NMR Studies on Iron-Pnictide Superconductors

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We present NMR results on iron-pnictide superconductors of $LaFeAs(O_{1-x}F_x)$ and $BaFe_2(As_{1-x}P_x)_2$. In $LaFeAs(O_{1-x}F_x)$, $1/T_1$ in the undoped LaFeAsO exhibits a distinct peak at $T_N \sim 142$ K below which NMR spectra become broadened due to the internal magnetic field attributed to an antiferromagnetic (AFM) ordering. In the x=0.04 sample, $1/T_1T$ of ^{75}As exhibits a Curie-Weiss temperature dependence down to 30 K, suggesting the development of AFM spin fluctuations, and decreases below superconducting(SC)-transition temperature $T_c \sim 16$ K. The AFM fluctuations are significantly suppressed with F-doping, and a pseudogap behavior is observed in $1/T_1T$ in the x=0.11 sample with a maximum $T_c \sim 23$ K in $LaFeAs(O_{1-x}F_x)$ [1]. The spin dynamics vary markedly with F-doping, which is ascribed to the change of the nesting between hole and electron Fermi-surfaces by the electron doping, and the pseudogap behavior in $1/T_1T$ is shown to originate from the characteristic energy dependence of the density of state around the Fermi energy. The significant suppression of $1/T_1T$ upon F doping while T_c remains nearly unchanged suggests that the low-energy AFM fluctuations probed by the NMR measurements do not play an important role in the superconductivity in $LaFeAs(O_{1-x}F_x)$[2].

On the contrary, $1/T_1T$ in $BaFe_2(As_{0.67}P_{0.33})_2$ with a maximum $T_c \sim 30$ K in $BaFe_2(As_{1-x}P_x)_2$ continues to increase down to T_c, indicating the development of the AFM fluctuations, and sharply decreases below T_c due to opening of the SC gap. The AFM fluctuations are suppressed and T_c also decreases with increasing P content. From the analyses of $1/T_1T$ in the normal state, it is shown that the maximum T_c sample is located in the vicinity of the quantum critical point of the AFM ordering, and that the AFM fluctuations are intimately related to the superconductivity in $BaFe_2(As_{1-x}P_x)_2$. It was found that the relationship between the AFM fluctuations and superconductivity are quite different between $LaFeAs(O_{1-x}F_x)$ and $BaFe_2(As_{1-x}P_x)_2$.

We also show that the SC gap in $BaFe_2(As_{0.67}P_{0.33})_2$ revealed by $1/T_1$ below T_c possesses the residual density of state near E_F, suggesting the presence of the nodes in the SC gap[3]. This is different from other iron-pnictide superconductors. We discuss possible SC state in $BaFe_2(As_{0.67}P_{0.33})_2$ and other iron pnictides, and the similarity between $BaFe_2(As_{0.67}P_{0.33})_2$ and heavy-fermion superconductors.

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