Seminar of SFB 910

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"Brownian molecules formed by delayed harmonic interactions"

A time-delayed response of individual living organisms to information exchange within flocks or swarms leads to the formation of complex collective behaviors. A recent experimental setup by Khadka et al. [1] employing synthetic microswimmers, allows to realize and study such behavior in a controlled way, in the lab. Motivated by these experiments, we study a system of N Brownian particles interacting via a retarded harmonic interaction. For $N \leq 3$, we characterize its collective behavior analytically via linear stochastic delay-differential equations, and for $N > 3$ by Brownian dynamics simulations. The particles form nonequilibrium molecule-like structures which become unstable with increasing number of particles, delay time, and interaction strength. We evaluate the entropy fluxes in the system and develop an approximate time-dependent transition-state theory to characterize transitions between different isomers of the molecules. We also discuss how our results change when the time delayed control is not continuous but rather piece-wise constant in time as in the real world experiments.

[1] U. Khadka et al., Nat. Commun. 9 3864 (2018)
[2] D. Geiss, K. Kroy, and V. Holubec, New J. Phys., 21, 093014 (2019)

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