TRANSPORT AND SPIN DYNAMICS IN SPIN-POLARIZED ^{3}He AND ^{3}He-^{4}He MIXTURES

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I will give a brief overview of recent results on transport and spin dynamics in spin-polarized helium systems. In helium systems all transport and kinetic processes can be separated into two groups of longitudinal and transverse processes. The former group includes all traditional transport processes plus spin effects without changes in direction of magnetization, while the latter covers dynamics of transverse components of magnetization, including the spin waves. A very weak coupling between the longitudinal and transverse processes is caused only by the magnetic dipole-dipole interaction or non-linear effects.

The phenomenological description of longitudinal phenomena is rather straightforward in all temperature regions, and is similar to classical or quantum binary "mixtures" of spin-up and spin-down components with polarization playing the role of the mixture concentration. Here the effects of polarization result from the changes in density of states and effective interaction including the disappearance of the *s*-wave scattering. Generally, it is practically impossible to analyze and compare different contributions without model assumptions. It is difficult to make reliable qualitative predictions even for low polarizations The existing experimental data, though very interesting, are also not very conclusive except for very dilute mixtures. I will give a brief review of what is already well established and what seems to be reasonable to expect. At ultralow temperatures, when the mean free paths become very large, one should consider the wall scattering. The roughness of the walls results in a formation of a new length scale for transport which is related to the correlation functions of surface inhomogeneities. This, in turn, leads to various new localization and mesoscopic effects.

The transverse dynamics is more interesting and complicated because of the existence of unique collisionless zero-temperature attenuation and an important role of molecular field. Both effects have been analyzed and explained recently on the basis of exact microscopic theory of Fermi liquids at $T = 0$ and kinetic theory of dilute Fermi gases at arbitrary temperatures. Both descriptions are consistent with each other and, qualitatively, with recent experimental data on ^{3}He↑ and ^{3}He↑-^{4}He mixtures. The zero-temperature attenuation and the molecular field can be described as an imaginary (pole) and real (principal) parts of the same interaction function. This interaction function is related to the scattering T-matrix and, at low temperatures, irreducible vertex function. Macroscopically, the picture somewhat resembles that in collisionless plasma with strong molecular field and Landau damping. An interesting situation occurs for helium mixtures near the concentration at which the NMR line shift changes sign, and the imaginary and real contributions to the spectrum effectively change places while the spectrum remains, in contrast to earlier predictions, quadratic (mostly diffusive with a small real spin-wave part). Other unresolved questions concern mostly the low-temperature behavior of attenuation in dense Fermi liquids.

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