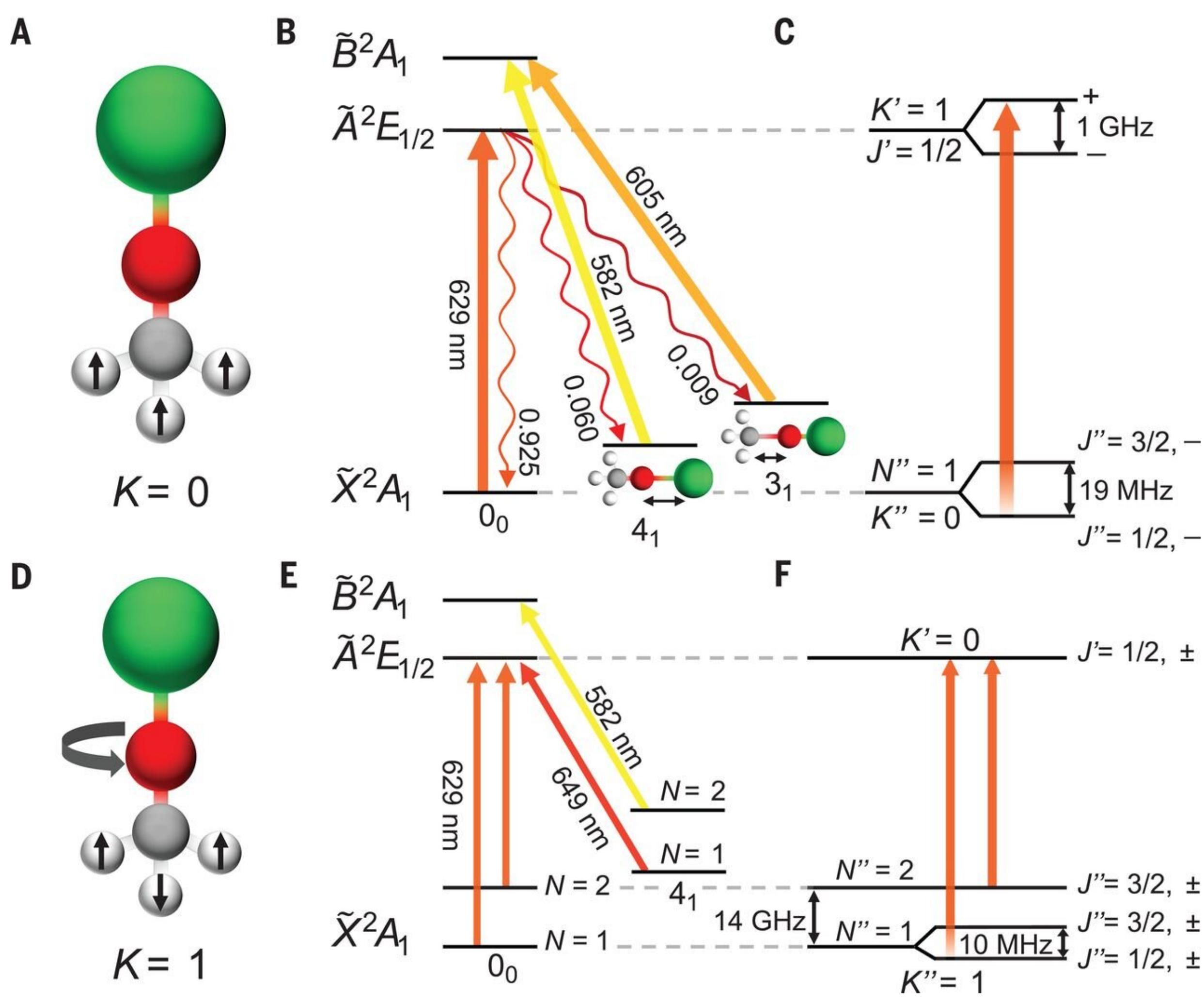
Nonlinear polyatomic molecule, CaOCH3 laser-cooled to ~700 mK

September 11 2020, by Bob Yirka



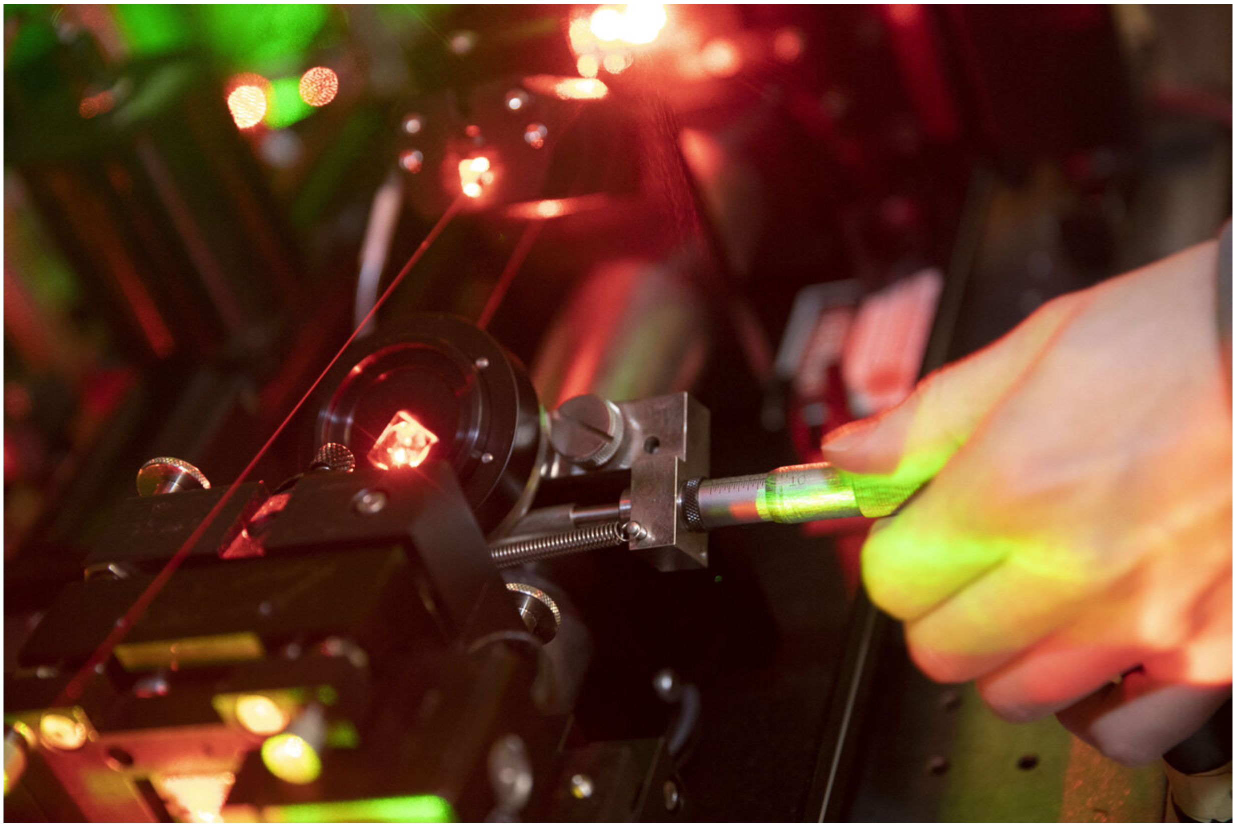
CaOCH3 laser cooling schemes. Credit: *Science* (2020). DOI: 10.1126/science.abc5357

A team of researchers at Harvard University has developed a way to cool nonlinear polyatomic molecules to extremely cold temperatures. In their paper published in the journal *Science*, the group describes their method and possible uses for it. Eric Hudson with the University of California, Los Angeles, has published a Perspective piece in the same issue describing the decades-long history of work involved in attempting to cool complex molecules, and also outlines the work by the team in California.

As Hudson notes, the first real breakthroughs in chilling complex molecules to extremely low temperatures came about over the past 30 years, starting with a team that developed a technique that involved firing lasers in scattershot fashion at a particle to reduce its heat. They won a Nobel prize for their efforts. Hudson describes it as somewhat like firing ping-pong balls at a bowling ball to slow it down. As time passed, researchers refined the method to use it on progressively more complicated molecules, most of which were gasses.

In recent years, the focus of such efforts has turned to complicated non-gas molecules. The team in this new effort has extended that research by demonstrating laser cooling of the nonlinear polyatomic molecule $CaOCH_3$ along a single dimension of a laser beam, down to a temperature of ~700 mK. They also showed that using the technique allowed for separate deterministic cooling of two nuclear spin isomers.

The technique involved applying a combination of rotational-vibrational spectroscopy applications on the transitions of molecular states. Such transitions involve measuring changes in both the rotational and vibrational states of a molecule. Notably, when such transitions occur, they can either absorb or emit photons with the frequency proportional to the differences in the energy levels.



GSAS Students, Yicheng Bao (right) and Loic Anderegg work with lasers for laser cooling CaF molecules in the Doyle Lab in the Lyman Building. Credit: Kris Snibbe/Harvard Staff Photographer

Hudson suggests the work proves that it is possible to laser cool nonlinear polyatomic molecules to extremely cold temperatures, which, he notes, is likely to open the door to new three-dimensional cooling of a variety of quantum objects. He further suggests that the new technique is likely to be used in advanced quantum computers, timing devices and chemistry.

More information: Debayan Mitra et al. Direct laser cooling of a symmetric top molecule, *Science* (2020). DOI: 10.1126/science.abc5357

Press release