Finding Memory in Nonlinear Ionization

January 8 2007

David Rayner and his colleagues at the National Research Council (NRC) of Canada in Ottawa have shown that when transparent solids, such as glass, are ionized with short intense laser pulses the material is subtly changed.

"When you put a laser shot into transparent material, it remembers that there was a laser shot, so when another comes along, the interaction is slightly different." Rayner performed the experiment with a graduate student, Marina Gertsvolf, and a post-doc, Pattathil Rajeev, as well as colleagues from the University of Ottawa and NRC. The memory identified by the experiment is essential in building nanostructures within the solid. The results are detailed in a letter titled "Memory in Nonlinear Ionization of Transparent Solids" published in *Physical Review Letters*.

Such nonlinear ionization memory is not limited to transparent solids. "It works with viscous transparent liquids as well," Rayner tells *PhysOrg.com*. "Even though we focus on glass in this letter, it can be applied to other transparent solids or viscous liquids. The key is to use materials in which the atoms can't move between laser shots. That way local memory can build up."

The local memory that Rayner refers to is not what we normally think of for data storage. "It's not like a usual computer memory," he explains. "In our case the memory mainly affects the absorption of intense laser light." Rayner speculates that a laser shot creates many pebble-like nanostructures in the material scattered across a focal region. "Then, when you ionize with the next light pulse memory comes into play. The pebble-like nanostructures ionize preferentially and grow."

Rayner says that their experiment provides insight into the self-ordered nanostructures that have been observed in the UK and Japan, as well as in Ottowa. "We wanted to look at the onset of ionization. We looked specifically for the memory that had been postulated to be behind the ordering."

Since the memory is only written with intense light, and mainly affects the adsorption of intense light, a very focused beam of light is needed in order to create the initial pebble-like structure. "The memory builds with time and exposure," says Rayner.

Understanding memory in nonlinear ionization has several applications. One of the main applications that Rayner and his co-authors address in the letter is related to understanding "multishot optical or electrical breakdown phenoma in dielectrics." But there is more. Rayner points out that information written in glass has security-based applications, such as storing secure information efficiently and in a robust container. Additionally, the nanostructures that ultimately grow as a consequence of the memory can be used for creating templates for laying down metals into lines and wires.

"We ended up with an interesting consequence as a result of this research," explains Rayner. "We are learning to control the fabrication of these nanostructures, and this means that you can do a variety of things with them." Another use includes using what is learned about nanostructures to create channels for microfluids. "Our work might even help advance microsurgery in transparent soft matter," Rayner enthuses. "The interaction of intense light with transparent matter is quite topical and quite important."