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In situ thermometry of a cold Fermi gas via dephasing impurities

The precise measurement of low temperatures is a challenging yet fundamental task for quantum science. In particular, in-situ thermometry of cold atomic systems is highly desirable due to their potential for quantum simulation. I will present some of our recent work [1] showing that the temperature of a non-interacting Fermi gas can be accurately inferred from the non-equilibrium dynamics of impurities immersed within it, using an interferometric protocol and established experimental methods. Adopting tools from the theory of quantum parameter estimation, we show that our proposed scheme achieves optimal precision in the experimentally relevant temperature regime for degenerate Fermi gases [2]. We also discover an intriguing trade-off between measurement time and thermometric precision that is controlled by the impurity-gas coupling, with weak coupling leading to the greatest sensitivities. This is explained as a consequence of the slow decoherence associated with the onset of the Anderson orthogonality catastrophe, which dominates the gas dynamics following its local interaction with the immersed impurity.

[1] M. T. Mitchison, T. Fogarty, G. Guarnieri, S. Campbell, T. Busch and J. Goold, Phys. Rev. Lett. 125, 080402 (2020).
[2] M. Cetina et al., Science 354, 96 (2016).

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