# Spotting Ice! (SPICE): infrared light-field tracking of icy particles

**A STFC CASE+ Studentship with Dynamic Imaging Analytics Ltd (DIAL)**

**Supervision team:** Dr Helen Jane Fraser & Dr David Hall (Open University)

**External supervisor:** Dr Neil Murray (DIAL)

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

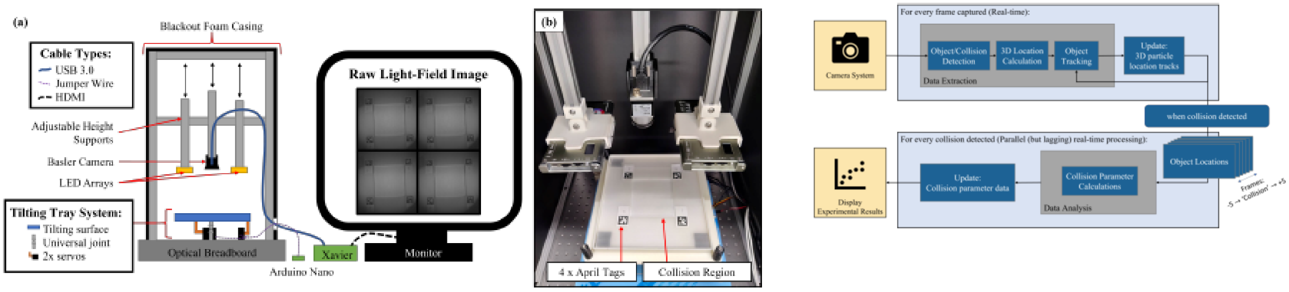


**Figure:** Conceptual set-up and operation of the light-field motion tracking system at the OU, in the calibration rig (a) schematic of the calibration rig with variable lights, camera and motion systems, to enable us to test the tracking of sub 5mm marble on a continuous motion surface, with an example multi-lens image; (b) photo of the same set-up showing the April tags used for tracking and frame alignment and a top view of the collision region; (c) schematic showing the development from single frame light-field images to tracking algorithms. This PhD will develop this system from visible monochromatic to hyper-spectral infrared sensors to detect and track icy particles.

## Project highlights:

- Fully funded STFC CASE+ studentship working directly between the Open University and industry (DIAL) to address technology challenges facing imaging and particle tracking in today's space and astronomy research, with an enhanced stipend, industrial training and placements, and the potential for a 12-month industrial role within DIAL post-PhD.
- Technology development applicable to space and wider industrial applications.
- Technology applied to research problems in astronomy and space science, specifically address the question of how icy grains aggregate during planet formation.

## Project description:

The overarching aim of our research is to study the structure and behaviour of the dusty and icy material that dominates the space environments where stars and planets form. In particular, we are interested to understand how ice particles collide, stick, aggregate and grow, since these are the first stages of planet formation. The challenge is that our icy particles are often very small (about the same diameter as the width of a human hair), and moving very slowly (relatively speaking just a few centimetres per second – which if you were swimming at the same pace would mean it could take you 45 minutes or more to swim one length of a 25 m swimming pool!!). At this velocity, particles are influenced by gravity on Earth, and that makes it difficult to collide them together, so typically we conduct these experiments in microgravity. To complicate matters further the type of ice that dominates in space is not like an ice cube from a fridge, but more like a fluffy sponge - it's amorphous ice.

So to be able to study such systems we combine constraints determined from observations from world-class telescopes with laboratory experiments, first conducted on Earth but then conducted on parabolic flights, or sub-orbital flights, to study icy grain aggregation. These experiments combine many techniques - but the dominant one is ultra-fast camera technology - much like the images you may have seen of slow-mo crash-test dummy images - we do the same - take multiple images (a video) of our particles colliding to work out what happens to them.

And although this studentship is motivated by a science research question (how planetary seeds form in discs around newly forming stars, especially at the snow line), what we really need is increasingly more sophisticated camera technologies to elucidate the collision outcome processes. So-called light-field tracking enables us to identify the exact positions (locations in space) and velocities of our particles during the experiments. But it turns out ice is not very easy to spot. So, the aim of this proposal is to develop hyper-spectral infrared camera technology - where instead of looking for the icy grains with visible light, we will look at them at a variety of infrared wavelengths (up to 4 filters) where ice has spectral features specifically associated with water. The PhD candidate will develop a camera, test it in our particle colliding experiments, and therefore be able to identify between icy and dusty grains, and potentially between amorphous and crystalline ices too during the collision processes.

The development of hyper spectral light-filed tracking camera technology will greatly benefit our research and enable us to study more complex systems and feed data back to the astronomy and space science community, but a hyper spectral light-field tracking IR camera has the potential to be a more widely applicable technology. Think of those areas like transport and food manufacture where ice play an important role in health and safety. This project is reliant on the unique partnership between the OU (academia) and DIAL, an SME with patents and expertise in camera technologies. Without this partnership, the proposed technology development, and its testing in a research environment, could not be realised, and would not lead on to applications beyond astronomy.

**References:**


1. Daly, Ellen C.; Murray, Neil J.; Evagora, Anthony M.; Fraser, Helen J. (2023). Development of light-field motion tracking technology for use in laboratory studies of planet formation. In: *Proceedings SPIE 12571. Real-time Processing of Image, Depth and Video Information 2023*, SPIE, article no. 1257108. DOI: https://doi.org/10.1117/12.2664938
2. Murray N, Evagora A, Murray S, Barber S, Mortimer J and Martin D (2020). Samcam for the ESA prospect lunar volatiles prospecting package; and a new family of 3D multispectral cameras for space exploration. In: *51st Annual Lunar and Planetary Science Conference (2326) 1918 (2020).*


**Requirements:** Candidates for this PhD should have a strong academic record in Physics or Engineering or Space Science, evidenced by a MSc, Masters or MEng at 2:1 or above, with some research project experience included in the study. International candidates should send confirmation with their application of their IETLS scores. It would be an advantage (but not necessary) to have laboratory experience with some of the following: optics, photonics, image sensors and filters, particularly in the IR, video systems, vacuum, temperature control and mechanical pistons. Programming with Matlab, Python, and / or Jetson Xavier processors would also be an advantage (though not necessary).