

**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 Paul McMillan ([paul.mcmillan@astro.lu.se](mailto:paul.mcmillan@astro.lu.se));

**Project Title: The disturbances of the outer Milky Way**

**Project Description**

Like most disc galaxies, the Milky Way’s disc is not flat: it has a significant warp, with one side rising above the plane of the disc by at least a kiloparsec, and the other dipping below it by a similar amount. Why so many galaxies are warped remains unknown. Moreover, we have recently discovered that the Milky Way’s warp does not behave as models predict that warps should – it is precessing at a high speed in the same direction that the galaxy rotates, while theory predicts that it should precess slowly in the opposite direction.

This is not the only disturbance seen in the Milky Way’s disc. Near the beginning of the warp, the velocity distribution of the stars is broken into two components. Nearer the Sun, the stars have been disturbed such that when we plot their vertical height above the plane against their vertical velocity, a clear spiral stands out, which persists but changes in character as we look at other nearby parts of the Galaxy. Note that the timescales on which stars’ orbits change are millions of years, so we are inferring everything from the observed current positions and velocities of stars.

These discoveries were only possible because of the incredible data from the European Space Agency’s *Gaia* mission, publicly released over the last 5 years (with further releases to come). *Gaia* is mapping the positions and velocities of almost two billion stars in the Milky Way with ever-increasing precision, 100 times more precisely than they were ever before measured. The Milky Way is, by far, the galaxy that we can observe in the greatest detail, and our understanding of the Milky Way has come on leaps and bounds with this new data, as we see the structure of the Galaxy in focus for the first time. We find ourselves in the same situation as biologists when microscopes were able to resolve individual cells, but they lacked the theory to explain how these all fit together as the building blocks of plants and animals. In our case, we are, for example, left to ask: are all these disturbances in the Milky Way due to a single event, or are we seeing the consequences of multiple events?

There are plausible candidates in either case. The Sagittarius dwarf galaxy is currently being torn apart by the Milky Way, but may in the past have been heavy enough to dramatically shake the disc. To date this has been the favoured theory for most of this behaviour. However, it is possible that the nearby Large Magellanic Cloud may have had an important tidal influence on the Milky Way’s disc, and even that so-called ‘dark-matter subhaloes’ (i.e., gravitationally bound structures made purely of dark matter) passing through the Galactic disc cause some of what we have seen.

In this project the student will make and analyse dynamical models of galaxies like the Milky Way in an effort to understand the links between what we are seeing in the different parts of the Galaxy. Naïve models of the disturbance seen in-and-around the Solar neighbourhood appear to give mutually contradictory results for different regions. The project will try to understand if this is because the models deal with the disc dynamics in too simplistic a way or because they assume a single disturbance.

The student will use cutting-edge dynamical modelling approaches and learn data analysis techniques to compare their results with what we can see of the Milky Way in *Gaia* data. This will involve working with existing software as well as creating their own programmes. These will be used to better understand the history of our own galaxy and, ultimately, the processes that shape all galaxies.

**References:**

Poggio, E., et al. (2020). “Evidence of a dynamically evolving Galactic warp.” Nature Astronomy 4: 590.

McMillan, P., et al. (2022). “The disturbed outer Milky Way disc”, Monthly Notices of the Royal Astronomical Society, 516, 4988.

Tremaine, S., et al. (2023). “The origin and fate of the Gaia phase-space snail”, Monthly Notices of the Royal Astronomical Society, 521, 114.

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.