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Field Dependent Ni K-edge EXAFS Studies of MgCNi₃ Superconductor.

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Beamline(s): X11A

Introduction: Our previous Ni K-edge EXAFS analysis of MgCNi₃ superconductor indicate that Ni-Ni pair distribution function (PDF) becomes unusually broad when $T < T^* \sim 70$ K [1]. Ni-Ni interatomic potential can be ascribed using a polynomial of degree four. Direct EXAFS fit to the experimental data indicate that the polynomial reduces to typical double-well potential at $T^* \leq 70$ K and to conventional single-well anharmonic potential at $T \geq 200$ K. The observed distortions could be a signature of local charge density waves (LCDWs) and/or local spin density waves (LSDWs). Strong enough external magnetic field supposes to enhance LSDWs. If local distortions were coupled with LSDWs one would expect to observe larger distortions in applied field.

Methods and Materials: Field dependent Ni K-edge EXAFS spectra were recorded at beamline X11A in the transmission mode up to $k_{\text{max.}} = 20 \text{ \AA}^{-1}$ (the momentum transfer, $Q = 2k_{\text{max.}} = 40 \text{ \AA}^{-1}$). Three set of data were collected at 70 K: Firstly, the magnetic field (of 2 Tesla) was parallel to the direction of x-ray beam (field cooled). Secondly, and the magnetic field (of 2 Tesla) was set perpendicular to direction of the x-ray beam. Lastly, there were no magnetic field applied. (Sample was heated up to room temperature and then zero-field cooled).

Results: Careful analysis of the collected data reveals no difference between EXAFS spectra collected at two directions of the applied magnetic field (that is expected for the powder sample). We have not observed any impact of the applied magnetic field up to $k_{\text{max.}} = 17 \text{ \AA}^{-1}$.

Conclusions: Absence of the coupling between local distortions and applied magnetic field could mean that the LSDWs do not form in MgCNi₃ despite the common perception (based on LDA calculations) suggesting MgCNi₃ to be on a verge of magnetic instability.

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References: [1] A.Yu. Ignatov, L.M. Dieng, T.A. Tyson, T. He, and R.J. Cava, "Observation of a low symmetry crystal structure for superconducting MgCNi₃ by Ni K- Edge x-ray absorption measurements", (Submitted to Phys. Rev. B).