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Spin noise spectroscopy to probe quantum states of ultracold fermionic atom gases BOGDAN MIHAILA, SCOTT CROOKER, KRASTAN BLAGOEV, DWIGHT RICKEL, DARRYL SMITH, Los Alamos National Laboratory, PETER LITTLEWOOD, Cavendish Laboratory, Cambridge, UK — Ultracold alkali atoms provide experimentally accessible model systems for probing quantum states that manifest themselves at the macroscopic scale. Recent experimental realizations of superfluidity in dilute gases of ultracold fermionic atoms offer exciting opportunities to directly test theoretical models of related many-body fermion systems that are inaccessible to experimental manipulation. However, the microscopic interactions between fermions are potentially quite complex, and experiments in ultracold gases to date cannot clearly distinguish between the qualitatively different microscopic models that have been proposed. Here, we theoretically demonstrate that optical measurements of electron spin noise can probe the entangled quantum states of ultracold fermionic atomic gases and unambiguously reveal the detailed nature of the interatomic interactions. We show that different models predict different sets of resonances in the noise spectrum, and once the correct effective interatomic interaction model is identified, the line-shapes of the spin noise can be used to constrain this model. Experimental measurements of spin noise in classical alkali vapors are used to estimate the expected signal magnitudes for spin noise measurements in ultracold atom systems and to show that these measurements are feasible.

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