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VENUE

Pedagogical University of Cracow, Podchorążych 2, 30 084 Kraków.
Lecture hall 110N and 102N
in the new building of PUC, the main entrance at Chmiela street.

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Magnetism of iron-based superconductors
parent compound PrFeAsO
studied by Mössbauer spectroscopy

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The compound PrFeAsO is a parent compound of the iron-based superconductors belonging to the ‘1111’ family. It crystallizes in the tetragonal structure. An itinerant 3d magnetic order develops at about 158 K and it is accompanied by an orthorhombic distortion of the chemical unit cell. A complete longitudinal 3d incommensurate spin density wave (SDW) order develops at about 138 K. A region between above two temperatures is called a “nematic” phase with poorly understood microscopic magnetic properties. Praseodymium orders magnetically at about 12 K leading to the substantial transferred field on iron nuclei due to the large orbital contribution to the magnetic moment. A reorientation of the praseodymium magnetic moments occurs at still lower temperatures [1].

Mössbauer measurements were performed on the powder sample in the temperature range 4.2 – 300 K by using 14.4-keV resonant transition in ⁵⁷Fe. Spectra develop shape typical for SDW magnetic order. Transferred field due to the praseodymium magnetic order and subsequent reorientation of praseodymium moments is seen below 12 K. The shape of SDW is almost rectangular at low temperatures and transforms into roughly triangular form around “nematic” transition at about 138 K.

Significant part of SDW along propagation direction is almost free of the ordered electronic spins above “nematic” transition, but still below transition to the magnetically disordered (non-magnetic) state. Hence, it is likely that somewhat “mysterious nematic” phase is a region of incoherent spin density wavelets typical for a critical region. On the other hand, one has to realize that this region is exceptionally broad on the temperature scale (almost 20 K) and the reasons for that are rather poorly understood. One possible hint could be strong scattering of the electronic spins on the large localized moments of praseodymium with significant orbital contribution. Figure 1 shows Mössbauer spectra at selected temperatures, corresponding hyperfine field \( B \) distributions \( W(B) \) and shape of the SDW \( B_{\text{SDW}}(q,x) \) plotted versus phase angle \( qx \). The symbol \( \langle B \rangle \) stands for the average hyperfine field, while the symbol \( B_{\text{max}} \) denotes maximum amplitude of SDW. Symbols h1, h3 and h5 denote amplitudes of respective harmonics within SDW.
Figure 1. Mössbauer spectra, hyperfine magnetic field distributions on the iron nuclei $W(B)$ and corresponding shape of SDW $B(qx)$ at selected temperatures. The spectrum of 78 K exhibits almost fully developed SDW, while spectra at remaining temperatures show transition from the phase having developed magnetic SDW order into the so-called “nematic” phase with partial magnetic order of 3d character. A transition occurs within orthorhombic phase.

Reference

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