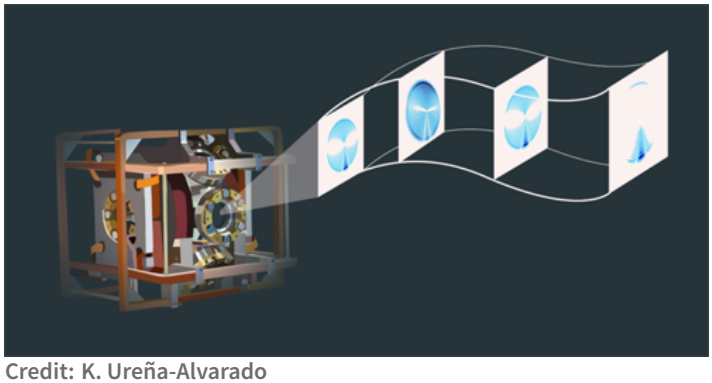
Watching Rydberg Molecules Vibrate in Slow Motion

Researchers have recorded for the first time the dynamics of vibrating Rydberg molecules, the slow-motion counterparts of regular molecules.

By **Martin Rodriguez-Vega**

The molecular vibrations in liquids and gases determine properties such as their capacity to absorb heat and their chemical reactivity. However, the small size of most molecules means that these vibrations are often too fast to be accurately analyzed. Now Yi-Quan Zou and collaborators at the University of Stuttgart, Germany, have found a workaround: instead of measuring the vibrations of conventional molecules, they consider giant "Rydberg molecules" [**1**]. The enormous size of such molecules—comparable to the size of bacteria—leads to slower vibrations that can be manipulated with weak electric fields, facilitating a controlled analysis.

Zou and colleagues start with a cloud of rubidium atoms at 20 μK. Using two pairs of lasers, they ionize one atom and excite a second atom to a Rydberg state—a state in which an electron occupies a high-energy level. The ion and the Rydberg atom naturally bond, forming a Rydberg molecule. Such ion-Rydberg-atom molecules are especially susceptible to external electric fields due to their huge dipole moment (1000 times larger than the water-molecule dipole moment), which Zou and colleagues use to control the molecular vibrations. After triggering such vibrations, they measure the positions of the ion and the Rydberg atom with an accuracy and a resolution that have not been achieved for the much more rapidly oscillating atoms in a normal molecule.



Credit: K. Ureña-Alvarado

The researchers say that their method can be extended to study more complicated dynamic processes in molecules, such as interactions with light. Additionally, direct tracking of atomic motions within molecules during chemical reactions could help devise strategies to control such reactions at the quantum level.

Martin Rodriguez-Vega is an Associate Editor for *Physical Review Letters*.

REFERENCES

1. Y. Q. Zou *et al.*, "Observation of vibrational dynamics of orientated Rydberg-atom-ion molecules," **Phys. Rev. Lett. 130, 023002 (2023).**