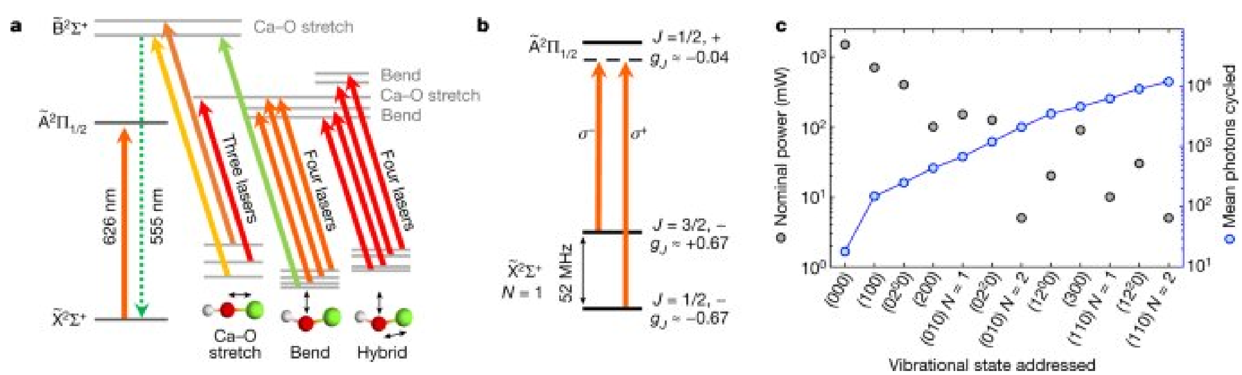
Creating ultracold polyatomic molecules by trapping and cooling them in three dimensions

June 2 2022, by Bob Yirka



Laser cooling and repumping scheme. Credit: *Nature* (2022). DOI: 10.1038/s41586-022-04620-5

A team of researchers at Harvard University, has developed a way to create ultracold polyatomic molecules by trapping and cooling them in three dimensions. In their paper published in the journal *Nature*, the group describes their technique and possible applications.

As the researchers note, laser cooling has created advances in many areas of science—it has made possible Bose-Einstein condensation computation with [neutral atoms](), for example. In this new effort, laser cooling was used to create ultracold polyatomic molecules for the first time.

The reason cooling is so effective in physics and chemistry is it reduces the complexity of molecules, and especially that of chemical reactions. The traditional means of cooling molecules is to shine lasers on atoms to cool them, and by association, the molecules that are formed from them. Another approach has involved using chemicals. And while laser cooling has proven to be an important tool, it can be problematic when attempting to gain 3D control of diatomic molecules. In this new effort, the researchers overcame that obstacle by using a magneto-optical trap (MOT), a device that uses both laser cooling and magnetics to create a trap that can be used to cool things such as atoms.

In their work, the researchers started by producing CaOH molecules, which were then chilled to 2 K. Next, the molecules were cooled further using counter-propagating lasers. They were then placed into the MOT equipped with six specially tuned laser beams. The last step involved shutting down the magnetic field and applying "optical molasses" to further cool the molecules—this cooled the molecules in 3D. The end result was molecules chilled to just 110 μK.

The researchers suggest their approach opens the door to new kinds of work involving the study of polyatomic molecules and also quantum simulations. They also suggest it could lead to new ways to study more complex and intricate reactions. They next plan to load optical tweezers with CaOH molecules and measure the quantum gate coupling that exists between any two of them.

More information: Nathaniel B. Vilas et al, Magneto-optical trapping and sub-Doppler cooling of a polyatomic molecule, *Nature* (2022). DOI: 10.1038/s41586-022-04620-5