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Thermoelectric energy conversion close to a phase transition

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From a thermodynamic viewpoint, thermoelectric systems are akin to heat engines producing electricity through direct conversion of heat into electrical power. Since the conduction electron gas is the system's working fluid, its properties influence the energy conversion efficiency. Here, we study thermoelectric energy conversion close to an electronic phase transition, focusing on the superconducting fluctuating regime in a 2D system just above the critical temperature. While in the normal phase, the conversion efficiency remains small even in idealized cases, we find that it increases sharply in the fluctuating regime, where 2D fluctuating Cooper pairs strongly influence the ability of the thermoelectric system to convert heat into electrical power. This occurs due to the behavior of the electron gas compressibility in this regime, which leads to the divergence of the isentropic expansion factor. The closer the temperature of the fluctuating Cooper pairs system is to the critical temperature, the larger the values of the power factor, reflecting the increase of the conversion efficiency. These theoretical results are backed up by experimental data obtained with a pnictide thin film, which shows that, close to the superconducting phase transition, the power factor is 300 times larger than it is in the normal phase at room temperature. While these increases of power factor and conversion efficiency are drastic, they are possible only in a very small range above the critical temperature. This indicates that, for practical applications, thermoelectric systems close to an electronic phase transition are not useful for electricity generation, but may serve more effectively as heat pumps.

Theme

Theme 3. Theoretical and experimental methods for quantum effects in energy processes

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