nature COMMUNICATIONS

ARTICLE

DOI: 10.1038/s41467-017-01308-7 OPEN

Using a quantum work meter to test non-equilibrium fluctuation theorems

Federico Cerisola[1,2], Yair Margalit[3], Shimon Machluf[4], Augusto J. Roncaglia[1,2], Juan Pablo Paz[1,2] & Ron Folman[3]

Work is an essential concept in classical thermodynamics, and in the quantum regime, where the notion of a trajectory is not available, its definition is not trivial. For driven (but otherwise isolated) quantum systems, work can be defined as a random variable, associated with the change in the internal energy. The probability for the different values of work captures essential information describing the behaviour of the system, both in and out of thermal equilibrium. In fact, the work probability distribution is at the core of "fluctuation theorems" in quantum thermodynamics. Here we present the design and implementation of a quantum work meter operating on an ensemble of cold atoms, which are controlled by an atom chip. Our device not only directly measures work but also directly samples its probability distribution. We demonstrate the operation of this new tool and use it to verify the validity of the quantum Jarzynksi identity.

[1] Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires Ciudad Universitaria, 1428 Buenos Aires, Argentina. [2] Instituto de Física de Buenos Aires, CONICET-UBA, Ciudad Universitaria, 1428 Buenos Aires, Argentina. [3] Department of Physics, Ben-Gurion University of the Negev, Be'er Sheva 84105, Israel. [4] Van der Waals-Zeeman Institute, University of Amsterdam, Science Park 904, PO Box 94485, 1090 GL Amsterdam, The Netherlands. Correspondence and requests for materials should be addressed to F.C. (email: cerisola@df.uba.ar) or to J.P.P. (email: paz@df.uba.ar)