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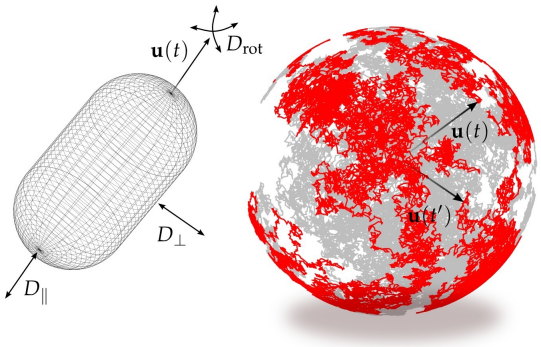
Spatio-temporal dynamics of a single active particle

The active Brownian particle (ABP) model has become a paradigm for dynamics far from equilibrium and has attracted considerable attention in the statistical-physics/soft-matter community [1]. In this model particles undergo directed motion along their axis of orientation which is subject to orientational diffusion. While it is rather easy to simulate the dynamics of such agents in a prescribed potential landscape, analytical progress even for the simplest set-ups has been difficult. In the presentation I will present exact solutions for the spatio-temperaol dynamics for three paradigmatic problems: the free particle [2,3], the motion in a uniform gravitational field as described by the equations of motion of Ref. [4], as well as the dynamics in a harmonic well. For each case we derive the corresponding Fokker-Planck equation and use techniques familiar from quantum mechanics to provide a complete solution. Each of the three examples displays striking differences from the their passive counterparts, such as oscillatory behavior in the intermediate scattering functions, the emergence of a resonance in the effective diffusion coefficient or non-monotonic behavior in the velocity-autocorrelation function.



[1] Clemens Bechinger, Roberto Di Leonardo, Hartmut Löwen, Charles Reichhardt, Giorgio Volpe, and Giovanni Volpe, Active particles in complex and crowded environments, Rev. Mod. Phys. 88, 045006 (2016).

[2] C. Kurzthaler, S. Leitmann, and T. Franosch, Intermediate scattering function of an anisotropic active Brownian particle, Scientific Reports 6, 36702 (2016).

[3] C. Kurzthaler, C. Devailly, J. Arlt, T. Franosch, W. C. K. Poon, V. A. Martinez, and A. T. Brown, Probing the spatiotemporal dynamics of catalytic janus particles with single-particle tracking and differential dynamic microscopy, Physical Review Letters 121, 078001 (2018).

[4] B. ten Hagen, F. Kümmel, R. Wittkowski, D. Takagi, H. Löwen, and C. Bechinger, Gravitaxis of asymmetric self-propelled colloidal particles, Nature Communications 5, 4829 (2014).