Controlling cold molecules

August 29 2006

“This is a chemist’s dream,” explains Roman Krems, a professor at the University of British Columbia in Vancouver, Canada. “We’ve been trying for 50 years to develop mechanisms to control molecular collisions externally.”

Krems and his student, T. Tscherbul, have written a theoretical paper explaining how cold molecules could be manipulated by an external electric field in their letter titled “Controlling Electronic Spin Relaxtion of Cold Molecules with Electric Fields.” It was published August 22nd in *Physical Review Letters*.

“Cold molecules,” Krems tells *PhysOrg.com*, “have lots of interesting applications.” Some of these applications include use in quantum computing and looking at time-reversal symmetry in nature. When molecules are cooled to temperatures below 1 K, the experimental realization of these long-standing problems becomes more practicable. Krems wants to work with molecules that are cooled to around ½ K or less.

However interesting these applications may be though, what Krems is really interested in is how they can be manipulated in chemical processes. And based on these theoretical results, he believes it should be possible to externally control cold molecules in a magnetic trap with electric fields. This means that collisions between molecules could be manipulated, and greater control over molecular dynamics could be asserted, something that would allow chemists to learn more details about chemical reaction mechanisms and test their chemical reaction

theories. It is, however, difficult to thermally isolate molecules in a magnetic trap.

“This sort of thing has been done with atoms,” says Krems, “but molecules present a different problem.” He explains that atoms are spherical, and that their magnetic spin does not re-orient after collision. Molecules, though, are a different story. “The problem with molecules is that they are not spherical. Their orientation changes. Applying an electric field may suppress spin re-orientation.” He pauses and then continues: “Being able to control molecular dynamics externally would be a great thing for chemistry.”

While the applications to chemistry are what excite Krems, he acknowledges that this new technique could also be helpful to physicists. The new technique using external electric fields to control molecular collisions could help with measurements of electric dipole moment of the electron in time-reversal symmetry experiments, where the idea is to find out whether or not symmetry is the proper order in nature. And, with quantum computing the hot topic of the day, this technique could be helpful in creating new ideas for quantum information processing. “Quantum computing with cold trapped molecules is popular right now. In the next six months I expect to see several new schemes.” And Krems and Tscherbul’s work could help with that.

While Krems and Tscherbul’s work is theoretical right now, Krems is fairly certain that it is possible to experimentally confirm the theory in the near future. “I’ve been talking with quite a few people,” he says. “There are a lot of experiments going on right now. I hope that this paper will stimulate experimentalists to include strong electric fields for measurements in their experimental apparatuses.”

Krems thinks it is possible that the theory could be confirmed in as little as half a year. “But,” he says, “you never know with these experiments.

Surprises may be on the way. We are always waiting for surprises." Krems' hopes are certainly high. "This is a very new field and it is expanding rapidly. There is a future for cold molecules in chemistry — a very bright future.

By Miranda Marquit, Copyright 2006 PhysOrg.com