169 years after its discovery, Doppler effect found even at molecular level

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Whether they know it or not, anyone who's ever gotten a speeding ticket after zooming by a radar gun has experienced the Doppler effect – a measurable shift in the frequency of radiation based on the motion of an object, which in this case is your car doing 45 miles an hour in a 30-mph zone.

But for the first time, scientists have experimentally shown a different version of the Doppler effect at a much, much smaller level – the rotation of an individual molecule. Prior to this such an effect had been theorized, but it took a complex experiment with a synchrotron to prove it's for real.

"Some of us thought of this some time ago, but it's very difficult to show experimentally," said T. Darrah Thomas, a professor emeritus of chemistry at Oregon State University and part of an international research team that today announced its findings in Physical Review Letters.

Most illustrations of the Doppler effect are called "translational," meaning the change in frequency of light or sound when one object moves away from the other in a straight line, like a car passing a radar gun. The basic concept has been understood since an Austrian physicist named Christian Doppler first proposed it in 1842.

But a similar effect can be observed when something rotates as well, scientists say.

"There is plenty of evidence of the rotational Doppler effect in large bodies, such as a spinning planet or galaxy," Thomas said. "When a planet rotates, the light coming from it shifts to higher frequency on the side spinning toward you and a lower frequency on the side spinning away from you. But this same basic force is at work even on the molecular level."

In astrophysics, this rotational Doppler effect has been used to determine the rotational velocity of things such as planets. But in the new study, scientists from Japan, Sweden, France and the United States provided the first experimental proof that the same thing happens even with molecules.

At this tiny level, they found, the rotational Doppler effect can be even more important than the linear motion of the molecules, the study showed.

The findings are expected to have application in a better understanding of molecular spectroscopy, in which the radiation emitted from molecules is used to study their makeup and chemical properties. It is also relevant to the study of high energy electrons, Thomas said.

"There are some studies where a better understanding of this rotational Doppler effect will be important," Thomas said. "Mostly it's just interesting. We've known about the Doppler effect for a very long time but until now have never been able to see the rotational Doppler effect in molecules."

Provided by Oregon State University

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