Brownian gyrators: from mono- to quadrupolar gyration

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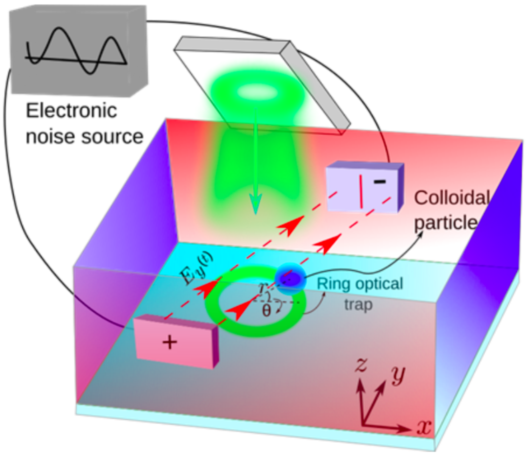
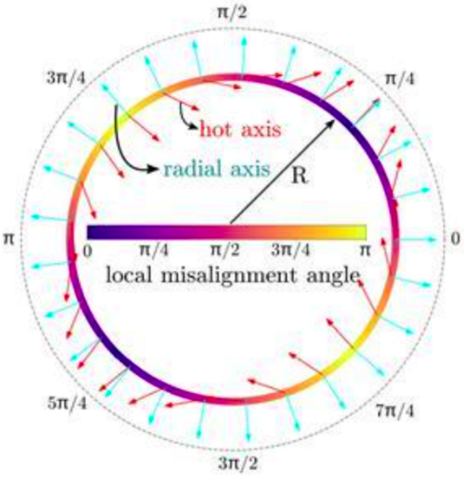
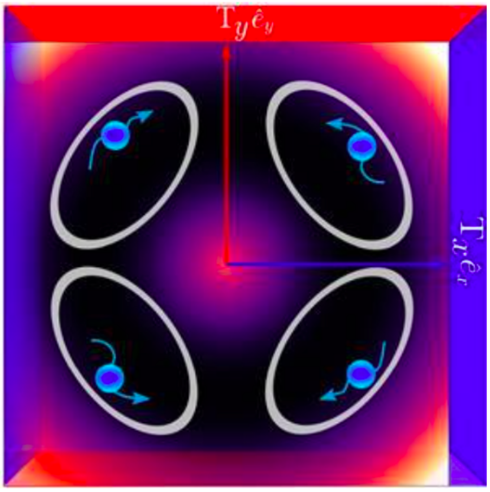
Thermally anisotropic Brownian systems-where different spatial directions are coupled to different effective temperatures-break detailed balance and generate circulating probability currents, exemplified by the Brownian gyrator. Such systems provide a minimal framework for studying nonequilibrium energy conversion and the emergence of directed motion and torques driven purely by fluctuations. We demonstrate how these anisotropic fluctuations can be harnessed as a microscopic heat engine, whose efficiency can approach Carnot performance at maximum power when appropriately loaded with external mechanical forces [1]. Furthermore, we show that confining a thermally anisotropic particle to a narrow ring produces quadrupolar steady-state gyration, a symmetry-protected circulation pattern arising solely from anisotropic noise [2]. These results highlight the rich flux structures and energetic functionalities enabled by thermal anisotropy.







References:

[1] I Abdoli, A Sharma, H Löwen, Phys. Fluids. 37 (4)

[2] I Abdoli, H Löwen, npj Soft Matter 2, 5, (2026)