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Competition between final-state and pairing-gap effects in the radio-frequency spectra of ultracold Fermi atoms

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Ultracold Fermi atoms allow the realization of the crossover from Bardeen-Cooper-Schrieffer (BCS) superconductivity to Bose-Einstein condensation (BEC), by varying with continuity the attraction between fermions of different species. In this context, radio-frequency spectroscopy provides a microscopic probe to infer the nature of fermionic pairing. In the strongly-interacting regime, this pairing affects a wide temperature range comprising the critical temperature T_c , in analogy to the pseudo-gap physics for high-temperature superconductors. By including final-state interactions affecting the excited level of the transition, calculations are here reported of radio-frequency spectra of ultracold Fermi atoms with balanced populations, both below and above T_c , and compared with available experimental data. In the superfluid phase below T_c our calculation rests on the use of the BCS-RPA approximation, while in the normal phase above T_c it includes the Azlamazov-Larkin type contribution which is familiar in the theory of “paraconductivity” fluctuations in superconductors, besides the density-of-states contribution. In both cases, the limit of a molecular spectrum is correctly recovered in the BEC regime of the crossover. A competition is revealed between pairing-gap effects which tend to push the oscillator strength toward high frequencies away from threshold and final-state effects which tend instead to pull the oscillator strength toward threshold. In addition, an energy scale associated with pairing is extracted from the spectra and related to a universal quantity recently introduced for Fermi gases.