Light-Field Motion Tracking in Laboratory Studies of Planet Formation

**Supervision team:** Dr Helen Fraser and Prof Simon Green

**External supervisor** Dr Neil Murray / Dr Anthony Evagora (DIAL Ltd)

**Lead contact:** Helen Fraser helen.fraser@open.ac.uk

**Description:**

**Overarching aim:** One of our key scientific drivers in the Astrochemistry group is to describe qualitatively and quantitatively the collisions that dominate the earliest stages of icy planetesimal-formation, to answer ‘how do planets form?’.

We aim to be the first in the world to develop and exploit an experimental payload to address this challenge, taking advantage of the high-quality, medium-duration microgravity environments in sub-orbital flight, to study sub-cm/s collisions between ensembles of ~nm-sized icy grains, forming µm-mm sized fluffy ice aggregates, that stick to form cm-sized icy pebbles. Without these specific microgravity conditions, our particles sediment (at the low velocities), the aggregates fall apart or compact (weight effects), and there is insufficient time to collide and aggregate all the particles.

The ability to attempt such collision experiments is only just emerging as sub-orbital flight providers commence operating, making this studentship timely for developing the underpinning technology ‘just in time’ to realize our scientific ambitions.

**This PhD**

This scientific aim is reliant on the deployment of appropriate video camera technology capable of operating in low pressure (< 10^{-4} mBar), temperature (< 180 K) and microgravity conditions, to record, track, and subsequently compute, the 3D motion of every particle in the ensemble, accounting for appropriate illumination, adapting to opacity changes as the aggregation progresses, accounting for dynamic changes in particle orientation, occlusion, shadowing and range as a function of time, and ensuring rapid data storage (no lost frames at a high frame rate > 500 fps) over a sustained (> 240 s) period, in a field of view not smaller than ~ 100 cm³.

Consequently, the aim of this studentship is to develop this capability in a single, light-field camera with micro-lens array, and produce the associated software processing tools (with industrial partner DIAL). The methodology involves bread-boarding a prototype camera to a flight-ready model through two evolutions, at each step benchmarking, testing, and space-qualifying the camera technology by employing it in a range of scientifically-motivated laboratory and microgravity experiments, focused on icy-grain aggregation relevant to planet-formation processes, exploiting existing experimental set-ups at the academic partner (OU).

*The major technological outcome* of the studentship will be to demonstrate that 3D motion tracking of an ensemble of icy particles undergoing aggregating collisions in simulated planet-forming environments can be performed using a single light-field camera operating in video mode, concurrently addressing our scientific outcome; to enhance our empirical understanding
of the processes that dominate the earliest stages of exoplanets, exomoon and exocomet formation.

References:


Qualifications required: MPhys significant experimental project work / research projects / internships in image technology / signals processing preferred. May suit Engineering students as much as those with a strong Physics background.