Chirality landscape in mixtures of active spinners

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In our work we study the fundamental properties of the dynamics in a binary mixture of active 3D-printed spinners. We have fabricated two sets of rotors provided with blades, these two sets are identical except for the fact that they have opposite natural spins (due to inverse blade tilt angles). The system is fluidized by a tunable air flow one clockwise, in this way, particles are provided with continuous rotation, so that one species spins clockwise (CW) and the other counter-clockwise (CCW). Moreover, turbulent streamlines generated by the upflow past the disks also provide them with Brownian-like translational motion [1].

Fig. 1. Picture of two 3D-printed particles, the natural spinning direction is indicated with arrows. We have printed them in different colors to tell them apart with our computer-vision tracking algorithms.

We performed a set of experiments with varying molar fractions of each component, at constant global density. As the first panel in Figure 2 shows, the trend of fluid vorticity vs. translational kinetic energy is opposite for each species, this confirming that fluid chirality is closely related to particle dynamical asymmetries (chirality), here substantiated by particle spin. Moreover, in close analogy with the mono-component system, we found that the system typically undergoes a regime with a complex and unstable mixture of multiple chiral vortexes as relative density approaches $1/2$. When the system achieves this kind of state, global vorticity approaches zero and the fluid flow appears as non-chiral [1]. This is very relevant since it demonstrates that a fluid of chiral particles does not necessarily develop a chiral flow.

More interestingly, a phase diagram of global vorticity vs. average kinetic energy and relative particle density shows that this kind of null global vorticity states occupy significant areas of the parameter space, as shown in the second panel of Figure 2.

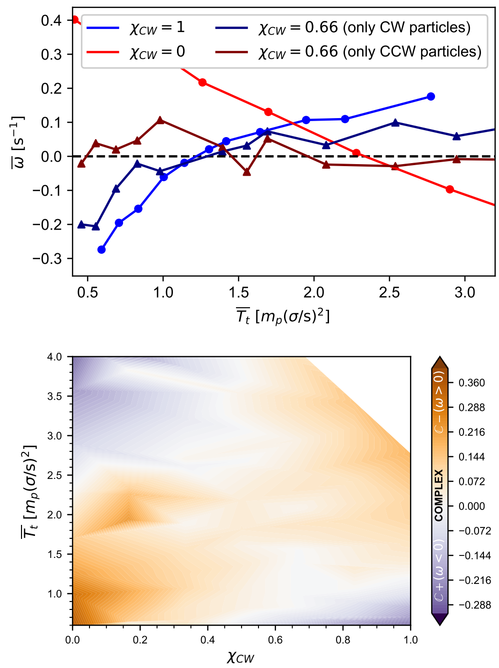

Fig. 2. First panel shows the chirality transition for the two monodisperse cases plus another set of experiments with $2/3$ of the particles having a natural CW spin and $1/3$ CCW; in that case, vorticity can be calculated for each species, displaying a different slope. The second panel is the chirality phase map. The sense of chiral motion (sign of $\overline{\omega}$) is indicated by a color gradient, orange means CW global motion ($\overline{\omega} > 0$), white, $\overline{\omega} = 0$, being the complex phase and purple meaning CCW motion. The y-axis represents mean kinetic energy (controlled by the air flow velocity) and χ_{CW} is the molar fraction of disks with CW natural spin: $\chi_{\rm CW} = N_{\rm CW}/N$

In our presentation, we will analyze in more detail this and other aspects of this system, such as mixing and segregation conditions.

[1] López-Castao, M. A., Seco, A. M., Seco, A. M., Rodríguez-Rivas, ., & Reyes, F. V. (2021). Chirality transitions in a system of active flat spinners. Retrieved from http://arxiv.org/abs/2105.02850