Project title: Exploring Our Solar System Through the New Discoveries from the Vera C. Rubin Observatory

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Helpful existing knowledge:	Programming skills

Project Description:

The small bodies in the Solar System are the bricks and mortar left over after the construction of planets. Their compositions, shapes, densities, rotation rates, and orbits help reveal their formation history, the architecture of their parent planetary system, the conditions in the planetesimal-forming disk, and the processes active in the Solar System today. The newly built Vera C. Rubin Observatory just came online and over the next few years it will transform our view of the Solar System. This next-generation ground-based observatory will spend ten years surveying the night sky as part of the Legacy Survey of Space and Time (LSST). The LSST will be the biggest astronomical dataset ever made. Rubin Observatory will image the visible night sky every ~3 nights during the LSST, covering a 9.6 square degree field in a single exposure down to 24.7 mag in r-band. The LSST will produce an unprecedented dataset to explore the Solar System's inventory. By delivering significantly larger samples than available today (between 3x-7x, the LSST will revolutionise our view of the Solar System, providing the best look at the small body populations (e.g. asteroids, comets, Kuiper belt objects, interstellar objects). With observations in multiple filters over several years, Rubin Observatory will also provide constraints on the rotational variability and surface composition for a large fraction of the small bodies it discoveries.

The project:

This PhD project will overlap with the first few years of the LSST and explore this ground-breaking new dataset. There is some flexibility depending on the exact interests of the student

in terms of which avenues will be explored in this project. There is scope for the project to focus on combining LSST discoveries with follow-up observations with other telescopes such as the Very Large Telescope, Blanco 4-meter Telescope, and Gemini Observatory to explore the frequency of cometary activity/rotational break-up events and study the distribution of rotational periods of the various small body populations. Some other potential research paths including studying the properties of the Manx (rocky tailless comets in the Oort cloud) comets with LSST data or using machine learning and other analysis techniques to identify outliers and new compositional classes within the LSST Solar System discoveries.

The Solar System group at Queen's led the development of Sorcha, an open-source python survey simulator that takes an input model small body population and biases it to what Rubin Observatory would have detected utilising the LSST pointing history, observation metadata, and search algorithm detection efficiency. These simulated detections can be compared to what LSST actually discovered to determine whether they are drawn from the same parent population. We expect Sorcha will be a powerful tool for Rubin early science.

The Queen’s University Belfast Solar System group is a member of the LOOK (LCO [Las Cumbres Observatory] Outbursting Objects Key) Project that aims to follow-up LSST discoveries of cometary activity. There are likely to be opportunities with this project for observations at UK-supported telescopes and observatories around the world.