com
*or on the web at* http://arxiv.org/abs/1008.1077

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## Equilibrium Configurations of Synchronous Binaries: Numerical Solutions and Application to Kuiper-Belt Binary 2001 $QG_{298}$

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We present numerical computations of the equilibrium configurations of tidally-locked homogeneous binaries, rotating in circular orbits. Unlike the classical Roche approximations, we self-consistently account for the tidal and rotational deformations of both components, and relax the assumptions of ellipsoidal configurations and Keplerian rotation. We find numerical solutions for mass ratios $q$ between $10^{-3}$ and 1, starting at a small angular velocity for which tidal and rotational deformations are small, and following a sequence of increasing angular velocities. Each series terminates at an appropriate "Roche limit", above which no equilibrium solution can be found. Even though the Roche limit is crossed before the "Roche lobe" is filled, any further increase in the angular velocity will result in mass-loss. For close, comparable-mass binaries, we find that local deviations from ellipsoidal forms may be as large as $10 - 20\%$, and departures from Keplerian rotation are significant. We compute the light curves that arise from our equilibrium configurations, assuming their distance is $\gg 1$ AU (e.g. in the Kuiper Belt). We consider both backscatter (proportional to the projected area) and diffuse (Lambert) reflections. Backscatter reflection always yields two minima of equal depths. Diffuse reflection, which is sensitive to the surface curvature, generally gives rise to unequal minima. We find detectable intensity differences of up to 10% between our light curves and those arising from the Roche approximations. Finally, we apply our models to Kuiper Belt binary 2001 $QG_{298}$, and find a nearly edge-on binary with a mass ratio $q = 0.93^{+0.07}_{-0.03}$, angular velocity $\omega^2/G\rho = 0.333 \pm 0.001$ (statistical errors only), and pure diffuse reflection. For the observed period of 2001 $QG_{298}$, these parameters imply a bulk density, $\rho = 0.72 \pm 0.04$ g cm$^{-3}$.

**To appear in: The Astrophysical Journal**
*For preprints, contact* orlyg@tapir.caltech.edu
*or on the web at* http://arxiv.org/abs/1006.5455

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## The Hill Stability of Inclined Small Mass Binary Systems in Three-body Systems with Special Application to Triple Star Systems, Extrasolar Planetary Systems and Binary Kuiper Belt Systems

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The dynamical stability of a bound triple system composed of a small binary or minor planetary system moving on a orbit inclined to a central third body is discussed in terms of Hill stability for the full three-body problem. The situation arises in the determination of stability of triple star systems against disruption and component exchange and the determination of stability of extrasolar planetary systems and minor planetary systems against disruption, component exchange or capture. The Hill stability criterion is applied to triple star systems and extrasolar planetary systems, the Sun-Earth-Moon system and Kuiper Belt binary systems to determine the critical distances for stable orbits. It is found that increasing the inclination of the third body decreases the Hill regions of stability. Increasing the eccentricity of the binary also produces similar effects. These type of changes make exchange or disruption of the component masses more likely. Increasing the eccentricity of the binary orbit relative to the third body substantially decreases stability regions as the eccentricity reaches higher values. The Kuiper Belt binaries were found to be stable if they move on circular orbits. Taking into account the eccentricity, it is less clear that all the systems are stable.

**Published in: Planetary and Space Science, 58, 1169 (2010 August)**
*For preprints, contact* r.donnison@qmul.ac.uk

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## Gravitational Effects of Nix and Hydra in the External Region of the Pluto-Charon System

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Two new companions to the Pluto-Charon binary system have been detected in 2005 by Weaver *et al.* (2006). These small satellites, named Nix and Hydra, are located beyond Charon's orbit. Although they are small when compared to Charon, their gravitational perturbations can decrease the stability of the external region (beyond Charon's orbit). The dynamical structure of this external region is analysed by numerically simulating a sample of particles under the gravitational effects of Pluto, Charon, Nix and Hydra. As expected the effects of Nix and Hydra decrease the external stable region. Agglomerates of particles can survive after $10^5$ orbital periods of the binary in some regions, such as coorbital to Nix and Hydra and between their orbits. We also analysed the effects of hypothetical satellites on the orbital evolution of Nix and Hydra in order to constrain an upper limit size. Some hypothetical satellites can be coorbital to Nix or Hydra without provoking any significant gravitational effects on them.

**To appear in: Monthly Notices of the Royal Astronomical Society**
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## Impactor Flux and Cratering on the Pluto-Charon System

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We study the impactor flux and cratering on Pluto and Charon due to the collisional evolution of Plutinos. Plutinos are those trans-Neptunian objects located at ∼39.5 AU, in the 3:2 mean motion resonance with Neptune. To do this, we develop a statistical code that includes catastrophic collisions and cratering events, and takes into account the stability and instability zones of the 3:2 mean motion resonance with Neptune. Moreover, our numerical algorithm proposes different initial populations that account for the uncertainty in the size distribution of Plutinos at small sizes. Depending on the initial population, our results indicate the following. The number of $D > 1$ km Plutinos streaking Pluto over 3.5 Gyr is between 1 271 and 5 552. For Charon, the number of $D > 1$ km Plutino impactors is between 354 and 1 545. The number of $D > 1$ km craters on Pluto produced by Plutinos during the last 3.5 Gyr is between 43 076 and 113 879. For Charon, the number of $D > 1$ km craters is between 20 351 and 50 688. On the other hand, the largest Plutino impactor onto Pluto has a diameter between ∼17 and 23 km, which produces a crater with a diameter of ∼31–39 km. In the same way, the largest Plutino impactor onto Charon has a diameter between ∼10 and 15 km, which produces a crater with a diameter of ∼24–33 km. Finally, we test the dependence of results on the number of Pluto-sized objects in the Plutino population. If 2 Pluto-sized objects are assumed in the 3:2 Neptune resonance, the total number of Plutino impactors both onto Pluto as Charon with diameters $D > 1$ km is a factor of ∼1.6–1.8 larger than that obtained considering only 1 Pluto-sized object in this resonant region. Given the structure of the trans-Neptunian region, with its dynamically different populations, it is necessary to study in detail the contribution of all the potential sources of impactors on the Pluto-Charon system, to obtain the main contributor and the whole production of craters. Then, we will be able to contrast those studies with observations which will help us to understand the geological processes and history of the surface of those worlds.

**To appear in: Astronomy & Astrophysics**
*For preprints, contact* gdeelia@fcaglp.unlp.edu.ar
*or on the web at* http://arxiv.org/abs/1007.0415

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## HST Astrometry of Transneptunian Objects

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We present 1428 individual astrometric measurements of 256 Transneptunian objects made with HST. The observations were collected over three years with two instruments, the Wide Field Planetary Camera 2 and the Advanced Camera for Surveys High Resolution Camera, as part of four HST programs. We briefly describe the data and our analysis procedures. The submission of these measurements to the Minor Planet Center increased the individual arc length of objects by 1.83 days to 8.11 years. Of the 256 total objects, 62 (24.2%) had arc length increases ≥3 years. The arc length for 60 objects (23.4%) was increased by a factor of two or greater.

**To appear in: Astrophysical Journal Supplement, 189, 336 (2010 August)**
*For preprints, contact* susank@psi.edu
*or on the web at* http://arxiv.org/abs/1006.5949

## Trans-Neptunian Objects with Hubble Space Telescope ACS/WFC

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We introduce a novel search technique that can identify trans-neptunian objects in three to five exposures of a pointing within a single Hubble Space Telescope orbit. The process is fast enough to allow the discovery of candidates soon after the data are available. This allows sufficient time to schedule follow up observations with HST within a month. We report the discovery of 14 slow-moving objects found within $5^o$ of the ecliptic in archival data taken with the Wide Field Channel of the Advanced Camera for Surveys. The luminosity function of these objects is consistent with previous ground-based and space-based results. We show evidence that the size distribution of both high and low inclination populations is similar for objects smaller than 100 km, as expected from collisional evolution models, while their size distribution differ for brighter objects. We suggest the two populations formed in different parts of the protoplanetary disk and after being dynamically mixed have collisionally evolved together. Among the objects discovered there is an equal mass binary with an angular separation ∼0.53".

**To appear in: The Astrophysical Journal**
*For preprints, contact* `Cesar.I.Fuentes@nau.edu`
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## Detection of a Trailing (L5) Neptune Trojan

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The orbits of small Solar System bodies record the history of our Solar System. Here we report the detection of 2008 LC18, which is the first known Neptune Trojan in the trailing (L5) Lagrangian region of gravitational equilibrium within Neptune's orbit. We estimate that the leading and trailing Neptune Trojan regions have similar sized populations and dynamics with both regions dominated by high inclination objects. Similar populations and dynamics at both Neptune Lagrangian regions indicate the Trojans were likely captured by a migrating, eccentric Neptune in a dynamically excited planetesimal population.

**Published in: Science**
*For preprints, contact* `sheppard@dtm.ciw.edu`
*or on the web at* `http://www.dtm.ciw.edu/users/sheppard/L5trojan/`

## Planetary Trojans - The Main Source of Short Period Comets?

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One of the key considerations when assessing the potential habitability of telluric worlds will be that of the impact regime experienced by the planet. In this work, we present a short review of our understanding of the impact regime experienced by the terrestrial planets within our own Solar system, describing the three populations of potentially hazardous objects which move on orbits that take them through the inner Solar system. Of these populations, the origins of two (the Near-Earth Asteroids and the Long-Period Comets) are well understood, with members originating in the Asteroid belt and Oort cloud, respectively. By contrast, the source of the third population, the Short-Period Comets, is still under debate. The proximate source of these objects is the Centaurs, a population of dynamically unstable objects that pass perihelion (closest approach to the Sun) between the orbits of Jupiter and Neptune. However, a variety of different origins have been suggested for the Centaur population. Here, we present evidence that at least a significant fraction of the Centaur population can be sourced from the planetary Trojan clouds, stable reservoirs of objects moving in 1:1 mean-motion resonance with the giant planets (primarily Jupiter and Neptune). Focussing on simulations of the Neptunian Trojan population, we show that an ongoing flux of objects should be leaving that region to move on orbits within the Centaur population. With conservative estimates of the flux from the Neptunian Trojan clouds, we show that their contribution to that population could be of order ∼3%, while more realistic estimates suggest that the Neptune Trojans could even be the main source of fresh Centaurs. We suggest that further observational work is needed to constrain the contribution made by the Neptune Trojans to the ongoing flux of material to the inner Solar system, and believe that future studies of the habitability of exoplanetary systems should take care not to neglect the contribution of resonant objects (such as planetary Trojans) to the impact flux that could be experienced by potentially habitable worlds.

**To appear in: International Journal of Astrobiology**

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## The Luminosity Function of the Hot and Cold Kuiper Belt Populations

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We have performed an ecliptic survey of the Kuiper belt, with an areal coverage of 8.9 square degrees to a 50% limiting magnitude of $r'_{\rm Sloan} = 24.7$, and have detected 88 Kuiper belt objects, roughly half of which received follow-up one to two months after detection. Using this survey data alone, we have measured the luminosity function of the Kuiper belt, thus avoiding any biases that might come from the inclusion of other observations. We have found that the *Cold* population defined as having inclinations less than 5° has a luminosity function slope $\alpha_{Cold} = 0.82 \pm 0.23$, and is different from the *Hot* population, which has inclinations greater than 5° and a luminosity function slope $\alpha_{Hot} = 0.35 \pm 0.21$. As well, we have found that those objects closer than 38 AU have virtually the same luminosity function

slope as the *Hot* population. This result, along with similar findings of past surveys demonstrates that the dynamically cold Kuiper belt objects likely have a steep size distribution, and are unique from all of the excited populations which have much shallower distributions. This suggests that the dynamically excited population underwent a different accretion history and achieved a more evolved state of accretion than the *Cold* population. As well, we discuss the similarities of the *Cold* and *Hot* populations with the size distributions of other planetesimal populations. We find that while the Jupiter family comets and the scattered disk exhibit similar size distributions, a power-law extrapolation to small sizes for the scattered disk cannot account for the observed influx of comets. As well, we have found that the Jupiter Trojan and *Hot* populations cannot have originated from the same parent population, a result that is difficult to reconcile with scattering models similar to the NICE model. We conclude that the similarity between the size distributions of the *Cold* population and the Jupiter Trojan population is a striking coincidence.

**To appear in: Icarus**
*For preprints, contact* `fraserw@gps.caltech.edu`
*or on the web at* `http://arxiv.org/abs/1008.1058`

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## Collisional Grooming Models of the Kuiper Belt Dust Cloud

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We modeled the 3-D structure of the Kuiper Belt dust cloud at four different dust production rates, incorporating both planet-dust interactions and grain-grain collisions using the collisional grooming algorithm. Simulated images of a model with a face-on optical depth of $\sim 10^{-4}$ primarily show an azimuthally-symmetric ring at 40–47 AU in submillimeter and infrared wavelengths; this ring is associated with the cold classical Kuiper Belt. For models with lower optical depths ($10^{-6}$ and $10^{-7}$), synthetic infrared images show that the ring widens and a gap opens in the ring at the location of of Neptune; this feature is caused by trapping of dust grains in Neptune's mean motion resonances. At low optical depths, a secondary ring also appears associated with the hole cleared in the center of the disk by Saturn. Our simulations, which incorporate 25 different grain sizes, illustrate that grain-grain collisions are important in sculpting today's Kuiper Belt dust, and probably other aspects of the Solar System dust complex; collisions erase all signs of azimuthal asymmetry from the submillimeter image of the disk at every dust level we considered. The model images switch from being dominated by resonantly-trapped small grains ("transport dominated") to being dominated by the birth ring ("collision dominated") when the optical depth reaches a critical value of $\tau \sim v/c$, where $v$ is the local Keplerian speed.

**To appear in: The Astronomical Journal**
*For preprints, contact* `Marc.Kuchner@nasa.gov`
*or on the web at* `http://arxiv.org/abs/1008.0904`

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## Properties of the Distant Kuiper Belt: Results from the Palomar Distant Solar System Survey

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We present the results of a wide-field survey using the 1.2-m Samuel Oschin Telescope at Palomar Observatory. This survey was designed to find the most distant members of the Kuiper belt and beyond. We searched ∼12,000 deg$^2$ down to a mean limiting magnitude of 21.3 in $R$. A total number of 52 KBOs and Centaurs have been detected, 25 of which were discovered in this survey. Except for the re-detection of Sedna, no additional Sedna-like bodies with perihelia greater than 45 AU were detected despite sensitivity out to distances of 1000 AU. We discuss the implications for a distant Sedna-like population beyond the Kuiper belt, focusing on the constraints we can place on the embedded stellar cluster environment the early Sun may be have been born in, where the location and distribution of Sedna-like orbits sculpted by multiple stellar encounters is indicative of the birth cluster size. We also report our observed latitude distribution and implications for the size of the plutino population.

**To appear in: The Astrophysical Journal**

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*or on the web at* `http://arxiv.org/abs/1007.2954/`

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## A Preliminary Assessment of an Orbiter in the Haumean System: How Quickly can a Planetary Orbiter Reach Such a Distant Target?

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With the recent discoveries of planetary objects beyond Neptune and Pluto, the vast majority of all sizeable Solar System planetary objects lie now beyond Uranus, where insertion into orbit after a reasonably short travel is still not within the current capabilities of today's spacecraft. Being able to go and stop at a transneptunian dwarf planet would represent a stepstone for ambitious long-term exploration goals. The pressure to send spacecraft to these bodies will grow, as, among the tens or hundreds of large objects, some will emerge as high priorities for science and exploration missions. It is subsequently necessary to prepare the technologies required for such spacecraft. In addition, being able to achieve a fast journey to a distant object will benefit also missions to closer targets. Thales Alenia Space has carried out a preliminary parameter exploration of such a mission with a challenging target: an orbiter in the Haumean system. The main parameters are the characteristics of the propulsion and power subsystems, as well as the mass of the spacecraft. The exploration has quantified the technological improvement needed for reaching these objects within a reasonable time.

**Published in: Acta Astronautica**

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# Pencil-Beam Surveys for Trans-Neptunian Objects: Novel Methods for Optimization and Characterization

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Digital co-addition of astronomical images is a common technique for increasing signal-to-noise ratio (S/N) and image depth. A modification of this simple technique has been applied to the detection of minor bodies in the solar system: first stationary objects are removed through the subtraction of a high-S/N template image, then the sky motion of the solar system bodies of interest is predicted and compensated for by shifting pixels in software prior to the co-addition step. This "shift-and-stack" approach has been applied with great success in directed surveys for minor solar system bodies. In these surveys, the shifts have been parameterized in a variety of ways. However, these parameterizations have not been optimized and in most cases cannot be effectively applied to data sets with long observation arcs due to objects' real trajectories diverging from linear tracks on the sky. This paper presents two novel probabilistic approaches for determining a near-optimum set of shift vectors to apply to any image set given a desired region of orbital space to search. The first method is designed for short observational arcs, and the second for observational arcs long enough to require nonlinear shift vectors. Using these techniques and other optimizations, we derive optimized grids for previous surveys that have used "shift-and-stack" approaches to illustrate the improvements that can be made with our method, and at the same time derive new limits on the range of orbital parameters these surveys searched. We conclude with a simulation of a future application for this approach with LSST, and show that combining multiple nights of data from such next-generation facilities is within the realm of computational feasibility.

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*For preprints, contact* alexhp@uvic.ca
*or on the web at* http://arxiv.org/abs/1004.3287

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# Pencil-Beam Surveys for Trans-Neptunian Objects: Limits on Distant Populations

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Two populations of minor bodies in the outer Solar System remain particularly elusive: Scattered Disk objects and Sedna-like objects. These populations are important dynamical tracers, and understanding the details of their spatial- and size-distributions will enhance our understanding of the formation and on-going evolution of the Solar System. By using newly-derived limits on the maximum heliocentric distances that recent pencil-beam surveys for Trans-Neptunian Objects were sensitive to, we determine new upper limits on the total numbers of distant SDOs and Sedna-like objects. While generally consistent with populations estimated from wide-area surveys, we show that for magnitude-distribution slopes of $\alpha > 0.7$–$1.0$, these pencil-beam surveys provide stronger upper limits than current estimates in literature.

**To appear in: Icarus**
*For preprints, contact* alexhp@uvic.ca
*or on the web at* http://arxiv.org/abs/1004.3288

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## The Discovery of the Kuiper Belt

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Only in the last two decades have astronomers been able to explore the fascinating realm beyond the outermost giant planet Neptune. Thousands of bodies are now known to be orbiting there. We asked the co-discoverer of the first of these trans-Neptunian worlds to tell us how he came to make the pioneering discovery that opened the outer reaches of our solar system to our view.

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*Preprints, on the web at* `http://www2.ess.ucla.edu/~jewitt/papers/2010/J10c.pdf`

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# PAPERS RECENTLY SUBMITTED TO JOURNALS

## Dynamics of Neptune's Trojans: II. Eccentric Orbits and Observed Ones

**L.-Y. Zhou**[1], **R. Dvorak**[2], **and Y.-S. Sun**[1]

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Submitted to: Monthly Notices of the Royal Astronomical Society
*For preprints, contact* `zhouly@nju.edu.cn`
*or on the web at* `http://arxiv.org/abs/1007.5362`

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## Estimating the Density of Intermediate Size KBOs from Considerations of Volatile Retention

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Submitted to: Icarus
*Preprints on the web at* `http://arxiv.org/abs/1008.1105`

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# CONFERENCE CONTRIBUTIONS

## The Potato Radius: a Lower Minimum Size for Dwarf Planets

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To appear in: Proceedings of the 9th Australian Space Science Conference
*Preprints on the web at* `http://arxiv.org/abs/1004.1091`

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# THESES

## The Compositional Variation of Small Bodies Across the Solar System

**Francesca E. DeMeo**[1]

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Small bodies hold keys to our understanding of the Solar System. By studying these populations we seek the information on the conditions and structure of the primordial and current Solar System, its evolution, and the formation process of the planets. Constraining the surface composition of small bodies provides us with the ingredients and proportions for this cosmic recipe. This thesis, comprised of studies of inner and outer Solar System small bodies, is dedicated to understanding the compositional gradient across the Solar System through spectroscopic and photometric measurements.

I present a taxonomy of visible and near-infrared spectral data based on 371 asteroid spectra, and discuss the difficulties of interpreting spectra without the entire wavelength range. I analyze the photometric colors of 23 Transneptunian Objects and Centaurs, nine of which have never been previously observed. I discuss objects that either have changed taxonomic classes from previous data or have significant changes in absolute magnitude. Furthermore, I interpret the surface composition of three outer Solar System small bodies, Jupiter-coupled object (52872) Okyrhoe, and TNOs (90482) Orcus and (73480) 2002 $PN_{34}$, by modeling spectroscopic measurements in the visible and near-infrared wavelength ranges. The spectra reveal varying amounts of $H_2O$ ice among these bodies. For Orcus I provide rough constraints for the presence of materials more volatile than water ice. I present a search for solid ethane, $C_2H_6$, on the surfaces of Pluto and Triton, based on near-infrared spectral observations. I model each surface using a radiative transfer model based on Hapke theory (Hapke, 1993) with three basic models: without ethane, with pure ethane, and with ethane diluted in nitrogen. While the presence of less than a few percent of ethane cannot be excluded on both bodies, there is no strong detection on either.

Finally, I review the current knowledge of the compositional distribution of material in our Solar System, providing the global view of small bodies. I particularly focus on the presence of water in all its phases which is especially pertinent our understanding of our own planet, Earth, and the life on it. I briefly compare the general structure of our Solar System to other imaged debris disks to put into perspective the detailed, though narrow, view of our own Solar System with the broad, low resolution view of others.

*Dissertation directed by M.A. Barucci and R.P. Binzel*
*Ph.D. awarded June 2010 from the Paris Observatory*
*For preprints, contact* `fdemeo@mit.edu`

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