Hyperfine Resonance of Positronium Atoms Using a Static Periodic Magnetic Field

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A positronium (Ps) atom has a ground-state hyperfine structure which is split into singlet and triplet spin states, called para-Ps and ortho-Ps, respectively. The transition energy is 8.4×10^{-4} eV (203 GHz), in the THz frequency domain. Usually the resonance of the hyperfine structure was measured using microwaves.

There is an another type of technique for the measurement of atomic resonances. When an atomic beam passes through a static periodic field, the atoms feel an oscillating field with a frequency $f=v/a$, where a is the period length of the field and v the atomic velocity. If f coincides with the transition frequency, a Motion Induced Resonance (MIR) occurs [1]. This was applied to atomic resonances using a periodic magnetic structure. Such "magnetic" resonance was only observed for the Zeeman sub-levels of Rb atoms at around 100 kHz.

Recently we succeeded in producing an energy-variable ortho-Ps beam from 0.2 to 3.3 keV [2]. We used this Ps beam and the MIR method for the observation of the hyperfine resonance of Ps. This is the first demonstration of this technique for a system including an antiparticle, for a purely leptonic system, and in the THz frequency domain. We developed a multi-layered transmission magnetic grating [3] realizing a strong magnetic field amplitude of around 0.15 T and 10% resolution as shown in Fig. 1(a). Ortho-Ps atoms pass through the periodic magnetic structure and are counted by a detector. At the resonance frequency, ortho-Ps atoms transition to para-Ps atoms which annihilate immediately and, hence, are not detected. Therefore, by counting the number of Ps atoms as a function of the velocity, we may observe the resonance signal. Figure 1(b) shows the preliminary analysis of the experimental results. The details will be presented at the conference.

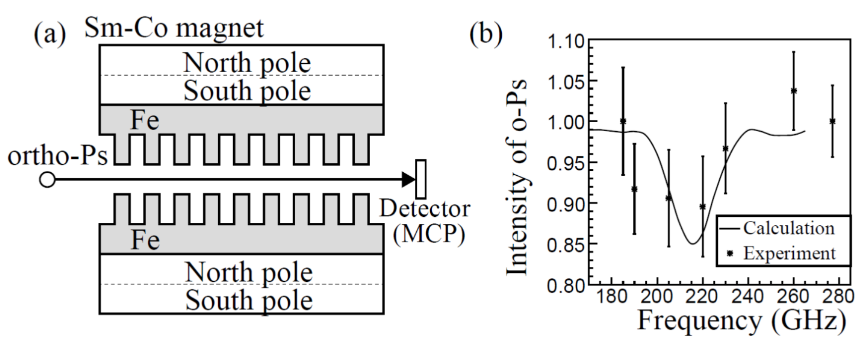

Fig. 1 (a) Conceptual drawing of the grating. (b) Resonance shape.

References

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