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Sustained oscillations in crowded active matter

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Key words: active matter, dense fluids, collective motion, self-organised oscillations, chaotic mixing, disordered systems, non-equilibrium statistical physics, numerical simulations.

Scientific context and project description: The framework of statistical mechanics provides us the tools to build a theoretical understanding of equilibrium systems. However, the vast majority of systems are out of equilibrium (e.g. biological processes), where a comparable theoretical framework is lacking. Supporting the general scientific aim to understand living systems, the field of active matter physics concentrates on unveiling the role of systematic motion that is at the heart of life's complexity. Going beyond thermal diffusion, life relies on the ability of agents on all scales (from molecular motors inside cells to entire organisms) to move autonomously in a systematic fashion.

Lacking a general theoretical framework, numerical studies are essential in the field of active matter. Intense focus has been on minimal models leaving important gaps on the baffling collective phenomena emerging when persistent particle motion competes with crowding at high densities. Only this year [1] turbulent-like collective motion has been reported in this regime that strikingly resembles the chaotic advective flows observed in dense bacteria or tissues [2, 3].

Under certain conditions, dense active systems can also feature sustained oscillations as for example observed in tissues and dense human crowds [4, 5]. The internship aims at unveiling the minimal ingredients required to observe oscillating flows in the standard models of dense active matter through numerical simulations.

Desired profile of the intern: We are looking for a student with a strong background in numerical simulations (Python, C++, etc.) and a solid knowledge in statistical mechanics. Extending the project to a PhD thesis requires applying for additional funding.

References

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