Physicists gain new understanding of quantum cooling process

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New research at the U of A is helping physicists better understand optomechanical cooling, a process that is expected to find applications in quantum technology.

Scientists have long understood that applying a properly tuned light field to a macroscopic (visible to the naked eye) object - in this case a mechanical oscillator - results in cooling the object. The process, optomechanical cooling, happens when pressure from photons (particles of light) converts energy stored in the object in the form of thermal phonons (particles of sound) into photons.

Ideally, the process would cool the object to its pure quantum state at which all thermal energy is removed. In reality, the quantum state cannot be achieved due to noise perturbations in the environment.

In their work, U of A researchers defined the new cooling limit, which advances understanding of the process. Their findings were reported in an article titled, "Radiation Pressure Cooling as a Quantum Dynamical Process," published June 9 in the journal *Physical Review Letters*.

"Like any evolution to a stable state, cooling a mechanical oscillator takes time and, in contrast to what was previously understood, the speed of the process decides what state will be finally achieved," said Bing He, first author of the paper and a researcher in the Department of Physics. "Our dynamical picture clarifies how an optomechanical system undergoes the transition from heating to cooling and vice versa, and

determines the conditions for achieving the `most quantum result' by the best cooling of the system."

The work will also help guide future experiments, said Min Xiao, a Distinguished Professor in the Department of Physics. "With our new dynamical results, not only the new experimental efforts can be guided, some previously reported experimental and theoretical results and conclusions might also need to be reanalyzed and re-examined," said Xiao.

More information: Bing He et al. Radiation Pressure Cooling as a Quantum Dynamical Process, *Physical Review Letters* (2017). DOI: 10.1103/PhysRevLett.118.233604

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