**University of Leicester Future 100 PhD Scholarship**

**Project Reference: PHYS-Rosotti**

**Section 1 – *Supervisor Information***

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| **First Supervisor**  | Dr Giovanni Rosotti |
| **School/Department** | Physics & Astronomy |
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| **Proposed Second Supervisor** | Prof. Richard Alexander |

**Section 2 – *Project Information***

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| **Project Title** | Characterising turbulence and accretion mechanisms in proto-planetary discs |
| **Project Highlights:** | 1. | Use different techniques in comparison with new telescope data of exquisite quality to characterise the level of turbulence in proto-planetary discs |
| 2. | Build synthetic proto-planetary disc populations to compare with observational data |
| 3. | Work as a member of two different international collaborations and interact with scientist from all over the world |
| **Project Overview** |
| Proto-planetary discs are structures composed of dust and gas rotating around young stars – it is in these very discs that planets are formed. To understand how planets form, therefore, it is necessary to understand physical mechanisms operating in discs. The least understood mechanism is turbulence, which theoretically is expected to affect myriads of other processes: among others, the way planets grow and migrate. If present, turbulence is the reason these discs accrete mass onto the star, but an alternative paradigm is emerging in which accretion is instead driven by winds launched by the magnetic field. While characterising turbulence in discs is a long-standing problem, we now finally have access to data from the radio-telescope ALMA in Chile that can shed light on this problem. The goal of the project is to use the best observations now available to characterise and measure the level of turbulence in discs. The supervisor is part of two international collaborations, AGE-PRO and exoALMA, that were recently awarded large allocations on ALMA (100 and 150hr, respectively). Specifically: a) Constraining how discs accrete is the primary goal of AGE-PRO – it will do this by measuring for the first time disc radii in gas tracers for a large sample across different ages. The more turbulent discs are, the faster they are expected to become larger and the observational sample can therefore be used to measure turbulence. In the alternative wind scenario, discs would instead shrink with time – this can also be tested against the observations. To account for other effects such as the diversity in initial conditions the measurement will require a comparison with synthetic disc populations. The student will be part of a core modelling team constructing these populations. b) On the other hand, exoALMA will measure with unprecedented precision the velocity of the gas in these discs – while the primary goal is using this information to find forming planets, the supervisor recently showed that the information can also be used to measure turbulence reconstructing small-scale variations in the gas. We will explore these and other avenues to place the strongest constraints yet on disc turbulence. |
| **Methodology**  |
| This is a project at the interface between theory and observations. Part a) will require the development of a numerical tool to construct synthetic discs populations, significantly extending and perfecting preliminary versions written by the supervisor. During the project we will also generate simulated observations from these synthetic populations (part a) and from other disc models (part b), using existing radiative transfer codes. We will analyse these simulated observations as they were real data in order to quantify how well we can measure turbulence and other parameters. The benefit of large collaborations is that we will be provided with high-quality, reduced data and therefore we will not have to deal with the technicalities of taking and reducing observational data, but the student will nevertheless have to acquire some familiarity with handling astronomical images. Most of the coding for the project (for both parts) will use the Python language, one of the most used programming languages in the coding industry – previous knowledge is highly desired although not essential, and the student will acquire significant experience in Python by the end of the PhD. An example of the methods and science of the project can be found in these references:1. Observed sizes of planet-forming disks trace viscous spreading - <https://ui.adsabs.harvard.edu/abs/2020A%26A...640A...5T/abstract>
2. The efficiency of dust trapping in ringed protoplanetary discs - <https://ui.adsabs.harvard.edu/abs/2020MNRAS.495..173R/abstract>
3. Secular evolution of MHD wind-driven discs: analytical solutions in the expanded α-framework - <https://ui.adsabs.harvard.edu/abs/2021MNRAS.tmp.3115T/abstract>
4. Effect of MHD wind-driven disk evolution on the observed sizes of protoplanetary disks - <https://ui.adsabs.harvard.edu/abs/2021arXiv211200645T/abstract>
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