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μSR Study of the Relationship between the Magnetism, Superconductivity and Electronic Nematicity in Iron-Chalcogenide Thin Films

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The iron-chalcogenide FeSe exhibits various electronic states such as superconductivity, the so-called electronic nematicity, as well as a magnetic order under hydrostatic pressure. Therefore, this system attracts considerable research attention in an effort to understand the interplay between the different electronic states. In S-substituted thin films of $FeSe_{1-x}S_x$ in which positive chemical pressure is induced by the smaller S substitution for larger Se, we formerly found a kink in the temperature dependence of the electrical resistivity at highly S-substituted thin films of $x \geq 0.18$ without the nematic state [1]. The kink has been observed around the magnetic transition temperature T_N in bulk FeSe under pressure [2]. To investigate the possible magnetism in $FeSe_{1-x}S_x$ and compare with Te-substituted $FeSe_{1-y}Te_y$ in which negative chemical pressure is induced, we performed muon-spin-relaxation (μSR) measurements [3].
Zero-field μSR time spectra of $FeSe_{1-x}S_x$ with $x = 0.3$ and 0.4 revealed the formation of a short-range magnetic order at low temperatures. The value of T_N is higher in $x = 0.4$ than in $x = 0.3$, suggesting a S-induced magnetic order in the $FeSe_{1-x}S_x$ thin films. For slightly S-substituted $x = 0.1$ with the nematic state, on the other hand, it was found that a long-range magnetic order was formed at low temperatures. As the value of T_N at $x = 0.1$ is higher than that of $x = 0.4$, distinct magnetic states would be formed in the slightly (with nematic) and highly (without nematic) S-substituted $FeSe_{1-x}S_x$.

[1] F. Nabeshima *et al.*, J. Phys. Soc. Jpn. **87**, 073704 (2018).
[2] T. Terashima *et al.*, J. Phys. Soc. Jpn. **84**, 063701 (2015).
[3] F. Nabeshima *et al.*, Phys. Rev. B **103**, 184504 (2021).

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