

**Funding Source: STFC**

**Proposed start date: September 2023**

**Closing date for applications: May 19th 2023**

**Eligibility:** UK/International

**Department/School:** School of Physics and Astronomy

**Supervisors:** Dr. Chrysa Avdellidou (chavdell@gmail.com), Prof. John Bridges (jcb36@leicester.ac.uk)

**Project Title:** Looking inside planetesimals by studying asteroid collisional families.

**Project Description:**

Planetesimals were the first generation of large objects that accreted directly from the protoplanetary disk of our solar system that subsequently formed our planets. This population should have had compositional gradient according to the heliocentric distance they were formed. Asteroids, along with all small bodies, such as comets, trans-Neptunian objects and irregular satellites, are what is left of the original planetesimal disk from the planet-formation era. But not all asteroids are planetesimals. Most asteroids are collisional fragments.

In this break up process, fragments are launched in space at moderate velocities (<1km/s), where fragments keep orbital elements like that of their parent body. Thus, fragments become themselves new asteroids, clustered in orbital space. These clusters of fragments are called *asteroid families.* However,family members disperse over time. A non-gravitational effect, called the *Yarkovsky effect*, slowly changes asteroids’ orbital semimajor axis, *a.* Asteroids, as they move, encounter orbital resonances with the planets, that change their orbital eccentricity *e,* and inclination *i*, but not their *a*.

There are catalogues of asteroid family membership based on asteroid family identification typically performed by Hierarchical Clustering Methods (HCMs), which look for clusters of asteroids in the orbital element space (*a,e,i*), with significant contrast with respect to the local background. These methods work well for young (compact) families, but they are only capable to identify the core of the older and more dispersed ones. Thus, when catalogued family members are removed from the Main Belt, the remaining asteroids still form large “halos” around the core of the removed families, indicating that families are bigger and perhaps their members more compositionally diverse than what we currently know.

A careful assessment of compositional diversity or homogeneity of family members can reveal key information about the nature of the broken planetesimal. The breakup of a planetesimal with a homogenous composition would produce a family of asteroid fragments all sharing the same composition. On the other hand, the disruption of a fully differentiated planetesimal would produce a family with diverse composition: Some family members originating from the planetesimal’s core would have a metallic composition, members from the planetesimal’s mantle an olivine-rich composition, and members from the planetesimal’s crust a composition dependent on the original *undifferentiated* material from which the planetesimal formed as well as the degree of heating that it experienced. Therefore, by characterising the asteroid families we can look inside the original planetesimals.

**Open key questions** are: What were the sizes, compositions, and internal structures of the planetesimals of our solar system? The aim of this PhD project is to re-assess the membership of known asteroid families by investigating the existence of a halo or even discover new ones, using novel techniques that our team has been developing. The next step will be to retrieve the physical properties of the members of the families under study that are publicly available with focus on the asteroid spectra. Gaia Data release 3 has already published more than 60,000 asteroid spectra which will be updated at a new release in 2024. The student will be supported to apply for further observing time, while he/she will have the opportunity to feed with new data the largest database of asteroid physical properties. As a final goal the composition of asteroid families will be linked to known meteorites.

Successful PhD candidates would have some prior background in coding (Python), while some knowledge of planetary surfaces or observational spectroscopy is desirable.

**References:**

* Avdellidou, C., et al. 2022, *A&A*, 665, id.L9, 13 pp.
* Bolin, B. T., et al. 2017, *Icarus*, 282, 290
* Delbo, M., Avdellidou, C., & Morbidelli, A. 2019, *A&A*, 624, A69
* Delbo, M., et al. 2017, *Science*, 357, 1026
* DeMeo, F. E., et al. 2015, in Asteroids IV (P. Michel, et al. eds)
* DeMeo, F. E., et al. 2009, *Icarus*, 202, 160
* Nesvorny, D., Broz, M., & Carruba, V. 2015, in Asteroids IV (P. Michel, et al.eds), 297
* www.mp3c.oca.eu

How to apply:

Use the application link on the web page

Include with your application:-

* CV
* Degree Certificates and Transcripts
* Details of any study currently being undertaken
* Personal statement
* Enter the supervisor’s name and project title in the Proposal Section (no proposal required)
* Enter contact details of two academic referees in the boxes provided or upload reference letters if already obtained.
* Evidence of English language if applicable.
* In the funding section include: Ref: STFC

The University of Leicester School of Physics and Astronomy has advertised a number of PhD opportunities. If you are applying for more than one University of Leicester project, please indicate if this is your first, second or third choice, in your application.