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Van der Waals Interactions and Dipole Blockade in a Cold Rydberg Gas Probed by Microwave Spectroscopy THANH LONG NGUYEN, RAUL CELISTRINO TEIXEIRA, CARLA HERMANN AVIGLIANO, TIGRANE CANTAT MOLTRECHT, JEAN MICHEL RAIMOND, SERGE HAROCHE, SEBASTIENS GLEYZES, MICHEL BRUNE, Laboratoire Kastler Brossel, College de France — Dipole-dipole interactions between Rydberg atoms are a flourishing tool for quantum information processing and for quantum simulation of complex many-body problems. Microwave spectroscopy of a dense Rydberg gas trapped close to a superconducting atom chip in the strong dipole blockade regime reveals directly the many-body atomic interaction spectrum. We present here a direct measurement of the interaction energy distribution in the strong dipole blockade regime, based on microwave spectroscopy. We first apply this method to the observation of the excitation dynamics of the Rydberg gas, conditioned by dipole-dipole interactions, in either the strong blockade regime or the so-called facilitation regime. We also observe with this method the atomic cloud expansion driven by the repulsive Van der Waals interaction after excitation. This measurement, in good agreement with Monte Carlo simulations of the excitation process and of the cloud dynamics, reveals the limits of the frozen gas approximation. This method can help investigate self-organization and dynamical phase transitions in Rydberg-atom based quantum simulators. This study thus opens a promising route for quantum simulation of many-body systems and quantum information transport in chains of strongly interacting Rydberg atom

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