Roton–Roton Crossover in Strongly Correlated Dipolar Bose–Einstein Condensates

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We study the effect of pair–correlations on the ground state and the excitations of a polarized, dipolar Bose–Einstein condensate by using the hypernetted–chain Euler Lagrange method for ground state calculations and the correlated basis function Brillouin-Wigner perturbation theory for excitations. The dipolar gas is trapped in the polarization direction by a harmonic potential. Because of the anisotropy of the dipole–dipole interaction the strength of the correlations can be tuned by the trap frequency. The correlations in the parallel, infinite dimension increase with *increasing* confinement strength, whereas the correlations in the perpendicular, i.e. polarization direction increase with *decreasing* confinement. In both limits of strong and weak confinement, we observe a roton–maxon excitation spectrum whereas there is no roton in the intermediate region. This crossover between two roton regimes is interesting since the two rotons have different physical origins. In the strong confinement regime the roton is due to the strong repulsion in the parallel direction, whereas in the weak confinement regime it results from the attractive part of the interaction. In the latter case the roton is directly related to the instability of dipolar Bose–Einstein condensates found in previous mean–field calculations. We studied the dynamic structure function to obtain information not only about the excitation energies but also about their lifetimes.