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BCS to BEC evolution for mixtures of fermions with unequal masses[1]

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I discuss the zero and finite temperature phase diagrams of a mixture of fermions with unequal masses with and without population imbalance, which may correspond for example to mixtures of ^{6}Li and ^{40}K, ^{6}Li and ^{87}Sr, or ^{40}K and ^{87}Sr in the context of ultracold atoms. At zero temperature and when excess fermions are present, at least three phases may occur as the interaction parameter is changed from the BCS to the BEC regime. These phases correspond to normal, phase separation, or superfluid with coexistence between paired and excess fermions. The zero temperature phase diagram of population imbalance versus interaction parameter presents a remarkable asymmetry between the cases involving excess lighter or heavier fermions [1, 2], in sharp contrast with the symmetric phase diagram corresponding to the case of equal masses. At finite temperatures, the phase separation region of the phase diagram competes with superfluid regions possessing gapless elementary excitations [3] for certain ranges of the interaction parameter depending on the mass ratio. Furthermore, a phase transition may take place between two superfluid phases which are topologically distinct. The precise location of such transition is sensitive to the mass ratio between the two species of fermions. Signatures of this possible topological transition are present in the momentum distribution or structure factor, which may be measured experimentally in time-of-flight or through Bragg scattering, respectively. Lastly, throughout the evolution from BCS to BEC, I discuss the critical current and sound velocity for unequal mass systems as a function of interaction parameter and mass ratio. These quantities may also be measured via the same techniques already used in mixtures of fermions with equal masses.

[1] M. Iskin, and C. A. R. Sa de Melo, Phys. Rev. Lett. 97, 100404 (2006).
[2] M. Iskin and C. A. R. Sa de Melo, Phys. Rev. A 76, 013601 (2007).
[3] Li Han, and C. A. R. Sa de Melo, arXiv:0812.xxxx

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