Stoner Ferromagnetism in a spin-1/2 thermal Bose gas

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The notion of competing orders is fundamental to our understanding of strongly correlated systems. One such example is the interplay between magnetism and superconductivity or superfluidity. While superconductivity expels magnetic fields in weakly coupled systems, in strongly correlated materials, superconductivity and magnetism are often in close proximity to one another, and one order appears as the other disappears. While most of these phenomena occur at low temperatures due to quantum fluctuations, thermal fluctuations can also lead to the appearance of intermediate phases, which break fewer symmetries compared to the fully ordered low temperature state. In this talk, I will discuss the interplay between superfluidity and magnetism in a pseudo-spin-1/2 Bose gas. Remarkably, at finite temperatures, near the Bose condensation transition, strong interactions give rise to magnetism even in the absence of superfluidity. This is a bosonic analog of the well known Stoner ferromagnetic transition in itinerant electrons.

I will also show how interactions can lead to other exotic phases such as a Bardeen Cooper Schrieffer-like paired state for bosonic systems. While this phase is less ordered compared to the Bose condensate and is typically unfavored at low temperatures, thermal fluctuations allow for the appearance of such a state. I will discuss the implications of these results to ongoing experiments on strongly correlated bosonic gases.

FIG. 1: (color online) Itinerant Ferromagnetism in a pseudo-spin-1/2 Bose gas – Intra-species interactions are repulsive, while the inter-species interaction $g_{\uparrow\downarrow}$ varies. $T_c$ is the ideal gas Bose condensation temperature (only $T > T_c$ is shown), $a_{\uparrow\downarrow}$ is the inter-species scattering length, and $n$ is the total density. For $|g_{\uparrow\downarrow}|$ greater than a critical value, system develops ferromagnetic order in z-direction (ZFM)/x−y plane (TFM) above the superfluid transition. Dashed line shows the transition between the normal unpolarized state (UN) and the paired state. TFM is always favored over pairing in 3D.