Soft modes in Fermi liquids

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We use kinetic theory to discuss soft modes in Fermi liquids in both the collisionless and the hydrodynamic regimes. In the collisionless regime the basic soft modes are the are continuum of particle-hole excitations and all of their moments with respect to momentum. In addition to the continuum, there are well-known zero-sound modes that reflect angular fluctuations of the Fermi surface. In addition to the latter, radial fluctuations of the Fermi surface lead to a novel propagating entropy mode. At nonzero temperature all of these modes acquire a mass. With increasing temperature that mass increases, and the collisionless regime shrinks. At the same time, a hydrodynamic frequency regime opens up that displays the five hydrodynamic modes governed by conservation laws, namely: two first-sound waves, two shear-diffusion modes, and one heat-diffusion mode. We discuss the relation of these results to previous work that used field-theoretic methods, as well as the origins of the various soft modes.