MAGNETIC STRUCTURE EVOLUTION OF $FeP_{1-x}As_x$ ($0 < x < 0.5$)

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Transition-metal pnictides have attracted considerable attention due to their diverse electronic, magnetic, and structural properties. The MX family of binary compounds, which includes FeAs, FeP, CrAs, MnAs, and MnP, are particularly noteworthy for exhibiting magnetic phase transitions triggered by changes in temperature, external magnetic fields, or pressure and adopting a double helical magnetic structure at low temperatures[1]. Furthermore, CrAs, MnP, and WP have been found to become superconductors while the helical magnetic ordering is completely repressed[2].

A comprehensive study of FeP powder samples using ^{57}Fe Mössbauer and ^{31}P NMR spectroscopy across a wide temperature range was conducted by Sobolev et al[3]. At temperatures below T_N the ^{57}Fe Mössbauer spectra exhibit a complex Zeeman pattern with line broadening and significant spectral asymmetry. It is consistent with an anisotropic and anharmonic space-modulated helicoidal magnetic structure. In this study the magnetic properties of $FeP_{1-x}As_x$ ($x = 0.1, 0.33, 0.5$) and the effect of substituting phosphorus with arsenic were studied by combining the benefits of ^{57}Fe Mössbauer and ^{31}P NMR techniques.

At room temperature, the ^{57}Fe Mössbauer spectra of $FeP_{0.5}As_{0.5}$ exhibit narrow symmetric lines in a quadrupole doublet, indicating that the iron atoms in $FeP_{0.5}As_{0.5}$ occupy equivalent crystal positions. To analyze the spectra obtained at temperatures below T_N, we employed a model previously proposed in [3], which has been successfully applied to FeP spectra. Our findings indicate that the helical ordering of the iron magnetic moments at $T < T_N$ is associated with the magnetocrystalline anisotropy in the helical plane of $FeP_{0.5}As_{0.5}$. Also, they could only be accurately described within the previously mentioned model by incorporating a high anharmonicity parameter.

Field-sweep ^{31}P NMR spectra at various fixed frequencies and zero-field NMR spectra measurements at 4.2 K were done on a single-phase polycrystalline sample of $FeP_{1-x}As_x$ ($x = 0.1, 0.33, 0.5$). However, a significant reduction in the symmetry of the magnetic structure was observed in $FeP_{1-x}As_x$ with substitution levels $x \geq 0.33$, leading to a substantial narrowing of the ^{31}P NMR spectra. In that case, instead of an abrupt shift from the paramagnetic state to the helical spin state at 120 K, we discovered that a gradual transition to a spin glass state occurs within a temperature range of 20-30 K.

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