EPSC Abstracts
Vol. 13, EPSC-DPS2019-395-1, 2019
EPSC-DPS Joint Meeting 2019
© Author(s) 2019. CC Attribution 4.0 license.

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

The Deep Ecliptic Exploration Project (DEEP): A new NOAO survey of the faint outer Solar System

David E. Trilling (1), David Gerdes (2), Chad Trujillo (1), Scott Sheppard (3), Cesar Fuentes (4), Hilke Schlichting (5), Andrew McNeill (1), Mario Juric (6), Matt Holman (7), Ed Lin (2), Larissa Markwardt (2), Michael Mommert (8), William Oldroyd (1), Matt Payne (7), Darin Ragozzine (9), Andrew S. Rivkin (10), Megan E. Schwamb (11)
(1) Northern Arizona University, Flagstaff, AZ, USA, (2) University of Michigan, Ann Arbor, MI, USA, (3) Carnegie Institution for Science, Washington, D.C., USA, (4) Universidad de Chile, Santiago, Chile, (5) UCLA, Los Angeles, CA, USA, (6) University of Washington, Seattle, WA, USA, (7) Center for Astrophysics | Harvard & Smithsonian, Cambridge, MA, USA, (8) Lowell Observatory, Flagstaff, AZ, USA, (9) Brigham Young University, Provo, UT, USA, (10) Johns Hopkins University Applied Physics Lab, Laurel, MD, USA, (11) Queen's University, Belfast, Belfast, UK (david.trilling@nau.edu)

Abstract

We have begun a new NOAO Survey progam to carry out a deep search of the faint outer Solar System with the Dark Energy Camera (DECam) and the 4-meter Blanco telescope at the Cerro Tololo Inter-American Observatory (CTIO) in Chile. We will measure the size distribution and physical properties of 5000 Kuiper Belt Objects (KBOs) down to VR=27. We will measure the size distribution, colors, and shape distribution of KBOs as a function of dynamical class. Our data set will also allow us to measure the colors, size distribution, and shape distribution of main belt asteroids, and enable a rich array of other science investigations. Our results will help elucidate the composition and structure of the outer Solar System and the origin of our planetary system.

Observations and data analysis

We have been allocated 46.5 nights to carry out this project, in semesters 2019A–2021B. As of this writing, we have just started to analyze our data from our April, 2019, observing run; we have upcoming runs in May, June, July, August, and September, 2019, as well as runs in 2020 and 2021.

DECam has a field of view of 3 deg^2. Our observations consist of four hours of continuous observation of each field, allowing us to reach VR$\approx$27 in a final stacked image (see below). We will survey 12 unique pointings in our first year (Figure 1) for a total coverage of 36 deg^2. Given our best current understanding of the brightness distribution of KBOs, this implies a yield of around 5000 KBOs in our data set.

Our long stares are divided into many 120 second exposures. We combine the individual images into composite images through a "shift and stack" technique that sums at various rates of motion and directions corresponding to different locations in the outer Solar System. The resulting deep images will contain KBOs that are far too faint to be detected in individual images. Synthetic objects will be inserted into our data in order to measure our detection efficiency and debias our observational results.

Expected results

We will have two year arcs for more than 90% of the 5000 objects that we will detect (Figure 2). Thus, high fidelity dynamical classifications will be possible, and the resulting small positional uncertainties means that follow-up observations of individual objects with JWST or other facilities would be feasible. Weather permitting, we also will obtain VR-i colors for the bright half of our sample. Thus, we will know orbits and dynamical classes; colors, for some objects; and (partial) lightcurves, for objects that are bright enough to be detected in individual frames.

Our short exposure times also allow us to carry out ancillary asteroid science: we will measure color and (partial) lightcurves for tens of thousands of main belt asteroids.

Thus, our expected results are as follows:

1. Measure the KBO size distribution down to $\sim$50 km
2. Measure the colors of thousands of faint KBOs
3. Derive the shape distribution of KBOs from partial lightcurves

4. Measure colors, sizes, and shapes of KBOs as a function of dynamical class and of size

There are a number of additional, secondary science goals related to Centaurs and the physical properties of asteroids. Our data could also be used for astrophysical investigations including searches for transiting exoplanets and other transient events that appear in our time-series observations.

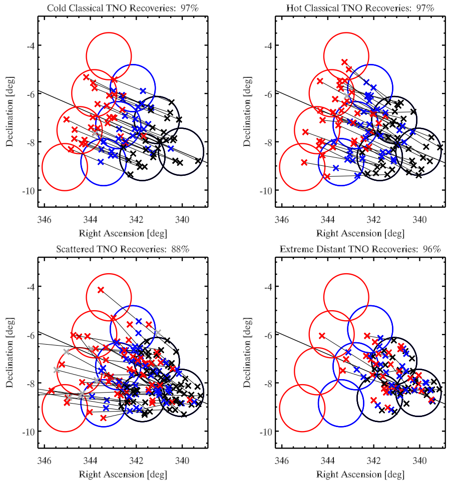

Figure 1: A visualization of our recovery efficiency for our field pattern in the A semester is shown (a similar pattern will be observed in the B semester). The circles approximate the DECam field positions. Black fields will be imaged in Years 1–3, blue in Years 2–3, and red in Year 3. Four populations of TNOs are modeled with simulated discovered objects are shown as crosses with color coding for the year they are imaged (again, black, blue and red for Years 1, 2, and 3). Grey crosses represent objects that are not imaged in a given year and grey lines connect object positions across epochs. Recovery efficiency is shown in the title and is nearly 90%, or more, for all classes of objects. The objects shown are only representative in order to depict orbital motion; the full density simulation is not shown here, for clarity.

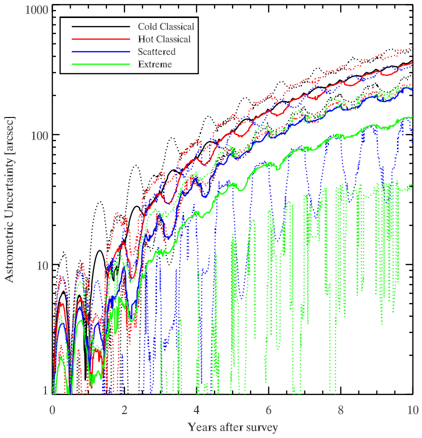

Figure 2: Astrometric uncertainty after our survey is completed, for different classes of KBOs. Gaussian noise of 0.6 arcseconds was applied to objects detected in our sky coverage simulation. Orbits were then fit to these noise-added positions using the technique of Bernstein and Khushalani (2000). A decade of predicted positions of each object from the fit orbits was then compared to the actual location from the simulation orbits to determine astrometric uncertainty. Solid lines mark the median orbit uncertainty while dashed lines bound the 90% confidence region for each orbit type (black = cold classical, red = hot classical, blue = scattered, green = extreme).