Giant Viscosity Enhancement in a Spin-polarized Fermi Liquid

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Introduction

At extremely high magnetic fields (B~ 14 T) and low temperatures (T~ 2 mK) the separation of the spin levels can become greater than the Fermi energy, and the nuclear spin polarization tends to unity. As a consequence the s-wave scattering is strongly suppressed because only antiparallel pairs can scatter in s-wave orbital states and the number of antiparallel pairs drops with increasing spin polarization. The viscosity along with other transport properties depends on the quasiparticle-quasiparticle scattering and its measurement can provide a sensitive test of the predicted suppression of s-wave scattering at very low temperatures. One expects a strong enhancement of the viscosity of Fermi systems for conditions of high B/T. Dilute 3He in liquid 4He is an almost ideal sample to test this prediction for experimentally accessible magnetic fields and temperatures.

Experimental

In a previous study [1] at the NHMFL High B/T facility, pulsed NMR was used to demonstrate the existence of a novel damping of spin currents in 3He-4He mixtures. In this new study [2] a special composite vibrating-wire was used to measure the momentum transport (viscosity) in 3He-4He mixtures under similar high B/T conditions. Here we summarize the reports of results for measurements of the viscosity using a vibrating wire at very low temperatures (2<T<100 mK) [2]. The required experimental conditions were met using the nuclear demagnetization refrigerators of the NHMFL High B/T facility.

Samples were prepared from gaseous mixtures to have 200ppm 3He concentrations. Careful NMR calibration measurements at low temperatures established that the condensed samples in the low temperature cells contained 150 ppm 3He, the difference with the gas concentration being attributed to surface absorption during the condensation process.

Results and Discussion

The results of the viscosity measurements are shown in Figure 1. The data shows the exponential increase of the viscosity for high spin polarizations; i.e. for T<10 mK and B > 11 T. The results can be used to test theories of transport in degenerate, highly polarized Fermi liquids, and in particular test the current models for quasiparticle interactions in 3He-4He mixtures which are mediated by phonon exchange.

Conclusions

The giant enhancement of the viscosity of a prototype dilute Fermi system has been demonstrated experimentally for 150 ppm 3He in liquid 4He. The quantitative dependence is in good agreement with the expected dependence on polarization estimated from current models of quasiparticle-quasiparticle scattering at low temperatures.

References