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2012 IUPAP C10 Young Scientist Prize on the Structure and Dynamics of Condensed Matter Lecture: Spin Fluctuations and Pairing in Fe-based Superconductors

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The origin of superconductivity in the Fe-based superconductors, like that in other unconventional superconductors, remains shrouded in mystery. How the pairing bosons emerge either due to or in spite of the strong magnetic interactions found in the Fe-based superconductors is one of the most thoroughly investigated questions in the field. A prominent example of the interplay of superconductivity and magnetism is the dramatic shift of spectral weight from the low energy spin excitations to an energy which is related to the superconducting gap resulting in a peak in the spin excitation spectrum localized in both momentum and energy which occurs at the onset of superconductivity. The appearance of the new peak in the spin excitation spectrum below the superconducting transition temperature is referred to as s spin resonance and is most commonly interpreted as indicating a sign change of the superconducting order parameter on different portions of the Fermi surface and thus is consistent with an extended s-wave or s$\pm$ pairing symmetry in many Fe-based superconductors. We will review the observations and implications of the spin resonance across the Fe-based superconductors. In particular we will examine the relationship between the resonance energy and the superconducting transition temperature as a function of chemical doping and pressure. While the spin resonance provides important information about pairing symmetry, there does not appear to be sufficient spectral to explain the pairing strength. Thus the remainder of the spin excitation spectrum must be examined to determine if spin fluctuations are ultimately responsible for pairing in the Fe-based materials. Consequently, we will discuss in detail the way in which the spin excitations evolve from the nonsuperconducting compounds to their superconducting relatives as a function of chemical doping.