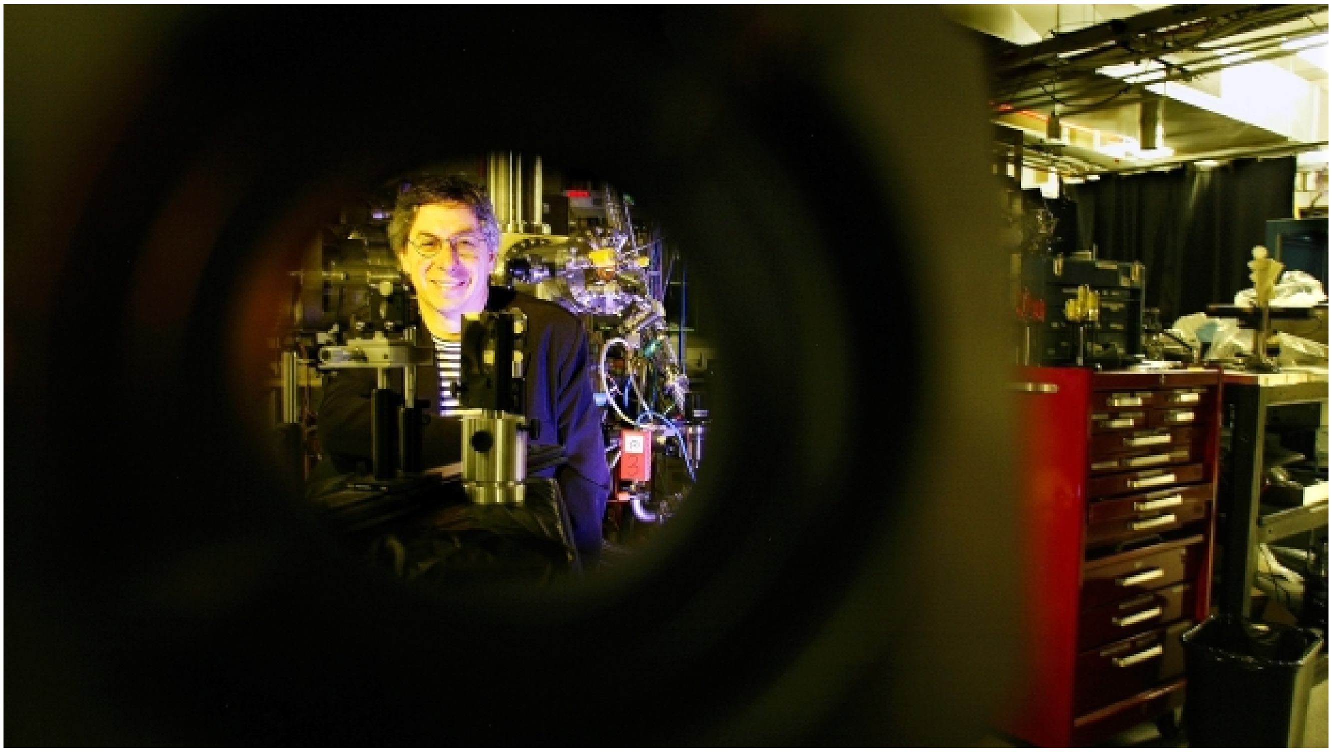
An Ottawa science lab discovers that lasers do mess with molecules

BY TOM SPEARS, THE OTTAWA CITIZEN MARCH 15, 2012



NRC Scientist Albert Stolow and his team have been shooting short bursts of laser light at molecules.

Photograph by: Julie Oliver, The Ottaw a Citizen

OTTAWA — A molecular science lab in Ottawa has shown that while lasers are terrific tools for studying how molecules work, they can also throw curves at those who use them.

Molecules obey the rules of the microscopic world, the rules of quantum mechanics. In that world, the process of observation itself can change the result.

At the National Research Council, Albert Stolow's team has been shooting short bursts of laser light at molecules. Intense laser light in particular can capture an astonishingly brief moment in time, like a super-fast camera: The moment when a chemical reaction happens.

But his new work shows that by observing a molecule with these lasers, scientists actually shuffle around its electrons and may see an altered version of the basic chemistry.

Chemical reactions happen with blinding speed. Atoms form bonds with each other by sharing electrons, or break their bonds to split molecules apart. The electrons within molecules can move so fast that science needs a special word for the short space of time — attoseconds.

One attosecond is a billionth of a billionth of a second. And modern intense lasers can produce pulses of light measured in attoseconds.

That pulse can isolate the moment when the electrons rearrange in a chemical reaction. But the question remained: Does the laser also have an unintended effect on the molecule that it hits?

Prevailing theory, Stolow says, was that intense lasers do have an effect, but only on a single electron within the molecule. The rest of the molecule was supposed to be largely unaffected.

He wasn't so sure. The problem was that all experiments so far tended to be on very small molecules, such as a pair of atoms bonded together. He moved up a step to an industrial chemical called butadiene, which is a little bigger — 10 atoms of carbon and hydrogen.

His study, published Friday in the journal Science, shows that the laser's electric field slams into the electrons and "pushes around" many of them, causing a bigger change in the molecule than others had suspected. In other words, the research tool briefly changes the molecule. And that means that anyone using intense lasers to investigate chemical reactions will have to take into account the unintended side effects from the laser itself.

Stolow says that in the world of very small particles, or quantum science, "there is no such thing as looking without touching.

"It's a complication we have to face," he said. "How will this tool be used if it's going to be applied to more important chemical and physical questions? How does the observation change the system you're looking at?

Team member Jochen Mikosch, an avid sailor, compares the research to sailing. "You set out from shore and you don't know what awaits you," he said. Many times the group thought it knew where the work was headed, "but often the outcome was completely different ... That's something I like very much about science."

It's like having a new car, he says. "We're taking it for a test drive and saying: These are the issues. You're going to have the change the oil, and steer in a certain way, and change the tires.' These are the issues you'll have to face for the tool to be used."

German and Dutch physicists were part of the team. The work was done in the NRC's building on Sussex Drive.