Mirrors could be a key to quantum computing

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"We want to push the envelope," Pierre Meystre tells *PhysOrg.com*. "We are trying to figure out how big an object can be and still be measured quantum mechanically."

The idea, he says, is to get a better idea of *where* the boundary between quantum mechanics and classical mechanics exists. "Quantum mechanics was invented to deal with atoms and molecules," Meystre continues, "but the idea is to apply the concepts to bigger and bigger systems until we see where the rules for quantum mechanics aren't needed and we see classical mechanics."

In order to study this subject, Meystre directed his post-doc student Mishkat Bhattacharya to try and create a model for cooling a mirror to its quantum mechanical ground state. Instead of using two mirrors, as is regular practice, Meystre directed Bhattacharya to use three mirrors. The University of Arizona theorists report the results of this modeling in *Physical Review Letters*. Their piece is titled, "Trapping and Cooling a Mirror to Its Quantum Mechanical Ground State."

"There are many advantages to using three mirrors rather than two," explains Bhattacharya. "With two mirrors, you can only get the irradiation from one side. Three mirrors allow you to set it up so that the middle mirror, the one we are cooling, gets the trapping force from both dies."

Another advantage, Bhattacharya says, is that three mirrors helps resolve one of the conflicting technical demands on such systems. “The mirror needs to be small to be brought to its quantum mechanical ground state, but it needs to be big for practical mechanical use.” Three mirrors allow a setup in which the two mirrors on the end can be larger, while the middle mirror is properly small.

Bhattacharya also explains that another way to cool a mirror is to make it stiff, to stop its oscillations. With careful calculations, it is possible to use the two end mirrors to reduce the oscillations of the middle mirror. “What we have is a system that traps and cools the mirror two ways. With the laser radiation we can take the energy away, or we can stop the oscillations.”

Beyond the interest in the theoretical sense, Meystre and Bhattacharya point out that they have practical uses in mind for their system. “We hope to be able to use very cold mirrors as sensors,” says Meystre. “While the behavior of quantum mechanics is interesting from a curiosity standpoint, we can also see practical uses for this technique of mirror cooling.”

Beyond more sensitive sensors and the ability to detect and control condensate properties, Bhattacharya sees potential in one of the more popular aims of modern quantum sciences: information processing. “It is much easier to handle mirrors than to pinpoint where an atom or molecule is, and then try to manipulate it,” he points out. “This could lead to an efficient quantum computer.”

While Meystre and Bhattacharya point out that this has been done through modeling only, they also emphasize that a proof of principle has already been done by an unrelated group (who hadn’t read Meystre and Bhattacharya’s research) and available on the Los Alamos server (xxx.lanl.gov/abs/0707.1724). Additionally, Meystre and Bhattacharya believe that there is sufficient technology to establish experimental parameters for the system now.

"The uses for this mirror trapping and cooling system are going to be very exciting," Bhattacharya insists. "For practical technology in general, and in the field of quantum physics, we have modeled something very useful."