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Diffusive transport in corrugated channels

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Diffusive transport of particles or, more generally, small objects, is an ubiquitous feature of physical and chemical reaction systems. In configurations containing confining walls or constrictions, transport is controlled by both, the fluctuation statistics of the jittering objects and the phase space available for their dynamics. Consequently, the study of transport at the macro- and nano-scales must address both Brownian motion and entropic effects.

For particles undergoing biased diffusion in static media enclosed by confining geometries, transport exhibits intriguing features [1] such as 1) a decrease in nonlinear mobility with increasing temperature or 2) a broad excess peak of the effective diffusion above the free diffusion limit. These paradoxical aspects can be understood in terms of entropic contributions resulting from the restricted dynamics in phase space. If, in addition, the suspension medium is subjected to external, time-dependent forcing, rectification or particle separation becomes possible [2].

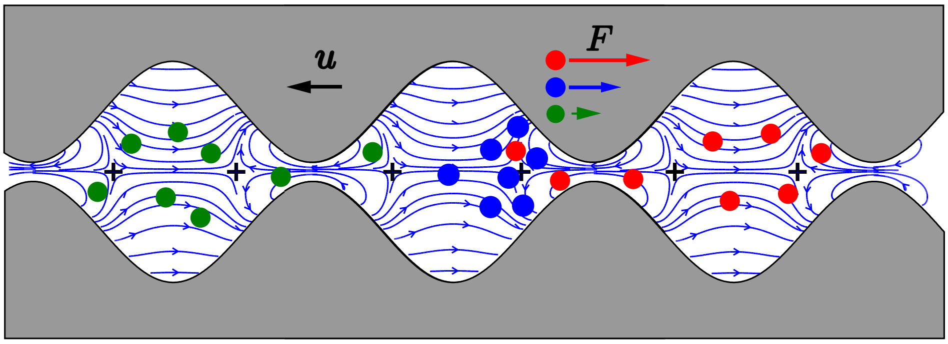

Figure 1: The competitive action of the constant force F and the pressure-driven fluid flow u in microchannels with periodically corrugated walls yields an effective entropic force field (blue lines) exhibiting characteristic stagnation points (black crosses). As the particles' properties determine the strength of the force F, separation of Brownian particles is achieved: While some particles (blues circles) are trapped, other particles are gradually sifted out to the left (green circles) and to the right (red circles).

In presence of a fluid flow across the microfluidic channel (see sketch), where a solute of Brownian particles is subjected to an external bias and a pressure-driven flow, a new phenomenon emerges [3]: namely, the identically vanishing of the average particle flow which in turn is accompanied by a colossal suppression of diffusion. This entropy-induced phenomenon, termed hydrodynamically enforced entropic trapping, offers the unique opportunity to separate particles of the same size in a tunable manner.

References

[1] P.S. Burada, P. Hänggi, F. Marchesoni, G. Schmid, P. Talkner: *Diffusion in confined geometries*. ChemPhysChem **10**, 45–54 (2009)

[2] D. Reguera, A. Luque, P.S. Burada, G. Schmid, J.M. Rubi, P. Hänggi: *Entropic splitter for particle separation*. Phys. Rev. Lett. **108**, 020604 (2012)

[3] S. Martens, A. Straube, G. Schmid, L. Schimansky-Geier, P. Hänggi: *Hydrodynamically enforced entropic trapping of Brownian particles*. Phys. Rev. Lett. **110**, 010601 (2013)