Observation of Roton Mode Population in a Dipolar Quantum Gas.

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The concept of a roton, a special kind of elementary excitation, forming a minimum of energy at finite momentum, has been essential to understand the properties of superfluid helium. In quantum liquids, rotons arise from the strong interparticle interactions, whose microscopic description remains debated. In the realm of highly-controllable quantum gases, a roton mode has been predicted to emerge due to magnetic dipole-dipole interactions despite of their weakly-interacting character. This prospect has raised considerable theoretical interest; yet roton modes in dipolar quantum gases have remained elusive to observations. Here we report experimental and theoretical studies of the momentum distribution in dipolar Bose-Einstein condensates of highly-magnetic erbium atoms, revealing the existence of the long-sought roton mode. The roton excitation manifests itself with the appearance of peculiar peaks at well-defined and large momentum that we trigger via an interaction quench. We observe that the value of the roton momentum follows the predicted geometrical scaling with the inverse of the confinement length along the magnetization axis. From the growth of the roton population, we probe in real time the roton softening of the excitation spectrum and extract the corresponding value of the roton gap. Our results provide a further step in the quest towards supersolidity in dipolar quantum gases.