A molecular bond between ions and Rydberg atoms

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Atoms with a highly excited electron, called Rydberg atoms, can form unusual types of molecular bonds. The bond differs from the well known ionic and covalent bonds not only by its binding mechanism, but also by its bond length ranging up to several micrometres. We report the observation a new type of molecular bond based on the interaction between the ionic charge and a flipping induced dipole of a Rydberg atom with a bond length of several micrometres. We measure the vibrational spectrum and spatially resolve the bond length and the angular alignment of the molecule using a high-resolution ion microscope. As a consequence of the large bond length, the molecular dynamics is slow and can be directly observed under the microscope. These results pave the way for future studies of spatio-temporal effects in molecular dynamics, e.g., beyond Born- Oppenheimer physics, and more generally on (ionic) impurities in quantum gases.