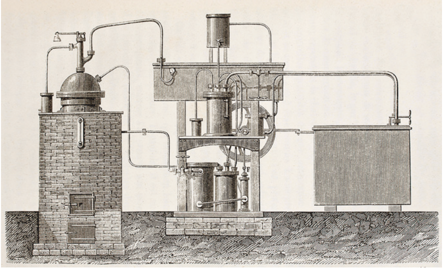
research highlights

QUANTUM THERMODYNAMICS

Chilling motion

Nat. Commun. **10**, 202 (2019)



Credit: Oldtime / Alamy Stock Photo

The laws of thermodynamics regulate the operational principles of macroscopic heat machines. Their statistical nature means that if we were able to realize microscopic ones, composed of just a few quantum systems, deviations from these laws may be possible. This regime is within experimental reach, as proven by Gleb Maslennikov and co-workers, who have now reported the creation of the quantum version of an absorption refrigerator — a machine first invented in 1850 (pictured) — with three trapped ytterbium ions.

In the language of thermodynamics, the hot and cold bodies and the work medium of this machine are modes of motion of the three-ion chain. The authors observed near-equilibrium and far-from-equilibrium cooling of the cold mode. In the latter scenario, non-thermal occupation of the modes was reported, a sign that quantum coherence is transiently created during the fridge's evolution. Squeezing the initial state of the work medium showed that the presence of quantum resources impacted the fridge's operation, but didn't lead to overall improved performances. *FL*

https://doi.org/10.1038/s41567-019-0431-x

SCALING LAWS

The long and short of it

eLife **8**, e38187 (2019)

In the complex world of living matter, the scaling law linking the metabolic rate of an organism with its body mass almost seems peerless — both in its simplicity and its longevity. But what drives the scaling? That different species elude quantitative comparison and single species span too narrow a size range has made this a difficult question to answer. Now, Albert Thommen and colleagues have sought help from the remarkable flatworm *Schmidtea mediterranea*, which grows when fed and shrinks when starved — exhibiting a 40-fold range in body length.

Using microcalorimetry, Thommen and co-workers confirmed the expected scaling, then devised a theoretical framework casting growth and shrinkage as a function of the organism's metabolic energy budget. Armed with both model and data, they identified an increase in the mass per cell due to size-dependent energy storage as the cause of the scaling in the starving worms. It remains to be seen whether the same mechanism underpins allometric scaling in all animals. *AK*

https://doi.org/10.1038/s41567-019-0429-4

CRITICAL PHENOMENA

Two at once

Nat. Mater. https://doi.org/gfs4t8 (2018)

What happens when two types of quantum critical behaviour exist in the same material? This question has been answered by Awadhesh Narayan and collaborators by introducing the concept of multiferroic quantum criticality.

They predicted that europium titanate should exhibit both magnetic and multiferroic quantum critical points, and that alloying with the right amount of barium and strontium would cause the two to be coincident, making the material bicritical. At this point, the scaling behaviour of the magnetic and dielectric susceptibilities should change as the quantum fluctuations associated with one order impacts the other. Also, different forms of superconductivity tend to arise from these ordered phases — *s*-wave for ferroelectric and *d*-wave for antiferromagnetic — and investigation of what happens to the pairing in this case is an open direction for future work. *DA*

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QUANTUM GASES

Explore the bad

Science **363**, 379–382 (2019)

The transport properties of conventional metals can be understood in terms of Landau–Fermi liquid theory. The theory holds that conductivity arises when a quasiparticle carrying the same amount of charge and spin as a single electron responds to an external field. Despite its remarkable success, the theory fails to explain the behaviour of a broad class of correlated materials, referred to as 'bad metals'. Now, Peter Brown and co-workers have used a strongly interacting Fermi gas to study the underlying mechanism.

The minimum model for studying the physics of strongly correlated electrons is the Fermi–Hubbard model, which can be realized using ultracold atoms trapped in an optical lattice. Based on the measurements of the diffusion constant and the compressibility of the system, Brown and colleagues derived the conductivity through the Nernst–Einstein relation. The inverse of the conductivity exhibited linear temperature dependence, violating the Mott–Ioffe–Regel limit — a hallmark of bad metals. *YL*

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METROLOGY

Common ground

Metrologia **56**, 015016 (2019)

Sources emitting single photons are one of the key elements in emerging quantum optical technologies. During the development phase of devices for, say, radiometry with single photons, a fair comparison between the various stages requires common standards — a necessity that becomes even more important when the device is rolled out for mass production. But so far, there are no universal means to characterize single-photon sources.

Ekaterina Moreva and colleagues from the National Metrology Institutes of Italy, Germany and the UK have now joined forces to develop the first standardized technique to characterize single-photon sources and to provide common uncertainty estimation procedures. Using a Hanbury Brown and Twiss interferometer, the authors measured the coincidence and click probabilities from single photons emitted from a nitrogen–vacancy centre in diamond, allowing them to estimate the second-order correlation function — a parameter commonly used to describe single-photon sources. The independent results agree within uncertainty and mark the first step towards an international measurement standard for single-photon sources. *SR*

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