Title: Transport and self-assembly of active particles with optimal fuel consumption

Abstract: The study of the individual and collective behavior of self-propelled particles, which convert the chemical energy of the surrounding fluid into mechanical energy, is fundamental to understanding the out-of-equilibrium nature of active matter of which many biological and soft matter systems are composed. What is the energetic cost of structure formation, how to optimize fuel consumption and what are the mechanisms that lead to the formation of self-assembled structures and instabilities are problems of current interest.

We have analyzed the active particle self-assembly process by means of a multiscale stochastic model that considers the dynamics of the particles self-consistently coupled to the fuel concentration evolution equation, initially considered inhomogeneous. The proposed model allows to identify the different aggregation regimes and to calculate the energetic cost of structure formation. The analysis of the free energy of the particles leads us to establish a thermodynamic criterion of structure formation based on the behavior of the chemical potential as a function of the fraction of particles assembled. The study is extended to the case where hydrodynamic interactions take place. Periodic fuel injection into a cell containing active particles shows the existence of a resonant regime in which particle transport is amplified with minimum fuel consumption.

J. Miguel Rubi
Departament de Fisica de la Matèria Condensada, Universitat de Barcelona