PhD Project: « Fluctuation driven confinement forces»

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Project description:

The experimental confinement of systems down to the nano-scale has become one of the major axes of research in condensed matter physics. Of particular interest and relevance are systems in which strong fluctuations are cut off at the confinement scale leading "Casimir" confinement forces [1]. Such forces are particularly important in the region of a second order phase transition, where the confining dimension ultimately cuts off the diverging correlation length, giving a critical Casimir force [2]. Motivated by recent experiments in both Lyon and Bordeaux on confined binary fluid systems, we will in this project be interested in numerical and analytical studies of Casimir forces in model systems. The project will build on the recent thesis of David Lopes Cardozo [3], in which these critical effects were studied in relation to both magnetic thin films [4] and fluid systems [3]. In the future we will turn to different confining geometries, including the stability and evaporation of drops, as an internal degree of freedom becomes critical. We will also address dynamical effects and non-equilibrium phenomena, related to the critical dynamics of our model systems in confined geometry.

During the thesis the student will master critical phenomena and the finite size scaling aspects leading to Casimir forces as well as modern computational techniques for treating large-scale simulations for both "toy models" (spin systems) and simplified fluid models such as binary Lennard-Jones fluids. Numerical work will be accompanied by analytical methods such as density functional theory and hydrodynamic approaches. The work will be done in close collaboration with experimental groups in Lyon and Bordeaux. Funding for the project is guaranteed through an "Agence National de Recherche" research grant between Lyon and Bordeaux. The project will be jointly supervised by Professor Dean and Professor Holdsworth with time divided between the two centres.

[1] H. B. G. Casimir, Proceedings of the Royal Netherlands Academy of Arts and Sciences, 51, 793 (1948),

[2] M. E. Fisher and P.-G. De Gennes, Comptes Rendus de l'Académie des Sciences de Paris, 287, 207 (1978).

[3] D. Lopes-Cardozo, Ph. D. Thesis, "Finite size scaling and the critical Casimir force: Ising magnets and binary fluids", Ecole Normale Supérieure de Lyon 2015.

[4] David Lopes Cardozo, Hugo Jacquin, and Peter C. W. Holdsworth. Critical Casimir forces in a magnetic system: An experimental protocol. Phys. Rev. B, 90(18):184413, November 2014.