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Neutron investigations of the magnetic properties of $Fe_xMn_{1-x}S$ under pressure up to 4.2 GPa

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$Fe_xMn_{1-x}S$ belongs to the group of strong electron correlations compounds MnO. We present here experimental results for the antiferromagnetic iron-manganese sulfide system, based on X-ray and neutron diffraction studies. The neutron diffraction investigations were carried out at ambient conditions and at hydrostatic pressures up to 4.2 GPa in the temperature range from 65 to 300 K. Our results indicate that the Néel temperature of α-MnS increases up to room temperature by applying chemical (x_{Fe}) or weak hydrostatic pressure P. In $Fe_{0.27}Mn_{0.63}S$, the Néel temperature increases from 205(2) K ($P = 0$) to 280(2) K ($P = 4.2$ GPa) and the magnetization at 100 K decreases by a factor of 2.5 when increasing the hydrostatic pressure from 0 to 4.2 GPa. α-MnS, like to MnO, FeO, CoO and NiO, has a cubic (NaCl-type) structure, is an II type antiferromagnet and belongs to a systems with strong electron correlations. The Mott transition at 300 K in this substance is realized under the pressure $P_{\mathrm{c}} = 26{-}30$ GPa. High-pressure-induced phase transitions followed by the collapse of the localized magnetic moment are theoretically predicted [1, 2] and observed [3, 4] in strong electron correlations systems. The main experimental methods are the Mossbauer method and the investigation of XES spectra. The possibility of using the neutron diffraction method is limited to critical pressures up to 10 GPa. It was established earlier, that in the system of $Fe_xMn_{1-x}S$ solid solutions synthesized on the basis of α-MnS, with increasing x (that means the increasing of the chemical pressure), the values of the resistivity, optical gap and critical pressure P_{c} [5] are decrease.

In this paper, we present the results of an investigation of the magnetic properties of $Fe_xMn_{1-x}S$ ($x < 0.3$) by method of neutron diffraction.

Fig. 1 shows the temperature dependences of the square root of the integral intensity $|F_{\mathrm{mag}}| = M \approx \sqrt{I}$ for the magnetic peak $(1/2, 1/2, 1/2)$, which is typical for the antiferromagnetic phase of manganese monosulfide and its solid solutions, and is proportional to the magnetization (M) of the sublattices (I – the integrated intensities of the magnetic peak).

The decreasing of the sublattice magnetization $|F_{\mathrm{mag}}| \sim \sqrt{I}$ with the increasing hydrostatic pressure for $Fe_xMn_{1-x}S$ with $x = 0.27$ (see Fig. 1) was observed. For example, at 100 K the magnetization $|F_{\mathrm{mag}}|$ of the sample non-linearly decreases up to 2.5 times with increasing pressure up to 42 kbar (4.2 GPa). The Néel temperature of the $Fe_{0.27}Mn_{0.73}S$ sample at ambient pressure was derived from D1A and IN8 data, $T_{\mathrm{N}} = 205 \pm 5$ K. The shift of the Néel temperature up to 280 K was detected with increasing pressure up to 4.2 GPa. One of the possible mechanisms for the observed decreasing of the magnetization may be a spin crossover, with the changing of the magnetic state of manganese and iron ions.

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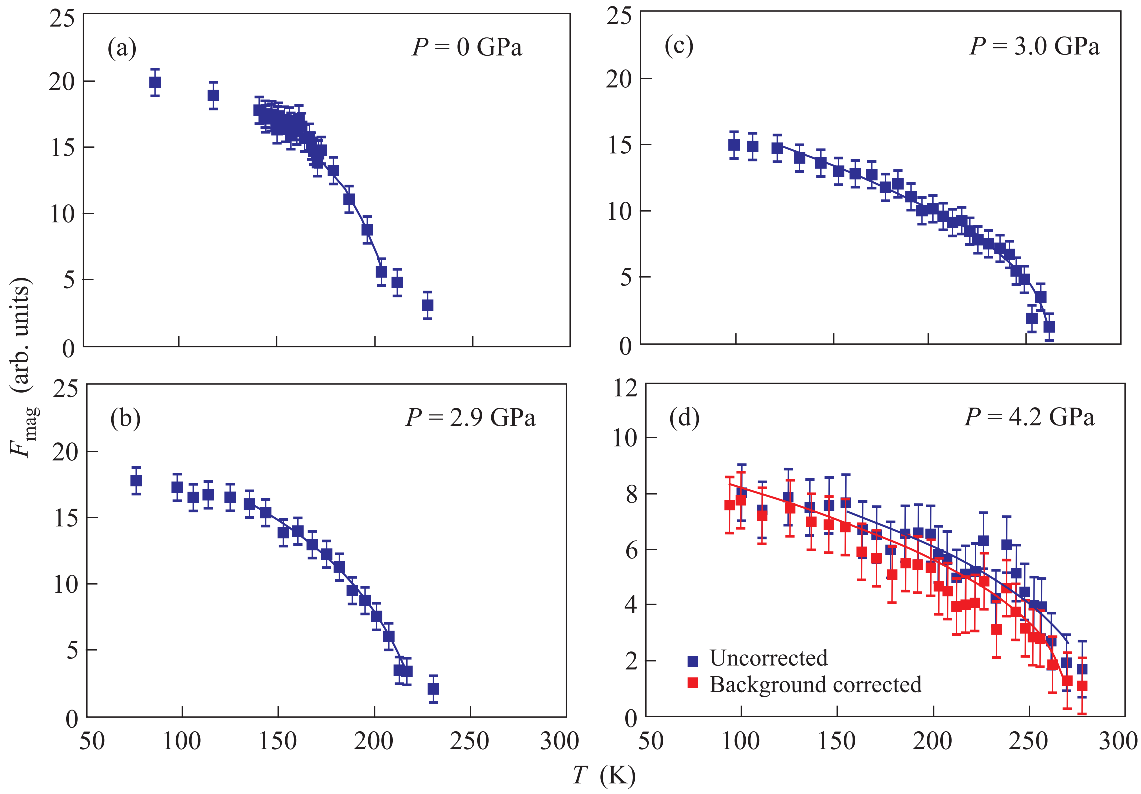

Fig. 1. (Color online) $|F_{\mathrm{mag}}|$ for $Fe_{0.27}Mn_{0.63}S$ as a function of the interpolated temperature T_{Inter} for different hydrostatic pressure values P (data: IN8@ILL)

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