

Magnetic properties of the Eu-monochalcogenides at extreme pressures

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The divalent Eu-chalcogenides EuX (X = O, S, Se, Te) are well-known model substances for Heisenberg magnetism because of the spin-only $J = S = 7/2$ 4f-moment of the Eu²⁺-ions and their simple NaCl structure. The variation of the magnetic ordering temperatures with pressure has been intensively studied in the NaCl phases up to 30 GPa using ¹⁵¹Eu-Mössbauer and neutron spectroscopy [1, 2], delivering important information on the pressure dependence of the magnetic exchange interactions.

Here we present for the first time systematic studies on EuO, EuS, EuSe and EuTe in their CsCl-type high-pressure phases up to 120 GPa using the ¹⁵¹Eu nuclear forward scattering (NFS) technique developed at the ESRF, where the present studies as well as previous studies on other Eu systems were performed [3]. The NaCl to CsCl phase transitions occur around 45, 20, 15 and 12 GPa for EuO, EuS, EuSe and EuTe, respectively. The samples were pressurized in a special diamond anvil cell designed to fit into the cryomagnet at ID22N. At each pressure we measured NFS spectra from 4 K up to 300 K to determine the magnetic ordering temperature T_M , the saturation magnetic hyperfine field B_{hf} and the isomer shift S_{IS} with respect to an applicable Eu reference absorber. The results on EuTe in the CsCl phase are already published [3].

In the CsCl-type high-pressure phases of EuSe, EuS and EuO we observe a further strong increase of the ferromagnetic ordering temperatures T_C , reaching 300 K at 77 GPa for EuSe, 295 K at 120 GPa for EuS and 165 K at 75 GPa for EuO. For EuS the pressure dependent slope of T_C denotes a saturation at the highest pressure in a strongly mixed valent state. In the case of EuO we found at even higher pressures a strong decrease of T_C to 110 K at 92 GPa, a behaviour resembling that of EuO around 30 GPa in the NaCl phase [1]. This behaviour points to the onset of a mixed-valent state in CsCl-type EuO, which is also reflected by the isomer shift and the variation of B_{hf} .

We discuss the present results in conjunction with models developed for magnetic and mixed-valent Eu systems, for instance for Eu metal at high pressures [4].

Work supported by the BMBF (grant no 05 KS4PPB/4)

References

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