Lineshapes of Dipole-Dipole Resonances in a Cold Rydberg Gas

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We have examined the lineshapes associated with Stark tuned, dipole-dipole resonances involving Rydberg atoms in a cold gas. Rb atoms in a MOT are laser excited from the 5p level to 32p_{3/2} in the presence of a weak electric field. A fast rising electric field pulse Stark tunes the total energy of two 32p atom pairs so it is (nearly) degenerate with that of the 32s_{1/2} + 33s_{1/2} states. Because of the dipole-dipole coupling, atom pairs separated by a distance R, develop 32s_{1/2} + 33s_{1/2} character. The maximum probability for finding atoms in s-states depends on the detuning from degeneracy and on the dipole-dipole coupling. We obtain the "resonance" lineshape by measuring, via state-selective field ionization, the s-state population as a function of the tuning field. The resonance width decreases with density due to R^{-3} dependence of the dipole-dipole coupling. In principle, the lineshape provides information about the distribution of Rydberg atom spacings in the sample. For equally spaced atoms, the lineshape should be Lorentzian while for a random nearest neighbor distribution it appears as a cusp. At low densities nearly Gaussian lineshapes are observed with widths that are too large to be the result of inhomogeneous electric or magnetic fields.

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