Critical Casimir forces and quantum phase transitions

Confined fluctuating fields exert forces upon enclosing surfaces. The first and most famous example, that of the quantum electromagnetic field confined between conducting plaques, has been predicted by Casimir almost seventy years ago [1]. Since then, this idea has been extended to classical statistical physics [2], where the order parameter plays the role of the fluctuating field. Close to a second-order phase transition, where the correlation length diverges, these forces take universal scaling forms characterized by the symmetry of the theory, the dimensionality and the boundary conditions (BC), but independent of the microscopic details of the system. These scaling functions have sparked experimental and theoretical interest. While simulations allow to choose between a variety of BC in the context of classical phase transitions, only Dirichlet BC has been realized experimentally yet.

In this talk, we show how periodic BC are in fact experimentally relevant in the context of quantum phase transitions, thanks to the well known exact mapping between classical and quantum field theories. In this context, it is the physical inverse temperature that plays the role of the confining length, and the scaling function of the classical force is closely related to the pressure of the quantum system, which we compute using field-theoretical techniques [3].

References

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[2] M. E. Fisher and P. G. de Gennes, C. R. Seances Acad. Sci., Ser. B **287**, 207 (1978).

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