



## FRONTIERS IN OPTICAL COHERENT AND ULTRAFAST SCIENCE

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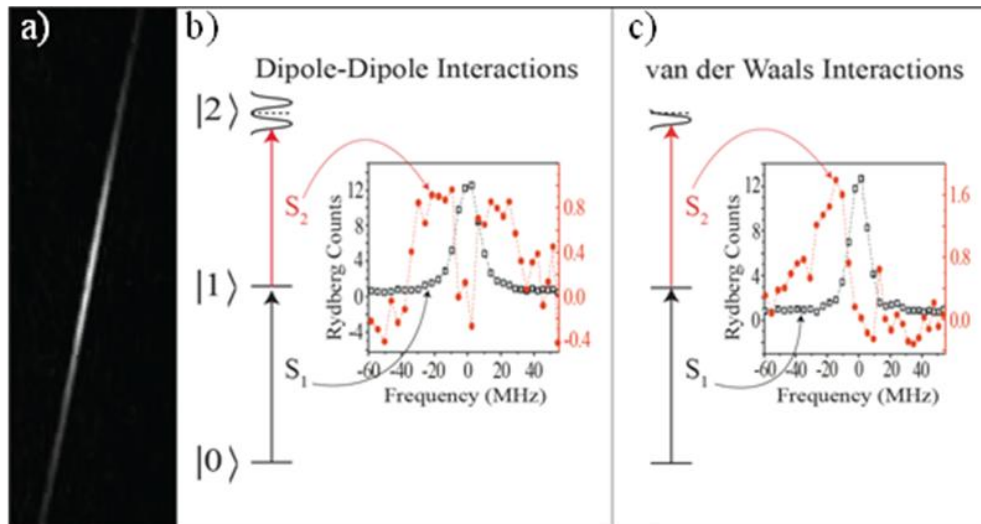
A nugget from FOCUS:

### Title: Double-resonance spectroscopy of interacting Rydberg-atom systems

Investigators: A. Reinhard, K. C. Younge, T. Cubel Liebisch, B. Knuffman, P. R. Berman, G. Raithel

Cold Rydberg atoms are atoms which are cooled until atomic motion is negligible and subsequently excited to very high energy states. Since these atoms interact strongly while moving only a fraction of their separation, a gas of cold Rydberg atoms behaves similarly to atoms in solids. Like solids, the energy levels of this gas are not discrete but consist of continuous *bands* of states, shifted in energy by these interactions. The energy shifts give rise to a phenomenon called the “dipole blockade,” or a reduction in the number of Rydberg atoms created in the sample. The blockade is an essential element in proposed schemes for neutral-atom quantum computing. These schemes could one day result in computers that are able to perform certain tasks exponentially faster than current computers.

To use the dipole blockade for quantum computation, it is important to understand the nature of these energy shifts in detail. In this work, we present the first direct spectroscopic measurement of the magnitude and sign of the energy shifts for two types of Rydberg-Rydberg interactions. These two types of interactions, resonant (dipole-dipole) or off-resonant (van der Waals), result in two different types of energy shifts of the second excited-state of our system (red circles in c and d) relative to the first excited state of our system (black squares in c and d). For van-der Waals shifts the second excited state consists of one band at lower energy while for dipole-dipole shifts it consists of two bands, one at high energy and one at low energy.



**Figure:** a) Image of trapped atoms system b, c) Energy spectra of the first two transitions in the collective system for two types of interactions: resonant dipole-dipole and off-resonant van der Waals