Magnetic fluid suspensions in microgravity environments

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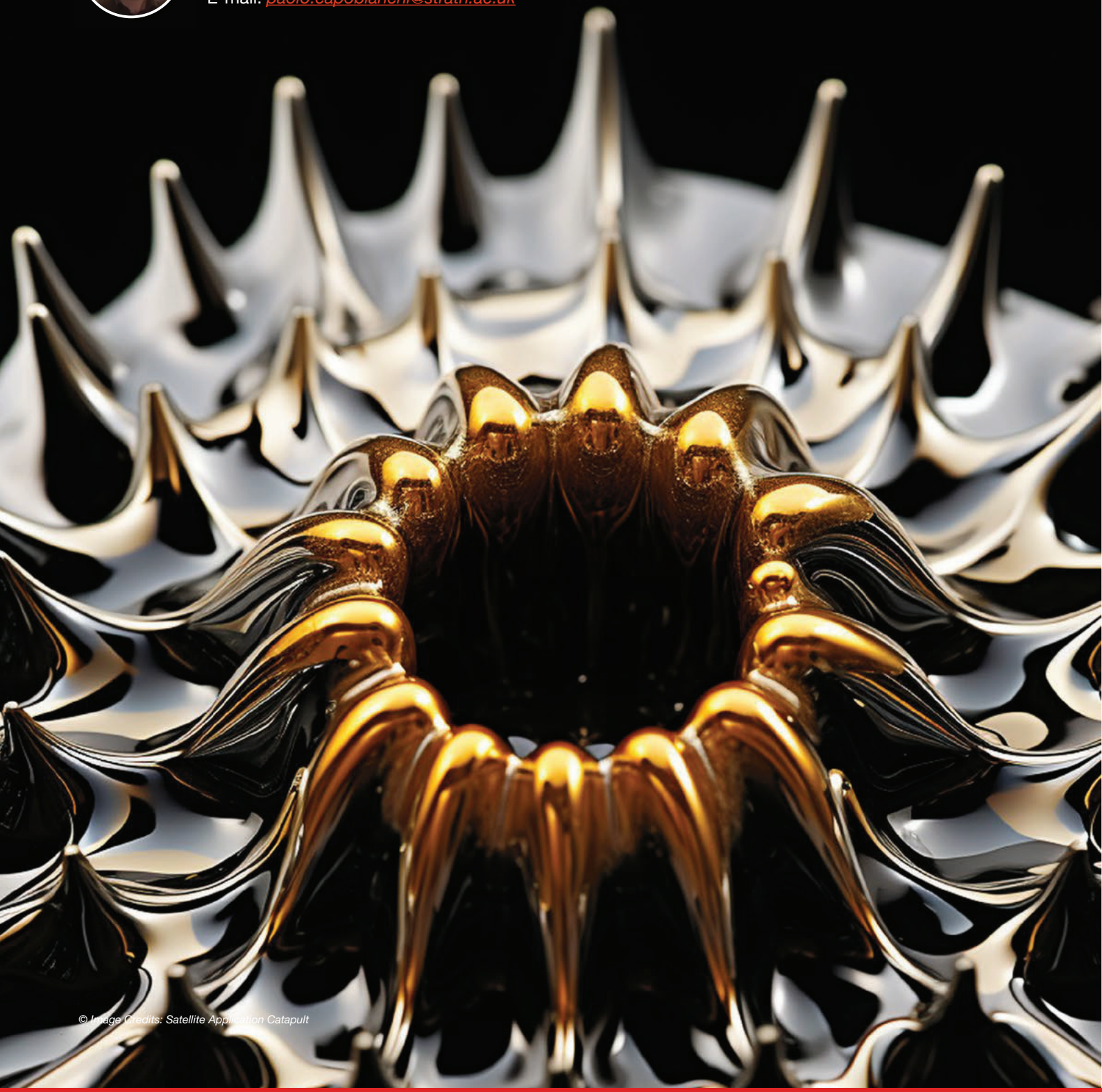

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Overview

Magnetic fluids such as magneto-rheological fluids and ferrofluids are a class of smart materials composed of magnetic particles dispersed in a conventional carrier liquid which find widespread use in many scientific and engineering problems. Recently, a range of new technological applications based of magnetic-amagnetic fluid pair systems exploiting the ability of the magnetic phase to target desired locations using magnetism for manipulation, transport and actuation guided by magnetic fields have appeared. While in the presence of micro-sized drops buoyancy is often negligible, at larger scales gravity becomes relevant and affects the dynamics of the system. Hence, a need has emerged to investigate the magnetic field-induced motion of large particles of magnetic fluids filtering out the effect of buoyancy through dedicated experiments in microgravity conditions.

Case Experience

In recent years, members of the James Weir Fluids Laboratory (JWFL) at the Department of Mechanical and Aerospace Engineering of the University of Strathclyde have started exploring systems constituted by ferrofluid drops surrounded by non-magnetisable liquids under the influence of magnetic fields [1,2]. It is well-known, in fact, that when a binary system of immiscible liquids, in which one phase is susceptible of magnetisation, is subjected to a magnetic field, a force appears at the interface. In the event of non-uniform magnetic fields, the force arising around a ferrofluid drop is uneven, and a net force propelling the drop arises. In order to investigate this mechanism in the absence of buoyancy and other gravitational effects, an experiment is being designed for execution on-board a parabolic flight or a sounding rocket. The experiment will consist of the observation of the motion of macro-sized ferrofluid drops subjected to a non-uniform magnetic field. A permanent magnet will be placed on one side of a container filled with a non-magnetisable liquid, while the ferrofluid drop is injected on the other side; the droplet motion will be recorded with a high-speed camera. The consideration of different drop sizes will allow the exploration of a wide range of conditions. These experiments might eventually be executed using the International Space Station if relevant calls or opportunities become available.

Opportunity for Research and Innovation

The magnetic field-induced motion of magnetic fluids droplets plays a crucial role in a variety of contexts of practical interest such as in lab-on-a-chip devices [3], microrobots technologies [4], in targeted drug delivery for cancer treatments and in electronic devices [5]. A comprehensive knowledge of the dynamics of these systems is therefore deemed necessary in many situations, and filtering out the effect of gravity provides ideal conditions for the investigation of the dynamics induced by the sole magnetic field. Owing to the multifaceted nature of the approach, and to the variety of conditions that will be considered, the study will provide a thorough understanding of the dynamics of magnetic fluids suspensions which will contribute to significant innovation in sectors relevant to mechanical, chemical, electronic, and biomedical engineering, with relevant repercussions on the growth of the UK's industrial assets.

References

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