Density and pseudo-spin rotons in a bilayer of soft-core bosons

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We study the dynamics of a bilayer system of bosons with repulsive soft-core Rydberg-dressed interactions within the mean-field Bogoliubov-de Gennes approximation. We find roton minima in both symmetric and asymmetric collective density modes of the symmetric bilayer. Depending on the density of bosons in each layer and the spacing between two layers, the homogeneous superfluid phase becomes unstable in either (or both) of these two channels, leading to density and pseudospin- density wave instabilities in the system. Breaking the symmetry between two layers, either with a finite counter flow or a density imbalance renormalizes the dispersion of collective modes and makes the system more susceptible to density wave instability.