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Spin Transport in a Unitary Fermi Gas

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We study spin transport in a quantum degenerate Fermi gas of ^{40}K near an s-wave interaction resonance. The starting point of our measurements is a transversely spin-polarized gas, where each atom is in a superposition of the lowest two Zeeman eigenstates. In the presence of an external gradient, a spin texture develops across the cloud, which drives diffusive spin currents. Spin transport is described with two coefficients: $D_0^\perp$, the transverse spin diffusivity, and γ, the Leggett-Rice parameter. Diffusion is a dissipative effect that increases the entropy of the gas, eventually creating a mixture of spin states. γ parameterizes the rate at which spin current precesses around the local magnetization. Using a spin-echo sequence, we measure these transport parameters for a range of interaction strengths and temperatures. At unitarity, for a normal-state gas initially at one fifth of the Fermi temperature, we find $D_0^\perp = 2.3(4)\,\hbar/m$ and $\gamma = 1.08(9)$, where m is the atomic mass. In the limit of zero temperature, γ and $D_0^\perp$ are scale-invariant universal parameters of the unitary Fermi gas. The value of $D_0^\perp$ reveals strong scattering and is near its proposed quantum limit, such that the inferred value of the transport lifetime $\tau_\perp$ is comparable to $\hbar/\epsilon_F$. This raises the possibility that incoherent transport may play a role. The nonzero value of γ tells us that spin waves in unitary Fermi gas are dispersive, or in other words, that the gas has a spin stiffness in the long-wavelength limit. Time permitting, we will also discuss a time-resolved measurement of the contact, through which we observe the microscopic transformation of the gas from ideal to strongly correlated.