**Dense polydisperse suspensions – a matter of complexity**

*Dr John Royer and Dr Chris Ness (both University of Edinburgh)*

Suspensions are ubiquitous in nature and industry, and their flow is notoriously challenging. Thanks to simulations and experiments carried out in Edinburgh, we now have a good understanding of the flow of suspensions comprising roughly monosized particles, but most work to date does not address the thorny issue of polydispersity. Industrialists know that the behaviour of suspensions with realistic levels of polydispersity are *qualitatively* different to their quasi-monodisperse counterparts, and our recent work indicates that new physics likely arises from the jump in complexity [1]. This project aims to transform our understanding of polydisperse suspensions using particle-based simulations that interrogate microphysics inaccessible to experiments.

Dense suspensions of micron-sized (radius *a*) particles often shear thicken: the viscosity increases dramatically under small changes in flowrate. Recent work shows that this originates in particle contacts. When the applied stress σ exceeds an ‘onset’ value σ\*, overcoming a repulsive force F\*, frictional contacts occur, constraining sliding and leading to a viscosity increase. These findings have been encoded in a successful phenomenological model (for details see [1]) linking the viscosity to the fraction of frictional contacts. Despite its practical utility, the model utterly fails for polydisperse suspensions.

The difficulty is that σ\*∝*F\**/*a*2, so that in a *polydisperse* suspension one must distinguish contacts between species of different sizes *a* and stiffnesses *F\*/a*. Consequently, polydisperse suspensions exhibit broad spectra of contact-type-dependent σ\* values. Writing an analytical form for the viscosity thus requires knowledge of the statistics of all possible contact types. This rapidly becomes intractable for realistic suspensions. We will address this challenge using particle-based simulations, aiming ultimately to write a predictive constitutive model that properly incorporates the physics of polydispersity. The student is expected to make progress in fundamental physics with real practical relevance.

The student will gain expertise in several areas of physics, including contact tribology, rheology and fluid mechanics, will become proficient in coding, simulation, high-performance computing and data analysis, and may have an opportunity to plan and carry out experimental measurements. There may be an opportunity for a secondment to our industrial partner in the US.

[1] B. Guy, C. Ness, M. Hermes, L. Sawiak, J. Sun and W. Poon. Soft Matter 16(1), 229-237 [[**https://doi.org/10.1039/C9SM00041K**](https://doi.org/10.1039/C9SM00041K)]