

Making statistics work: a quantum engine in the BEC-BCS crossover

Wednesday, 13 September 2023 22:40 (20 minutes)

Heat engines convert thermal energy into mechanical work both in the classical and quantum regimes. However, quantum theory offers genuine nonclassical forms of energy, different from heat, which so far have not been exploited in cyclic engines. We here experimentally realize a novel quantum many-body engine fuelled by the energy difference between fermionic and bosonic ensembles of ultracold particles that follows from the Pauli exclusion principle. We employ a harmonically trapped superfluid gas of ^6Li atoms close to a magnetic Feshbach resonance which allows us to effectively change the quantum statistics from Bose-Einstein to Fermi-Dirac, by tuning the gas between a Bose-Einstein condensate of bosonic molecules and a unitary Fermi gas (and back) through a magnetic field. The quantum nature of such a Pauli engine is revealed by contrasting it to a classical thermal engine and to a purely interaction-driven device. We obtain a work output of several 10^6 vibrational quanta per cycle with an efficiency of up to 25%. Our findings establish quantum statistics as a useful thermodynamic resource for work production.

Reference:

J. Koch, K. Menon, **E. Cuestas**, S. Barbosa, E. Lutz, T. Fogarty, Th. Busch, and A. Widera

arXiv:2209.14202 (2022)

Subject keywords:

Quantum Engines / Quantum Statistics / Ultracold Atoms / BEC-BCS Crossover

Primary authors: Ms KOCH, Jennifer (Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany); Ms MENON, Keerthy (OIST Graduate University, Onna, Okinawa, Japan); Dr CUESTAS, Eloisa (National Scientific and Technical Research Council of Argentina, Argentina and OIST Graduate University, Japan); Mr BARBOSA, Sian (Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany); Prof. LUTZ, Eric (Institute for Theoretical Physics I, University of Stuttgart, Stuttgart, Germany); Dr FOGARTY, Thomas (OIST Graduate University, Onna, Okinawa, Japan); Prof. BUSCH, Thomas (OIST Graduate University, Onna, Okinawa, Japan); Prof. WIDERA, Artur (Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany)

Presenter: Dr CUESTAS, Eloisa (National Scientific and Technical Research Council of Argentina, Argentina and OIST Graduate University, Japan)

Session Classification: Poster Session III

Track Classification: Other