Interference as a new method for cooling quantum devices

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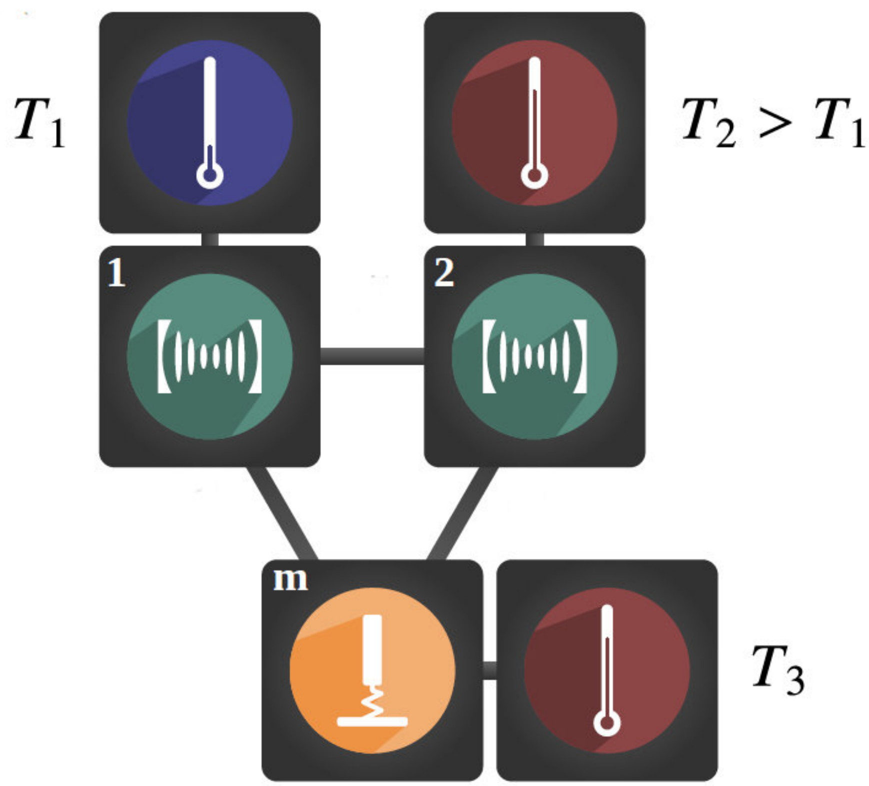

A mechanical system is coupled to two electromagnetic cavities and a heat bath, is proposed as a realization. In this model, the two systems are also connected to their own heat baths. Credit: Shabir Barzanjeh, André Xuereb & Matteo Aquilina

Theoretical physicists propose to use negative interference to control heat flow in quantum devices. Their study has been published in *Physical Review Letters*.

Quantum computer parts are sensitive and need to be cooled to very low temperatures. Their size makes them particularly susceptible to temperature increases from the thermal noise in the surrounding environment and that caused by other components nearby. Dr Shabir Barzanjeh, a postdoc at the Institute of Science and Technology Austria (IST Austria), together with Dr André Xuereb from the University of Malta and Matteo Aquilina from the National Aerospace Centre in Malta has proposed a novel method to keep quantum devices cool. Their theoretical approach relies on quantum interference.

Normally, if a hotter object is placed next to a cooler one, the heat can only flow from the hotter object to the cooler one. Therefore, cooling an object that is already cooler than its surroundings requires energy. A new method for cooling down the elements of quantum devices such as qubits, the tiny building blocks of quantum computers, was now theoretically proven to work by a group of physicists.

"Essentially, the device we are proposing works like a fridge. But here, we are using a quantum mechanical principle to realize it," explains Shabir Barzanjeh, the lead author of the study and postdoc in the research group of Professor Johannes Fink. In their paper, they studied how thermal noise flows through quantum devices and they devised a method that can prevent the heat flow to warm up the sensitive quantum device. They used a heat sink connected to both devices, showing that it is possible to control its heat flow such that it cancels the heat coming from the warm object directly to the cool one via special quantum interference.

"So far, researchers have focused on controlling the signal, but here, we study the noise. This is quite different, because a signal is coherent, and the noise isn't." Concerning the practical implementation of the mechanism that adds the phase shift to the thermal noise, Shabir Barzanjeh has some ideas, including a mechanical object that vibrates, or radiation pressure to control the oscillation. "Now it is the time for experimentalists to verify the theory," he says.

More information: Shabir Barzanjeh et al, Manipulating the Flow of Thermal Noise in Quantum Devices, *Physical Review Letters* (2018). DOI: 10.1103/PhysRevLett.120.060601

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