# Collective Modes of Dipolar Fermi Gas from Collisionless to Hydrodynamic Regime

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**Abstract.** We study the low-lying collective excitations of a Fermi gas at zero temperature confined to a triaxial harmonic trap, featuring the anisotropic long-range dipole-dipole interaction. In order to analyze the collective modes of this system, we follow Ref. [1] and solve analytically the underlying Boltzmann-Vlasov equation by using the relaxation-time approximation and by performing a suitable rescaling of the equilibrium distribution [2]. The resulting ordinary differential equations for the dynamics of the scaling parameters are linearized around equilibrium in order to determine both eigenvectors and eigenfrequencies of the collective modes. Due to the smallness of the dipolar interaction strength, the collisionless regime corresponds to the case of a noninteracting Fermi gas, i.e., the three low-lying modes represent one-dimensional cloud elongations along only one of the respective trap directions [3, 4]. In contrast to that, we get in the hydrodynamic regime the usual breathing, quadrupole, and radial quadrupole mode, where the cloud elongations are truly three- and two-dimensional, respectivley [5, 6]. We investigate in detail how the eigenvectors change when decreasing the relaxation time all the way from the collisionless to the hydrodynamic regime. We also analyze the quench dynamics, which is induced by a sudden rotation of the polarization of the atomic magnetic moments by 90°, and show that it can be understood by a superposition of the low-lying collective modes. These analytical and numerical calculations are relevant for understanding quantitatively the current Innsbruck experiment with ultracold fermionic erbium atoms, which interact via their magnetic dipole moments [7].

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