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The Classical and Large-a Solar System

Wesley C Fraser, Samantha Lawler, Rosemary E Pike, J. J. Kavelaars, Edward Ashton, Stephen D J Gwyn, Ying-Tung Chen, Brett J Gladman, Jean-Marc C. Petit

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HAL Authorization

The Classical and Large-a Solar System W. C. Fraser¹, S. Lawler², R. E. Pike³, JJ Kavelaars¹, E. Ashton⁴, S. Gwyn¹, Y.-T. Chen⁴, Y. Huang⁵, B. Gladman⁵, J.-M. Petit⁶, C. Semenchuck², L. Peltier⁷, M. Alexandersen³, B. Noyelles⁶, D. Hestroffer⁸, R. C.-K. Chang⁴, A. Connolly⁹, J. B. Kalmbach⁹, S.Y. Wang⁴, M. Eduardo⁷, M. Juric⁹, C. Van Laerhoven¹⁰, M. Bannister¹¹, P. Cowan¹², N. Tan¹¹, K. Volk¹³ ¹Herzberg Astronomy and Astrophysics, wesley.fraser@nrc-cnrc.gc.ca, ²University of Regina, ³CFA, Harvard Smithsonian, ⁴ASIAA, ⁵UBC, ⁶UTINAM-CNRS, ⁷UVic, ⁸IMCCE-CNRS, ⁹UWashington, ¹⁰RASC, ¹¹UCanterbury, ¹²UAukland, ¹³PSI.

Introduction: In this presentation we will show the first results of CLASSY: the Classical and Large-A Solar SYstem survey. This 2-year Large Program on the Canada-France-Hawaii Telescope is allotted 75 nights from 2022B through 2024A inclusive. Using shift'n'stack techniques [1], CLASSY is surveying 6 independent pointings (12.2 square degrees total) of the cold classical belt's forced midplane, achieving depths of $r \sim 26.8$ in search of Kuiper Belt Objects and extreme trans-Neptunian objects (eTNOs).

The Survey: By design, the vast majority of objects will be detected in 5 visits to each field across the first year (discovery), and will be tracked to a second opposition one year later (tracking). At time of abstract writing, $\frac{1}{2}$ of the discovery observations (6.1 sq. deg.) have been completed successfully. CLASSY has two primary goals: to provide observational tests of cutting-edge planet formation models such as those involving the streaming instability and pebble cloud collapse; and to test cosmogonic models of orbital emplacement, particularly at large semimajor axes ($a > 100$ AU). We will carefully measure the size-frequency distribution of classical TNOs for diameters $30 \leq D \leq 250$ km (assuming 16% albedos). This size range is critical for determining properties of the streaming instability and cloud collapse mechanisms that formed TNOs because it occupies a range of sizes between the central bodies that formed from the streaming instability, and the smaller secondary detritus ejected during cloud collapse. To facilitate our second science goal, CLASSY is the first survey designed explicitly to avoid longitudinal discovery biases that may be present in the known eTNOs sample. The survey layout is presented in Figure 1.

Preliminary Results: In this presentation we will summarize key properties of CLASSY and its operations. In particular we highlight new machine-learning techniques that we have developed both for vetting real versus bogus sources and for measuring astrometry and photometry of the CLASSY detections. These pioneering techniques have drastically reduced the human cost of the search and characterization of sources, while preserving the depth and accuracy of more traditional techniques. Importantly, with these methods, we have demonstrated sensitivity to sources with distances ≥ 200 AU, and have found a nearly zero false positive rate for sources with brightness well

below the survey threshold. We will conclude with a discussion of the latitudinal and radial distribution of distant sources found beyond the classical Kuiper Belt. Fig. 2 presents the preliminary distance distribution of the 105 sources discovered in the August-September 2022.

References: [1] Smotherman et al. (2021) AJ, 162, 245S [2] Trilling et al. (2022) DPS 5450102T

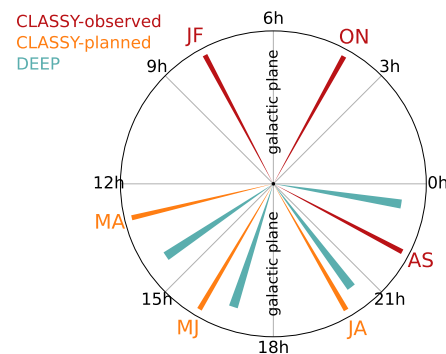


Figure 1: Telescope pointing layout of CLASSY, with those fields that have completed discovery observations at time of writing in red. The pointings of the DECam Ecliptic Survey (DEEP; [2]) are also shown for comparison.

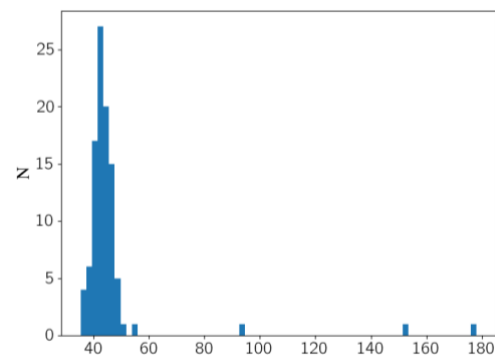


Figure 2: Histogram of distances at discovery for TNOs discovered in the preliminary search of the AS pointing which achieved a discovery depth of $r = 26.8$ (50% survey efficiency). These objects were discovered in the 2022 observations, and will be tracked in the 2023 opposition. Interesting targets such as candidate eTNOs (large a) will receive extra tracking to measure precise orbits.