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NMR Study of Superconductivity and Spin Fluctuations in Intercalated Iron Selenides $A_yFe_{2-x}Se_2$[1]

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The role of spin fluctuations in superconductivity is an essential topic in both cuprate and Fe-based superconductors. NMR works in several Fe-based superconductors proposed that the low-energy antiferromagnetic spin fluctuations (AFSF) is a possible pairing glue for superconductivity. However, studies on other systems such as KFe_2As_2 and $Li_{1-x}FeAs$ does not support a strong correlation between low-energy spin fluctuations and superconductivity. In the newly discovered $A_yFe_{2-x}Se_2$ superconductors with $T_c \sim 32$ K, our NMR study identifies unambiguously a paramagnetic superconducting phase, which is phase separated from the block antiferromagnetic state. The low-energy AFSF is not seen at all, even though the T_c is high. The $A_yFe_{2-x}Se_2$ are singlet superconductors evidenced from the NMR Knight shift K; However, the absence of the coherence peak in the spin-lattice relaxation rate $1/T_1$ suggests an unconventional behavior of superconductivity. In fact, we found that both the K and the $1/T_1T$ increase dramatically with temperature and follow a $a + bT^2$ form from Tc up to 300 K. Such behavior is strong evidence for spin fluctuations with a high-energy, local nature in 3D systems, and inconsistent with a band-gap effect. Furthermore, K and $1/T_1T$ saturate above 400 K, indicating an energy scale of 35 meV, which is distinct from the low-energy spin fluctuations. The above temperature enhanced spin fluctuations seem to be universal in Fe-based superconductors.

References: W. Yu et al., Phys. Rev. Lett. 106, 197001 (2011); Long Ma et al., Phys. Rev. B 83, 174510 (2011); L. Ma et al., arXiv:1103.4960.

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