EXPERIMENTAL SEARCH FOR THE VIOLATION OF FUNDAMENTAL SYMMETRIES IN $^{182}$W

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Fundamental symmetries are being investigated in oriented $^{182}$W via measurements of angular correlations of the gamma rays emitted following beta-decay of $^{182}$Ta. Nuclear orientation is achieved via hyperfine interactions in Fe with the help of a dilution refrigerator. In particular, the hindered 1189 keV transition is studied for P and PT violation. Current limits and future studies of P, PT and T violation in this and other nuclei are discussed.

1. Introduction

Angular correlation measurements of gamma rays emitted from cryogenically oriented nuclei provide what are currently some of the most sensitive tests of fundamental symmetry conservation in nuclear systems/1,2/. We have begun a search in $^{182}$W, using these techniques, for the violation of parity (P), time-reversal (T), and the simultaneous violation of parity and time-reversal (PT) symmetries. The interest in these symmetries stems from slightly different reasons. The presence of P violation in nuclear structure is reasonably well understood. A measurement of P violation in $^{182}$W will therefore provide a quantitative test of recent calculations of the size of these effects/3/. A large P violating effect in $^{182}$W also sets the stage for more precise limits on the size of PT violation in nuclear systems. On the other hand, the physical mechanism for T violation is not known, nor has T (or PT) violation been observed in nuclear systems. CP violation has been detected in the kaon system, however, implying that T and PT violation will appear at some level.

There are several reasons, from a theoretical and a practical standpoint, for selecting the mixed (E1,M2,E3) 1189 keV transition in $^{182}$W. The structure of $^{182}$W is advantageous, having two levels of opposite parity (the 2- state at 1289 keV and the 2+ state at 1221 keV) with the same total spin and projection K, placed about 68 keV apart (see Fig.1). This small energy difference ensures, in principle, that a P or PT violating interaction should produce relatively large mixings of the two states, giving rise to the "irregular", P or PT violating part of the 1189 keV transition. In addition, the regular part of the 1189 keV transition is hindered, while the irregular part arises from a collective vibrational transition. The greater speed of the irregular part implies an enhancement of the P or PT violating effect. For a more detailed discussion of the nuclear structure considerations prompting us to select $^{182}$W, see the paper by Griffiths and Vogel in these conference proceedings. Another important advantage, for the T and PT violation studies, is that the final state effects, which can produce a mimicry of T violation, are expected to be small/4/.

Experimentally, $^{182}$W is convenient because the desired states are well populated by beta-decay from $^{182}$Ta. This decay has a fairly long half-life
Figure 1: Level diagram of $^{182}$Ta.

(114 days) making it practical for studies at off-line facilities. Previous work has indicated that significant orientation of $^{182}$Ta can be produced at temperatures achievable in our dilution refrigerator. Finally, cascades exist which enable us to study T and PT violation through coincidence measurements of the angular distribution of emitted gamma rays.

2. Experimental Apparatus

Orientation of the nuclear sample is achieved by embedding it in an iron foil and cooling the foil in a dilution refrigerator. We expect an ultimate temperature for the $^{182}$W experiment between 17 and 24 mK. The sample is then immersed in a magnetic field generated by superconducting coils within the cryostat. Fields of 2 to 3 kG can be created at the iron foil. These fields are adequate to saturate the iron. Hyperfine interactions between the iron host and the nuclear sample then serve to orient the sample. For $^{182}$Ta, we expect hyperfine fields of about 66 T, which yield a hyperfine splitting of 21 mK.

Data collection and magnet control will be automated, controlled by a 386-33 PC microcomputer. A typical run involves acquiring data for roughly 10 minutes and then reversing the magnetic fields over about 30 seconds, waiting 2 minutes for the temperature to stabilize and then acquiring data for another 10 minutes. Data is collected in this fashion typically for several weeks.