α - Fe_2O_3

The magnetic structure of hematite has been determined in the neutron diffraction studies of Shull, Strauser and Wollan [3]. This work showed that below the Néel point there exist two antiferromagnetic states. Below approximately -20°C the magnetic axis lies along the trigonal axis as in Cr_2O_3. At room temperature the spins are in the (111) planes, remaining ferromagnetically coupled within the planes; adjacent planes, however, are antiferromagnetically coupled. As a further confirmation of the H-J predictions we have studied the (100) reflection of the low temperature phase of hematite. Since this reflection is purely magnetic in origin, we can expect from equation (2) that D will go from +1 to -1 as β goes from 0 to $\pi/2$. This complete reversal of the neutron polarization was found at $\beta = \pi/2$ as predicted.

In addition to confirming the spin direction in the low temperature state of hematite as being along the trigonal axis, studies were made at room temperature of the effect of applied magnetic fields on the spin system of hematite. In this case the spins in the (111) plane can point in a number of directions. Because of the trigonal symmetry of the rhombohedral cell it is probable that the moments are directed at one of three nearest neighbors and this would lead to a set of three easy directions 120° apart. The value observed for D would then be the weighted average resulting from all the antiferromagnetic domains, that is

$$\bar{D} = \frac{\sum_i D_i q_i^2 N_i}{\sum_i q_i^2 N_i}$$

where D_i is the value of the polarization change, q_i the value q (as previously defined) and N_i, the fraction of spins, in each of the easy directions. In the case of the (111) reflection $q_i = 1$ since all the spins are at right angles to the scattering vector and $\bar{D} = \sum_i D_i N_i / \Sigma N_i$. For zero magnetic field and the easy directions equally populated, $\bar{D}$ is calculated to be zero for all angles of β. A study of D as a function of β for zero field showed this to be the case. It should be noted that this result does not exclude the possibility of a still larger number of easy directions, in fact the observed data can be shown to be consistent with any number of easy directions equal to, or greater than three.

When a magnetic field is applied within the (111) plane and parallel to the neutron polarization vector $\underline{\lambda}$, the observed values of D for the (111) reflection are found to be changed and to become negative. This is seen in Fig. 3, where a plot of D versus applied field is shown. Increasingly large negative values for $\bar{D}$ indicate that the effect of the applied field is to turn spins perpendicular to the applied field. We can, in fact, use the measured values of