Analog of cosmological particle creation

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"In cosmology there's this quantum effect," Ralf Schützhold tells *PhysOrg.com*. "In the universe, there is a ground state, where it is empty. But if the universe starts to expand or contract, the vacuum is distorted, no longer empty. Particles are created."

The quantum effects described by Schützhold, a theorist at the Institute for Theoretical Physics at the Dresden University of Technology, in Germany, are small right now. "This effect right now is probably very tiny," he says. "But during the formation of the universe, quantum effects probably played a big role."

Schützhold and his colleagues, Michael Uhlmann at the Institute in Dresden, and experimental scientists Lutz Petersen, Hector Schmitz, Axel Friedenauer and Tobias Schätz at the Max Planck Institute for Quantum Optics in Garching, Germany, hope to model quantum particle creation using an analog of phonons in an ion trap. Their work is discussed in an article titled "Analogue of Cosmological Particle Creation in an Ion Trap," and published in *Physical Review Letters*.

"In this analog, we expect to see the same effect of quantum particle creation that happened in the universe. But instead of electrons and photons, as are present in the universe, we use phonons in an ion trap," Schützhold explains. He points out that through such an analog, it would be possible to "see cosmological effects and do experiments."

"One of the basic indications we propose to use," Schützhold says, "is pairs. Particles created by these quantum effects always come in pairs. In the ion trap, it would be the same thing. If there is a quantum effect, the phonons would come in pairs. If we find that we have two particles instead of one, there is a strong indication of quantum effects." Such detection in the ion trap would help rule out effects leading to particle creation due to such classical physics effects as heating.

Schützhold points out that understanding the quantum effects that lead to particle creation would not directly point to how the universe was formed. "This is a way to help understand possible quantum effects in the early universe, but it is not a direct test of cosmological particle creation." He pauses before continuing. "In the long run, this could help us understand issues of theory better."

One of the attractive qualities of the ion trap analog proposed by the scientists in Germany is that it is possible to see results using current technology. According to Schützhold, Schätz, head of the experimental group in Garching, says that they have already done a preliminary experiment where they cooled the ions close to the ground state and achieved optical pumping at 99 percent accuracy. "It's not fully ready, yet," he concedes, "but it should be ready maybe by the end of this year or the beginning of next year."

This experiment, Schützhold explains, is a way to probe the quantum effects behind particle creation and work toward understanding fundamental questions of quantum physics. "This quantum effect was just calculated in theory," he says. "Of course now we want to see it in an experiment…It hasn't been seen practically yet."

And while the technology to directly measure quantum effects in particle creation may be years down the road, Schützhold and his colleagues may have found a way to understand these effects now by using an experimental analog that might possibly model the same effects.