Magnetization distribution in anisotropic antiferromagnetic systems: An example of Co-olivine

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Neutron diffraction plays an important role for studying magnetism. The classical polarized neutron diffraction technique (flipping-ration measurements in an applied magnetic field) is used to study the magnetization distribution in paramagnetic and ferromagnetic materials [1]. It is much more difficult to make such measurements in antiferromagnetic systems where the cross-section is not often polarization dependent and, therefore, the classical method is not applicable. For some magnetic structures the recently developed zero-field spherical neutron polarimetry technique allows the determination of the magnetization distribution in the ground antiferromagnetic state [2]. Here, we show the possibilities and limitations of the techniques on the example of antiferromagnetic Co-olivine, Co_2SiO_4 [3]. Natural olivine $(Mg_{1-x}Fe_x)_2SiO_4$ is a major phase in the solar system. However, besides the fundamental importance for geologists and mineralogists, olivines display a surprising variety of chemical and physical properties. Synthetic Co_2SiO_4 crystallizes in the olivine structure and shows antiferromagnetic ordering below 50 K. Its magnetic structure has been studied by means of polarized neutron diffraction (flipping-ratio measurements) on a single crystal. The data refinement was done by using the recently developed local susceptibility approach, which assigns a site susceptibility tensor to each crystallographically independent site [4]. The results of the model-based refinement were compared with the model-free maximum-entropy reconstruction of the magnetization density. A field-induced magnetization shows anisotropy, which is rather small at high temperatures but becomes strongly enhanced when approaching the ordering temperature. The refinement revealed a significant orbital component to the total magnetic moment of the Co^{2+} ions. In addition, a non-negligible amount of magnetic moment on the oxygen positions was found, indicating a delocalization of the magnetic moment from Co towards neighbouring O owing to superexchange coupling. The relative strength of the exchange interactions is discussed. Some other systems and future perspectives in polarized neutrons are also briefly reported.

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