We demonstrate the existence of a collective "Higgs" branch in the pair-breaking continuum of superfluid Fermi gases and BCS superconductors, as suggested by Littlewood and Varma in 1982.
The existence of a collective mode clearly distinct from the edge of the continuum at 2Δ (twice the gap) was still controversial, in particular at zero wavenumber where a resonance corresponding to power-law damped oscillations of the pairing field was observed.
To reveal the collective mode, we perform a non perturbative analytic continuation of the pairing field propagator (including its amplitude-phase coupling) through the continuum branch cut. The collective branch exists as long as the chemical potential μ is positive and the wavenumber strictly positive and below $\sqrt{2m\mu}/\hbar$ (with m the fermion mass). The associated resonance is clearly observable as a broadened peak in the order-parameter-amplitude response function. We fully characterize its complex dispersion relation in the RPA, including in the strong coupling regime and at short wavelengths. In the long wavelength limit, the branch varies quadratically with the wavenumber, with a complex effective mass that we compute analytically. This contradicts the result of Littlewood and Varma that prevailed so far.

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