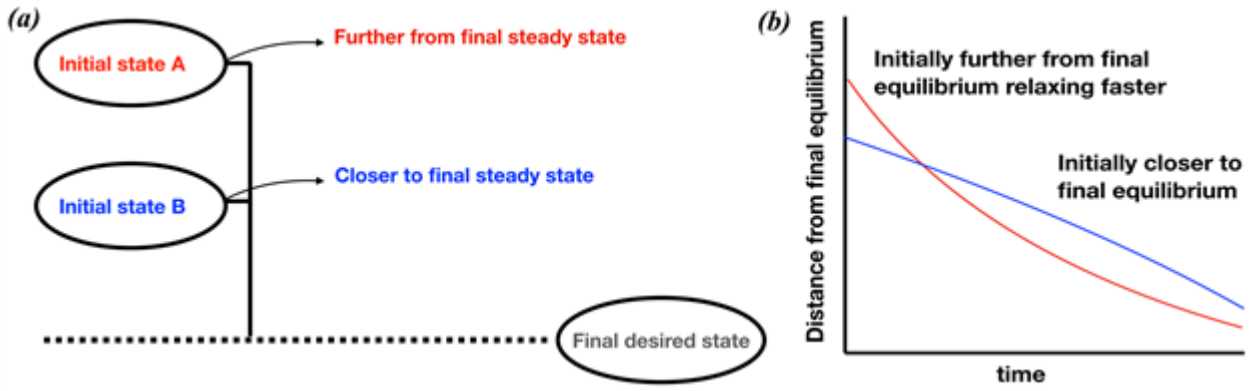
Mpemba effect in granular and Langevin systems

Apurba Biswas[1], V. V. Prasad[2], Arnab Pal[1], R. Rajesh[1]
[1]*The Institute Of Mathematical Sciences, CHENNAI, India,* [2]*Cochin University of Science and Technology, Cochin, India*

The Mpemba effect is a counter-intuitive relaxation phenomenon in which a hotter system equilibrates faster than a colder system when both systems are quenched to the same low temperature. The effect was first discovered in the case of water [1], where it is described in terms of freezing times. However, the effect is more general and can be studied in the context of quenched relaxation dynamics of generic physical systems [2, 3]. In this talk, we describe the Mpemba effect in driven granular gases [4, 5, 6], an example of an interacting many-particle nonequilibrium system, as well as a single-particle setup of a colloidal Langevin system [8]. Both these examples allow for a strong interplay between theory and experiment. An exact analysis determining the criteria for the Mpemba effect in both systems will be presented. For granular systems, we trace the cause of the Mpemba effect to anisotropy in the kinetic energies while for Langevin systems, it is the presence of metastable states in the energy landscape. In addition, we also analyze the effect of using different measures for specifying the distance from the steady state in the study of anomalous relaxation phenomena [7].



References

[1] E. B. Mpemba, D. G. Osborne: Cool? Phys. Educat., 4(3), 172–175 (1969).
[2] Z. Lu, O. Raz, Nonequilibrium thermodynamics of the Markovian Mpemba effect and its inverse, Proc. Natl. Acad. Sci. USA, 114(20), 5083–5088 (2017).
[3] A. Kumar, J. Bechhoefer, Exponentially faster cooling in a colloidal system, Nature, 584(7819), 64–68 (2020).
[4] A. Biswas, V. V. Prasad, O. Raz, R. Rajesh: Mpemba effect in driven granular Maxwell gases, Phys. Rev. E, 102, 012906 (2020).
[5] A. Biswas, V. V. Prasad, R. Rajesh, Mpemba effect in an anisotropically driven granular gas, Europhys. Lett., 136, 4 (2021).
[6] A. Biswas, V. V. Prasad, R. Rajesh, Mpemba effect in anisotropically driven inelastic Maxwell gases, J. Stat. Phys., 186, 1 (2022).
[7] A. Biswas, V. V. Prasad, R. Rajesh, Mpemba effect in driven granular gases: Role of distance measures, arXiv:2303.10900 (2023).
[8] A. Biswas, R. Rajesh, Arnab Pal (in preparation) (2023).