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Nonequilibrium fluctuations and nonlinear dynamic response of magnetic nanoparticles to time-dependent magnetic fields

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Response properties of magnetic nanoparticles to time-dependent magnetic fields are at the core of many emerging biomedical applications. While linear response to weak applied fields is well understood theoretically and studied in detail in numerous works, the nonlinear response to strong fields is less well understood and more difficult to study. Yet, some applications such as magnetic particle spectroscopy rely on the nonlinearity of the response.

Here, I will present some recent results on the nonlinear dynamic response of magnetic nanoparticles to arbitrary time-dependent fields [1] and more specifically to oscillating fields [2]. Finally, I will discuss a particular fluctuation theorem on strong nonequilibrium magnetization fluctuations in time-dependent magnetic fields and their consequences for local heat production in magnetic fluid hyperthermia [3].

References

- [1] P. Ilg. *J Magnet Magnet Mater* 610, 172540 (2024).
- [2] P. Ilg. *Phys Rev E* 111, 055411 (2025); P. Ilg. *Phys. Rev. E* 109, 034603 (2024).
- [3] P. Ilg. *Phys Rev B* 109, 174301 (2024).

Type:

Oral