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Report

The aim of this experiment was to obtain Magnetic Circular Dichroism (MCD) spectra of *paramagnetic materials in the hard x-ray range. So* far paramagnetic dichroism studies have been performed exclusively in the soft x-ray range. The interest of the experiment in the hard x-ray range is that it furthers the understanding of high energy XMCD and spin polarized EXAFS since the magnetic signal has to be generated by the paramagnetic atom itself, without contributions to the spin polarized backscattering of the neighboring magnetic atoms. Also, as we show in this report, it allows one to obtain valuable information on the 4f 5d exchange interaction. For this first experiment we studied the $L_{2,3}$ edges of Gd cyclam. We choose the cyclam system as test sample since it is of relevance to the more dilute biological samples that we hope to study in future.

In Fig. la and b we present the direct and dichroic spectra obtained in a field of 7 Tesla and 2 K using fluorescence detection. The flat pellet sample was mounted at 45 degrees incidence, The dichroic spectra were obtained by phase reversal of the helical undulator.

For each dichroic curve 6 (+) and 6 (-) spectra were pre and post-edge normalized and averaged. Both edges show a dichroic spectrum that is closely similar to the derivative. The amplitude is about 1.6 % for the L_3 and 7.5 % for the L_2 , the sign of the structure being opposite for the two edges, as normally the case for the L edges. In the case of the L_2 edge the dichroic spectra obtained via the normalization procedure are very close to those obtained from the raw data. To extract the L_3 spectrum normalization was unavoidable. Since it is very easy to obtain artificial derivate-like MCD spectra, naturally we checked the magnetic origin of the signal by reversing the magnetic field and obtained the proper inversal.

The fact that the spectrum is derivative-like means that the + and - helical spectra are shifted with respect to each other. The necessary shifts are too big to explain by a simple Zeeman splitting by the external field and one has to look for a stronger interaction. This may well be the 4f-5d exchange interaction. We arrive therefore at a qualitative picture in which the 4f magnetic moment is oriented by the external field, which then produces a 4f-5d exchange field that leads to an effective shift of the 5d spin up and spin down levels. A further quantitative analysis of the spectra is under way.