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报告

单原子层次上实验演示朗道尔原理

Demonstrating the Landauer Principle at Single-atom Level

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冯芒，研究员，博士生导师，多年从事原子分子物理、量子光学和量子信息方面的研究，主持 973 项目子课题、国家自然科学基金重点项目、面上项目多项。1996 年在中国科技大学获得理学博士学位，2000 年 - 2005 年在欧洲几所大学和研究所工作，2005 年 4 月起任中国科学院武汉物理与数学研究所研究员。迄今已经在 Science 子刊、Nature 子刊、物理评论快报等国际刊物上发表 SCI 收录的论文 230 余篇，获得他引 2400 余次。近几年致力于超冷离子体系的量子精密测量和量子力学基本特性的实验研究。

报告摘要 Abstract

In the information processing, a minimum amount of energy is required to be consumed against deleting a bit of information. This is known as the famous Landauer principle, which implies the irreversibility of logic operations and is associated with the elucidation of “Maxwell demon” – a paradox in thermodynamics for hundreds of years. Contrary to its classical version the quantum Landauer principle is based on a fully quantized system and quantized reservoir as well. So the deletion of information in a quantum bit (qubit) strongly depends on the reservoir temperature as well as the quantum correlation between the system and reservoir.

We report our recently experimental implementation for testing this quantized Landauer principle based on a single 40Ca+ ion confined in an electromagnetic potential. With the techniques of arbitrary quantum-state preparation, precise laser-control of the carrier and sideband transitions as well as precision measurement of quantum states, we modeled both the quantized system and reservoir in the single ultracold ion, and successfully observed the energy change of 10-28 joules due to eliminating information from a qubit. We show strong agreement between the experimental observation and the theoretical prediction. In particular, the experimental observations exposed an unprecedented thermodynamic effect which had never been reported before. Under the condition of quantum correlation, the energy cost of the system could be related to information generation instead of deletion.

This is the first experimental witness of the minimum energy cost in quantum logic operations, which will be helpful for understanding the fundamental physical limitations of irreversible logical operations at the quantum level.

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