Experiments on the Magnetic Properties of the Neutron

Certain experiments have been made to detect an alignment or polarization of neutrons, due to their magnetic moment, on passing through strongly magnetized materials. If the neutron has a magnetic moment of possibly −2 nuclear magnetons, it might be expected that while the magnetic forces are small, the long range of the atomic magnetic fields might give rise to an appreciable magnetic scattering for slow neutrons.[1, 2] If so, a change in the scattering of a neutron beam might be produced by a change in the orientation of the neutron moments.

In the first type of experiment, the scattering of a beam of thermal neutrons, on passing successively through two sheets of iron magnetized to saturation, was investigated. In one set of experiments the neutron beam passed normally through the two plates. In a second set the beam passed normally through the first plate, and at 70° to the normal through the second plate. In a third set the neutrons passed through both plates at an angle of 65° to the normal. In the first two cases, on reversal of the magnetization of the first plate, no changes in neutron transmission larger than the probable error (0.5 percent±1.5 percent) were observed. Table I shows the results for the third case in which readings were also taken with no field in the first plate. Under these conditions, the effect, it if exists, can scarcely be larger than 2 percent.

In the second type of experiment, as shown in Fig. 1, the neutrons were first passed through a sheet of iron magnetized to saturation (polarized at approximately 45° to the normal in one arrangement, and 30° in a second arrangement, and then scattered from the pole face of a second magnet (about 3000 gauss), which should serve as an "analyzer" if the scattering cross section depends on parallel or anti-parallel orientation of the neutron with respect to the field). Table II shows the results for 3 runs at 45° incidence and 2 runs at 30° incidence averaged together

TABLE I.

First Plate Field	Parallel to Second Plate	Anti-parallel to Second Plate	Zero
Total No. Counts	30,200	30,100	29,300
No./Minute	186.70±1.07	185.28±1.07	183.33±1.07
Differences		1.42±1.53	3.37±1.53
Background with Cd (averaged)	23.0		

TABLE II.

Polarizer Field Direction	Parallel to Analyzer Field	Anti-parallel to Analyzer Field	Zero Field, i.e., Unpolarized
Total No. Counts	12,700	11,500	15,600
No./Minute	50.81±0.48	49.40±0.44	48.80±0.40
Differences		1.41±0.66	2.01±0.65
Background with Cd (averaged)	22.4		

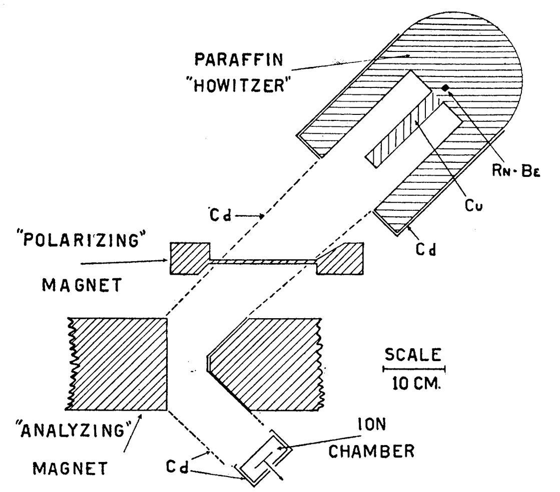

FIG. 1. Arrangement of apparatus for the second type of scattering experiment.

to increase the precision as they showed approximately the same trend. Runs were also taken with the polarizer field current zero, i.e., random orientation.

The difference 2.01±0.65 per minute between the unpolarized and the parallel case, and the difference of 1.41 ±0.66 per minute between the parallel and anti-parallel cases, are not considered to prove conclusively the existence of an effect. However, the consistency of the various runs is very good, and from a purely statistical standpoint, the probability that these results do not indicate a real effect should be small. The smaller difference, if real, between the parallel and anti-parallel cases, compared to the unpolarized case, may be reasonable if we consider that in the anti-parallel case, a considerable fraction of the neutrons after leaving the polarizing plate may lose their space quantization and reorient themselves parallel to the field of the large magnet. Hence there may be little difference between the two cases. The observed results in any given case would depend on the field configuration. It is, however, difficult to understand the direction of the changes, i.e., why the number per minute in the parallel case is larger than in the anti-parallel or in the unpolarized case. Tests have shown no appreciable effects due to the stray magnetic fields on the detection chamber.

The number of thermal neutrons per minute is only about 0.55 of the total count per minute, due to the background of faster neutrons, and hence these changes represent approximately 7.5±2.5 percent and 5±2.5 percent of the thermal neutron count. The nuclear cross section (scattering plus capture) is so large compared to the observable magnetic interaction cross section that detection of such effects is clearly difficult, but the indications are that further experiments are desirable.

J. R. DUNNING
P. N. POWERS
H. G. BEYER

Pupin Physics Laboratories,
Columbia University, New York City,
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[1] Bloch, Phys. Rev. **50**, 259 (1936).
[2] Schwinger, Unpublished.