Controlling Inter-Particle Distances in Crowds of Motile, Cognitive, Active Particles

Rajendra Singh Negi,[1,*] Priyanka Iyer,[1,†] and Gerhard Gompper[1,‡]

[1] *Theoretical Physics of Living Matter, Institute of Biological Information Processing and Institute of Advanced Simulation, Forschungszentrum Jülich, 52425 Jülich, Germany*

S-I. EXPOSURE TIME

Figure S1 illustrates the dependence of the scaled average exposure time $T_m Pe$ on the dimensionless ratio Pe^{β}/Ω for particle density $\Phi = 0.5625$. The relationship is investigated for vision angles $\theta = \pi$, $\pi/2$, and $\pi/4$. The exponent β is determined by achieving a good data collapse for various Pe and Ω, which is dependent on the vision angle. Specifically, $\beta = 1$ when $\theta = \pi$, $\beta = 2$ when $\theta = \pi/2$, and $\beta = -1/4$ when $\theta = \pi/4$. Here again, the scaled exposure time becomes nearly independent of particle density or vision angle for $Pe^{\beta}/\Omega \gtrsim 1$, with $T_m Pe = A$.. This behavior is similar at lower density (see main text Sec III-B).

S-II. EFFECTIVE DIFFUSION CONSTANT

We extracted the effective long-time diffusion constant at higher density $\Phi = 0.625$. Figure S2 show the effective diffusion D_0 as function of maneuverability Ω. We observed a similar trend as we get at lower density (see main text III-C). For systems with a vision angle of $\theta = \pi$, we observe a remarkable convergence of data points across various Pe values. As $1/\Omega$ decreases, the effective diffusion coefficient scales as $D_0/P_e^2 \sim 1/\Omega$, leading to a universal behavior where $D_0 \sim Pe^2/\Omega$, specifically, $D_{\rm eff} \sim v_0^2/C_0$, independent of rotational diffusion. In contrast, data points for a vision angle of $\theta = \pi/2$ exhibit significant scattering for $1/\Omega \lesssim 0.3$, and no discernible scaling behavior emerges. For lower values of maneuverabilities the values saturates to $2D_R$ which is the ABP limit.

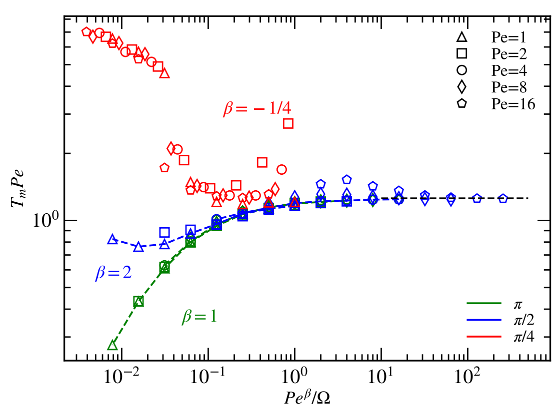

FIG. S1. Scaled average exposure time, $T_m Pe$, during which particles remain close to each other within a vicinity of radius R_0 uninterruptedly, for various Péclet numbers (Pe), as indicated. $\Phi = 0.625$.

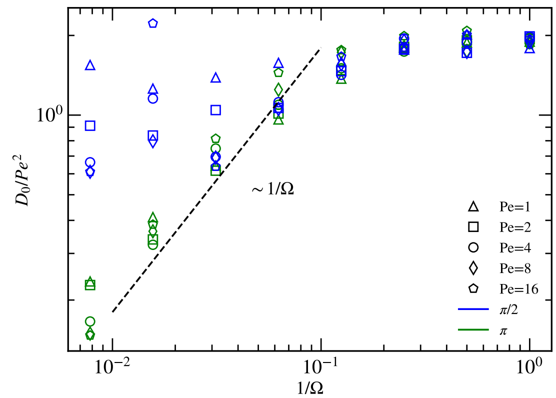

FIG. S2. Effective long-time diffusion constant extracted from the MSD at various indicated Pe for particle densities $\Phi = 0.625$.

S-III. MOVIE CAPTIONS

Movie M1: The dynamics of "overcautious distancing" regime particles at $Pe = 4$, maneuverability $\Omega = 128$, $\Phi = 0.25$, and vision angle π. The trajectory of one particle is shown.

Movie M2: The dynamics of particles in "wiggling and squirming" regime at $Pe = 4$, $\Omega = 16$, $\Phi = 0.25$, and vision angle $\pi/2$.

Movie M3: Band like motion of particles at particle density $\Phi = 0.5625$, $Pe = 4$, $\Omega = 128$, and vision angle $\pi/4$.

Movie M4: Band-like structures look like ordered strips of particles at particle density $\Phi = 2.5$, $Pe = 4$, $\Omega = 128$, and vision angle $\pi/4$.

* r.negi@fz-juelich.de

† p.iyer@fz-juelich.de

‡ g.gompper@fz-juelich.de