

# Hetero-pairing and pseudogap phenomena in the BCS-BEC crossover regime of an ultracold Fermi gas with mass imbalance

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We theoretically discuss strong-coupling properties of an ultracold Fermi gas in the case when Cooper pairs are formed between different species with different masses ( $m_L < m_H$ ). Including strong pairing fluctuations within a self-consistent  $T$ -matrix approximation, we self-consistently determine the superfluid phase transition temperature  $T_c$  for arbitrary ratio  $m_L/m_H$  of mass imbalance, over the entire BCS-BEC crossover region[1,2]. In particular, we find that a  ${}^6\text{Li}$ - ${}^{40}\text{K}$  Fermi gas mixture ( $m_L/m_H = 0.15 \ll 1$ ), which is a strong candidate for the mass-imbalanced Fermi gas superfluid, always has a finite  $T_c$  in the whole BCS-BEC crossover region. In the crossover region, we also show that the so-called pseudogap phenomenon associated with strong pairing fluctuations occurs, as in the case of ordinary mass-balanced Fermi gas ( $m_L/m_H = 1$ ). However, in contrast to the mass-balanced case, detailed pseudogap structures are very different between the light mass component and heavy mass component, although both the components equally contribute to pairing fluctuations. In the highly mass-imbalance regime ( $m_L/m_H \ll 1$ ), one finds that, while a clear pseudogap is seen in the density of states in the light mass component, such a dip structure is absent in the heavy mass component. Since hetero-Cooper pairs have recently been discussed in various fields, not only in cold Fermi gas physics, but also an exciton (polariton) condensate in semiconductor physics, as well as a color superconductor in particle physics, our results would contribute to the further understanding of these exotic Fermi superfluids.

- [1] R. Hanai, T. Kashimura, R. Watanabe, D. Inotani, and Y. Ohashi, Phys. Rev. A **88**, 053621 (2013).
- [2] R. Hanai, and Y. Ohashi, Phys. Rev. A (2014) in press (ArXiv:1407.7232).