Fast angular velocity measurement algorithm and the correlations in a quiral fluid of active flat spinners

Miguel Ángel López-Castaño[1], Alejandro Márquez Seco[1], Alicia Márquez Seco[1], Álvaro Rodríguez-Rivas[2] and Francisco Vega Reyes[1]

[1]Departamento de Física and Instituto de Computación Científica Avanzada (ICCAEx), Universidad de Extremadura, 06071, Badajoz, Spain

[2]Departament of Physical, Chemical and Natural System, Pablo de Olavide University, 41013, Sevilla, Spain

The dynamics of chiral fluids is an emergent research field and recently our group have been displayed some relevant aspects of chiral fluids dynamics [1]. Faced with the need to understand the dynamics of these interesting fluids, we present a new technique developed by our group to carrie out the study of autocorrelations data on disk-shaped rotor systems with a high rotational speed[2].

Our experimental set-up consists in a confined system of 2D active rotors, driven by a turbulent air flow impacting from below. The experiments have been carried out at a varied range of translational kinetic energies $\bar{T}_t$ and packing fractions. To analyze the trajectories recorded by a high-speed camera, we have develop a *particle tracking velocimetry* (PTV) algorithm, based on the analysis of the particles brightness profiles from a set of digital images. An advantage of this technique has allowed us to obtain some autocorrelation function with very high accuracy.

We have studied the spin velocity field $\Omega(r) = \langle w \rangle$, and its spatial average, $\bar{\Omega} = \langle \Omega(r) \rangle_r$, where r is the distance to the center of the set-up. We see that there are two different regimes for all packing fractions: when the thermalization is low $\bar{T}_t$, the field $|\Omega(r)|$ increases monotonically versus r, and attains its maximum value at the system boundaries. However, at higher $\bar{T}_t$, particle spin profile flattens, displaying a nearly constant value across all radii, and this value is found to be proportional to $\bar{T}_t$.

We have also studied the traslational correlation fuction and the temporal ensemble spin autocorrelation function, both are dynamic properties of great interest. The latter is shown in Fig.1, by measuring the peculiar spin velocity, and the outcome of the new algorithm allows us to observe the oscillations of the autocorrelation in its high intrinsic frequency, as well as the long-term relaxation. Interesting, it is the relaxation time exchange between the external and internal regions, observed when the translational kinetic energy is increased. Process related to the changes of sign of the global vorticity[1].

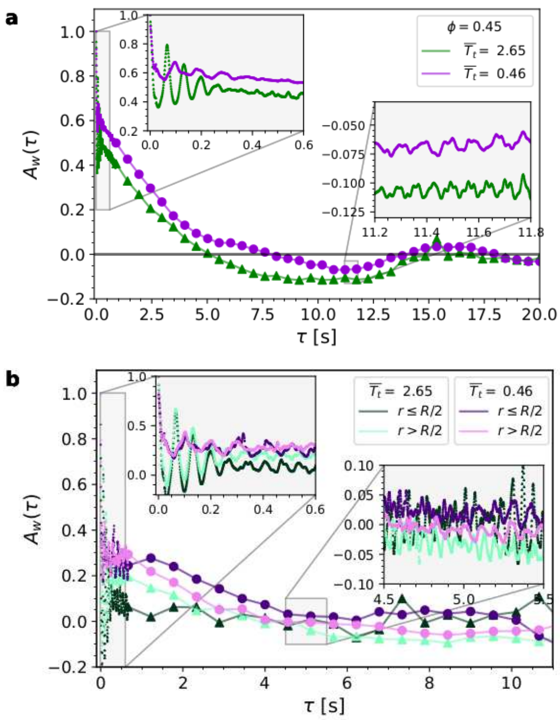

Fig. 1. (a) Spin autocorrelation function, it measures the degree of similarity between angular velocity for a single particle at two instants separated by a period τ. We compare two cases with the same density but different traslational kinetic energies ($\bar{T}_t$ in units of $m\sigma^2 s^{-2}$). (b) Our results demonstrate that spin autocorrelation is different inside the system with respect to the outer edge and that this behavior is reversed when thermalization varies, confirming a change in the total chirality observed in the system.

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[1] M. Á. López-Castaño, A. Márquez-Seco, A. Márquez-Seco, Á. Rodríguez-Rivas and F. Vega Reyes (2021), *Chirality transitions in a system of active flat spinners*. Preprint: arXiv:2105.02850

[2] M. Á. López-Castaño, A. Márquez-Seco, A. Márquez-Seco, Á. Rodríguez-Rivas and F. Vega Reyes (2021), *Fast measurement of angular velocity in air-driven flat rotors with periodical features*. Preprint: arXiv:2107.14186