Physicist proposes to use femtosecond, chirped laser pulse trains to reduce decoherence

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In a recent publication in the high impact journal *Optics Letters*, Svetlana Malinovskaya, Associate Professor of Physics at Stevens Institute of Technology, proposes to use femtosecond, chirped laser pulse trains to reduce decoherence. Controlling coherence can overcome current barriers in a variety of fields, from quantum computing to molecular selective bio-imaging.

Coherence is a natural phenomenon where molecules exist in a superposition of states. "In condensed phase, molecules interact with environment, for example, with water molecules. This interaction increases complexity of the energy distribution causing molecules to lose their quantum properties, such as coherence, faster than in the gas phase," Malinovskaya explained. "Loss of coherence is a problem in Raman microscopy, which is a prospective method for molecular identification and imaging. The molecules that are excited with a laser pulse lose their energy very fast. Sometimes this energy loss is on the same scale as the pulse duration, which negatively influences the Raman signal identifying the molecules."

In her recent publication in *Optics Letters*, "Prevention of decoherence by two femtosecond chirped pulse trains" (Vol. 33, Issue 19), Malinovskaya describes a method to counteract decoherence by using femtosecond chirped pulse trains. The key is to make the period of the pulse trains equal to the relaxation time of the vibrational energy of the target molecules. This way, you can selectively prepare the target molecules in the excited state and restore coherence periodically.

Recently, femtosecond pulse trains emitted from a mode-locked laser have been utilized to form the basis of the frequency comb spectroscopy. For contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique, the 2005 Nobel Prize was awarded in physics to John Hall, Theodor Hänsch and Roy Glauber. "Soon after, physicists have started to use pulse trains as a new way to control light and matter," Malinovsksya said. "Using the modulated laser pulse trains, we aim to affect predetermined properties of molecules. In addition to other achievements, we can now selectively address molecular vibrations of known frequency and optimize the Raman signal from them in the presence of decoherence."

One of the key applications of the pulse train manipulation lies in the biological imaging. Malinovskaya explained: "In order to get an image of a molecular specific structure one has to program the laser pulses to excite vibrations only in the predetermined molecular groups constituting target bio-compounds. No other methods allow one to see the difference in the structure built of, for example, saturated or unsaturated fats."

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