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Abstract for an Invited Paper  
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**The important role of temperature in BCS–Bose-Einstein condensation crossover phenomena with population imbalance<sup>1</sup>**

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Any comparison between theory and experiment in the cold Fermi gases requires that one include the effects of non-zero temperature  $T$ . In this talk we show how to include finite  $T$  in a way which is compatible with the generalized BCS-like ground state, assumed in essentially all  $T = 0$  calculations of gases with population imbalance. We use a pairing fluctuation theory of BCS–Bose-Einstein condensation (BEC) based on a  $T$ -matrix formalism. Distinguishing this theory from strict mean-field theories is our self-consistent treatment of incoherent, finite-momentum pairs along with single fermions. This leads to a pseudogap in the fermion excitation spectrum at finite  $T$  which is necessary in order to arrive at physically meaningful transition temperatures  $T_c(p)$ , where  $p$  is the polarization. We present phase diagrams in the  $p$ - $T$  plane with variable scattering length,  $1/k_F a$ , and identify the regions where bulk superfluidity, normal phases and phase separation appears. For the trapped Fermi gases, we present particle density profiles for general  $1/k_F a$  as well as a detailed comparison with recent measurements at both MIT and Rice University. We find reasonably good agreement with these experimental data.

1. C.-C. Chien, Q.J. Chen, Y. He, and K. Levin, *Intermediate temperature superfluidity in an atomic Fermi gas with population imbalance*, Phys. Rev. Lett. 97, 090402 (2006).
2. Q.J. Chen, Y. He, C.-C. Chien, and K. Levin, *Stability conditions and phase diagrams for two component Fermi gases with population imbalance*, cond-mat/0608454; Phys. Rev. A 74, 06xxxx (2006).
3. C.-C. Chien, Q.J. Chen, Y. He, and K. Levin, *Finite temperature effects in trapped Fermi gases with population imbalance*, Phys. Rev. A 74, 021602(R) 2006.

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