Particles near absolute zero do not break the laws of physics after all

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In theory, the laws of physics are absolute. However, when it comes to the laws of thermodynamics—the science that studies how heat and temperature relate to energy—there are times where they no longer seem to apply. In a paper recently published in the *European Physical Journal B*, Robert Adamietz from the University of Augsburg, Germany, and colleagues have demonstrated that a theoretical model of the environment's influence on a particle does not violate the third law of thermodynamics, despite appearances to the contrary. These findings are relevant for systems at the micro or nanometer scale that are difficult to decouple from the heat or the quantum effects exerted by their environment.

The authors focused on a model system favored by thermodynamics experts that consists of a free particle strongly coupled to a heat bath, representing the effect of its environment. Studies of such systems typically focus on how much energy is needed to raise their temperature by a certain amount, or so-called specific heat. Previous theoretical predictions suggested that, under certain circumstances, the specific heat can decrease below zero at a temperature of strictly zero (–273.15°C). This prediction appears to breach the third law of thermodynamics, which states that the specific heat must drop to zero value at strictly zero temperature.

The authors demonstrated that the third law of thermodynamics is not actually violated. In fact, a real particle will always be confined to a finite volume—even if that volume may be extremely large. Therefore,

they discovered that previous studies need to be modified in order to account for a spatial confinement of the particle. The new model demonstrates how the negative specific heat for a truly free particle is related to a dip in the specific heat, which should be observable in the presence of a confinement.

More information: R. Adamietz, G.-L. Ingold, and U. Weiss (2014), Thermodynamic anomalies in the presence of general linear dissipation: from the free particle to the harmonic oscillator, *European Physical Journal B*, DOI: 10.1140/epjb/e2014-50125-2

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