Research group claims first detection of water dimmers in atmospheric conditions

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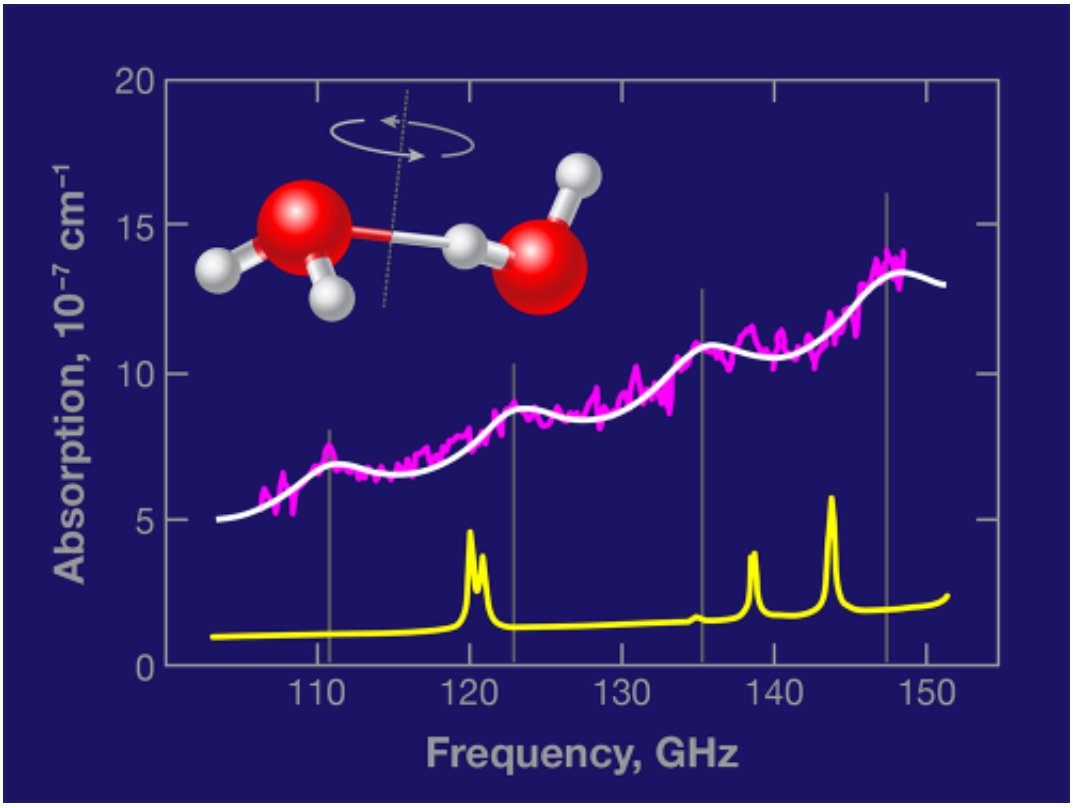

High-resolution spectroscopy is allowing scientists to detect the presence of water dimers (inset) in a sample of water vapor. The pink line is the measured spectrum and the white line is the calculated dimer spectrum. (The monomer contribution—indicated by the yellow trace—has been subtracted.) The vertical bars show the positions of the dimer rotational lines. The spectrum was measured in water vapor in equilibrium at 23 °C and 0.022 atm. Credit: *Phys. Rev. Lett.* 110, 093001 (2013) DOI:10.1103/PhysRevLett.110.093001

(Phys.org) —A team of physicists from Russia's Institute of Applied Physics, Russian Academy of Sciences, has built an exceptionally sensitive spectrometer that they claim, is the first to measure water dimmers in atmospheric conditions. In their paper published in the journal *Physical Review Letters*, the team describes how they built their spectrometer and then used it to detect, for the first time ever, water dimmers under natural atmospheric conditions.

Water dimmers are pairs of water molecules bound together by a hydrogen bond and are believed to exist in the Earth's atmosphere. Their presence is important because it is thought that they can help explain the discrepancy between results obtained from theories that describe how much radiation should be absorbed by water in the atmosphere and how much appears to actually be absorbed. Water dimmers are believed to absorb more radiation than single water molecules and thus could explain the difference.

Unfortunately, until now, no one has been able to measure water dimmers under natural conditions (they have been detected at unnaturally low temperatures)—spectrometers have not been sensitive enough to detect the difference in infrared spectral signatures between single water molecules and water dimmers.

In this new effort, the researchers built a special, more sensitive spectrometer that looks for rotational spectra of dimmers and regular water molecules, which theory has suggested should be more unique than the infrared spectra—it's in the extremely high-frequency part of the radio spectrum. The new spectrometer employs mirrors at either end of a cavity that serves as a resonator. By adjusting the mirrors, the researchers were able to optimally select certain frequencies of light which were impacted by gas in the chamber. In so doing they were able to identify a series of four absorption peaks associated with water dimmers.

The results obtained by the researchers have yet to be replicated in another lab, and thus their claims of their spectrometer detecting water dimmers in atmospheric conditions is still under review, but thus far there appears to be little reason to doubt the team's success; though there is one small hiccup. The four absorption peaks were much broader than theory had suggested and no one knows why. New research efforts will no doubt seek to find a reason even as other groups work to reproduce the groups' achievement.

More information: Water Dimer Rotationally Resolved Millimeter-Wave Spectrum Observation at Room Temperature, *Phys. Rev. Lett.* 110, 093001 (2013) DOI:10.1103/PhysRevLett.110.093001

Abstract
Water dimers (H2O)2 are believed to affect Earth's radiation balance and climate, homogeneous condensation, and atmospheric chemistry. Moreover, the pairwise interaction which binds the dimer appears to be of paramount importance for expounding a complete molecular description of the liquid and solid phases of water. However, there have been no secure, direct observations of water dimers at environmentally relevant temperatures despite decades of studies. We report the first unambiguous observation of the dimer spectrum recorded in equilibrium water vapor at room temperature.