Observation of superconducting Leggett modes from competing pairing instabilities in single layer $NbSe_2$

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In certain unconventional superconductors with sizable electronic correlations, the availability of closely competing pairing channels leads to characteristic soft collective fluctuations of the order parameters, which leave fingerprints in many observables and allow to scrutinize the phase competition. Superconducting layered materials[1–8], where electron-electron interactions are enhanced with decreasing thickness, are promising candidates to display these correlation effects. For example, while bulk $NbSe_2$ is essentially a conventional superconductor, recent experiments in the thin-film regime have shown evidence of competing unconventional nematic pairing[9,10]. In this work, we report the existence of a soft collective mode in single-layer $NbSe_2$, observed as a characteristic resonance excitation in high resolution tunneling spectra. This resonance is observed along with higher harmonics, its frequency $\Omega/2\Delta$ is anticorrelated with the local superconducting gap Δ, and its amplitude gradually vanishes by increasing the temperature and upon applying a magnetic field up to the critical values (T_C and H_{C2}), which sets an unambiguous link to the superconducting state. Aided by a microscopic model, we interpret this resonance as a collective Leggett mode that represents the fluctuation towards a proximate *f*-wave triplet state, due to subleading attraction in the triplet channel. Our findings demonstrate the fundamental role of correlations in superconducting 2D transition metal dichalcogenides, opening a path towards unconventional superconductivity in simple, scalable and transferable 2D superconductors.

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