Proposal For The Independent Measurement Of The Neutron Magnetic Moment

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Abstract. The magnetic moment of the neutron is accurately measured by comparing it with that of the proton using one principle that holds for both neutrons and protons. Other methods are only known to have an accuracy up to a few percent. We propose that the magnetic moment of the free neutron should be measured by an independent method. The main experimental issue is to control the magnetic field line integral along the neutron path to within the desired accuracy.

Keywords: Experimental proposal; Neutron magnetic moment

The neutron magnetic moment has been measured up to an accuracy of 0.2 ppm [1] by means of comparison with the proton magnetic moment via a magnetic resonance technique proposed by Ramsey [2]. When the neutron magnetic moment is measured by means of Larmor-precession in a known field, the obtained accuracy is much less due to the fact that the determination of the magnetic field line integral is much more inaccurate without a probe like a proton.

Indications of a different magnetic moment from other types of measurements have been obtained by Rauch [3], Wagh and Rachecka [4],[5] and Plomp [6]. These deviations are compatible with an increase in the expected magnetic moment of 0.9(3)%. The difference between these measurements and the previous ones is that the latter are performed for relatively small magnetic fields and the first are measurements with respect to the magnetic moment of the proton. The magnetic moment of the proton has been accurately determined for high magnetic fields only[1].

Further, a recent re-analysis of neutron lifetime experiments by Serebrov [7] exposes a systematic difference between experiments based on storage of ultra-cold neutrons and slow-neutron beam experiments. The neutron lifetime obtained by the latter experiments are compatible with an increase of 0.9(3)% with respect to the first. Again the difference being that the latter experiments are performed in a high magnetic field and the former with only a small (or Earth) magnetic field.

Assuming the above observed differences are more then experimental artifacts, the question arises if these deviations are related in view of their equal relative magnitude. In fact, such a connection might exists in view of an extended model of the neutron [8]. Is such a case an external magnetic field deforms the neutron, decreasing its magnetic moment corresponding to a decrease in the rotational speed of the neutron and an increase in its lifetime.

In view of the above it is unavoidable to check the above conjecture by performing measurements of the neutron magnetic moment as function of the applied magnetic field.

[1] Low magnetic fields measurements reported in [1] do not deviate significantly from the high field ones. However, the fields considered are the fields used in the experimental set-up, not the fields experienced by the core-bound protons used for the measurements.

Two types of experiments can be considered, relative and absolute.

The relative measurements determine the change in the neutron magnetic moment for different magnetic fields. In this case the magnetic field can be created by an accurately known small field added to an arbitrary (but fixed) large field. The magnetic moment can be determined by varying the small field. This can be done for increasing values of the large field. In this way the conjecture of the magnetic field dependence of the neutron magnetic moment can be tested.

For the absolute measurements an accurate knowledge of the magnetic field line integral along the neutron path is needed. This is an experimental difficulty that has been resolved already [9],[10]. Accuracies of the order of 0.01% can easily be obtained. Further also the wavelength of the neutron must be known within the required accuracy. This does not seem to be a very difficult task, allthough it sets some limitations on the neutron apparatus to be used.

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