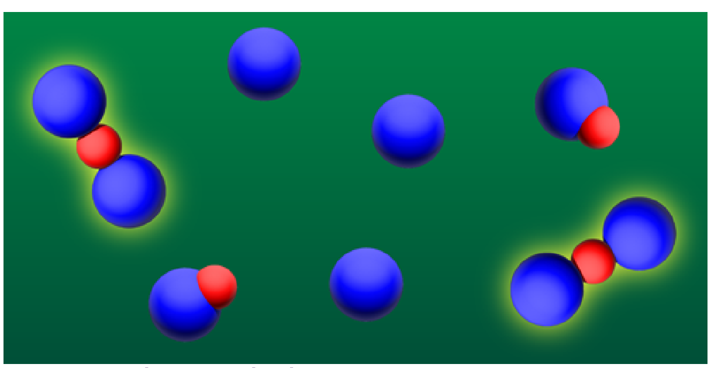
Ultracold Molecules Have Staying Power

Intermediate, nonreactive atom-molecule complexes last for a surprisingly long time.

By Rachel Berkowitz

Experiments with ultracold molecular gases offer a powerful lens on quantum chemistry, but in the decade since such systems were first developed, researchers have been puzzled by unexpected losses of molecules from traps. It's now understood that during chemical reactions between molecules and atoms, temporary intermediate complexes form—and it's these complexes that leak out. But without knowing how long the complexes persist, researchers can't be sure which of several possible mechanisms explains the loss. Matthew Nichols and his colleagues at Harvard University have now directly measured the lifetime of molecular complexes in an ultracold mixture of atoms and molecules, identifying both the escape mechanism and a discrepancy in current understanding of ultracold molecular collisions [**1**].

To probe the lifetime of temporary atom-molecule complexes, Nichols and his colleagues cooled potassium rubidium (KRb) molecules and rubidium (Rb) atoms to 480 nK and trapped them with two lasers. By rapidly changing the intensity of the beams, the researchers induced dynamics in the system that allowed them to measure, via photoionization and ion detection, how the populations of atoms, molecules, and their various combinations changed over time. They found that the temporary, nonreactive complex KRb_2 had a lifetime 10^5 times longer than theory predicts. This complex is susceptible to excitation by the light used to confine the ultracold mixture, and the complex's long lifetime means that such excitation can account for the loss of KRb_2 from the trap.



Credit: APS/Alan Stonebraker

Chemical reactions are determined by quantum interactions between molecules. The measurements by Nichols and his colleagues suggest that a more accurate framework for such interactions requires new theories that can explain long-lived complexes and reaction rates.

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REFERENCES

1. M. A. Nichols *et al.*, "Detection of long-lived complexes in ultracold atom-molecule collisions," Phys. Rev. X 12, 011049 (2022).