Magnetic resonance of rubidium atoms passing through a multi-layered transmission magnetic grating

Yugo Nagata[*1], **Shutaro Kurokawa**[†] **and Atsushi Hatakeyama**[†]

[*] Department of Physics, Tokyo University of Science, Shinjuku, Tokyo 162-0825, Japan
[†] Department of Applied Physics, Tokyo University of Agriculture and Technology, Koganei, Tokyo 184-8588, Japan

Synopsis We measured the magnetic resonance of rubidium atoms passing through periodic magnetic fields generated by a multi-layered transmission magnetic grating. The grating was assembled by stacking four layers of magnetic films so that the direction of magnetization alternated at each level. The experimental results were in good agreement with our calculations. We studied the feasibility of extending the frequency band of the grating and narrowing its resonance linewidth by performing calculation for the precision spectroscopy of the magnetic resonance.

Atomic resonance induced by a periodic static potential was predicted and observed decades ago. The resonance of energetic highly charged ions passing through a crystalline periodic electric field has been well studied at the energy levels of the X-ray region. The resonance frequency is determined by v/a, where v and a are velocity and period length, respectively. This type of technique can also be applied to the magnetic resonance and first observed for the Zeeman sub-levels of rubiduium (Rb) atoms using periodic magnetic fields for around 1 MHz [1]. This resonance is the so-called “motion-induced resonance" (MIR). If the frequency band of MIR is extended to more than around 1 MHz by shortening a and the linewidth is narrowed considerably by the larger number of periods N, MIR can be a strong spectroscopic technique for the measurement of magnetic resonance.

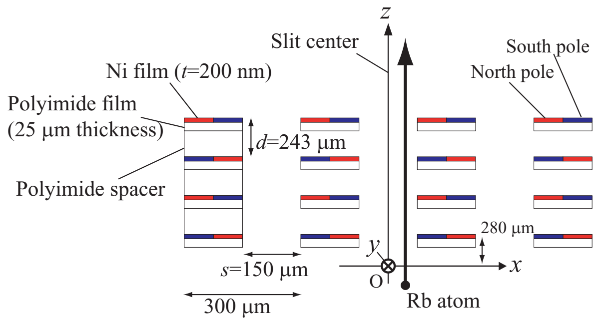

Figure 1. Multi-layered transmission magnetic grating.

To address this, we developed the multi-layered transmission magnetic grating as shown in Fig. 1. The grating was assembled by stacking Ni magnetic films having small slits in four layers so that the direction of magnetization alternated with each film. We used Rb atoms to measure the MIR using the grating. The magnetic field along z direction B_z was applied to lift the degeneracies of the Zeeman sub-levels of Rb atoms. A Rb beam polarized via optical pumping with the pump laser passes through the grating and then is detected using the probe laser. If the frequency between Zeeman sub-levels γB_z coincides with v/a, MIR is induced, where γ is the gyromagnetic ratio and is 4.67 GHz/T.

Figure 2 shows a typical MIR spectrum for v = 408 m/s obtained by changing B_z [2]. Red solid and blue dotted lines show the experimental result and a Fourier spectrum calculated from the magnetic field felt by Rb atoms, respectively. The horizontal axis shows a normalized frequency $\gamma B_z a/v$ so that the frequency of the first order Fourier component corresponds to 1. The calculation result is in acceptable agreement with the experimental result.

We will present the detail of experiments and calculations showing the multi-layered transmission magnetic grating can generate periodic fields with narrower linewidths at higher frequencies by assembling a larger N at a shorter a for the precision spectroscopy of magnetic resonance.

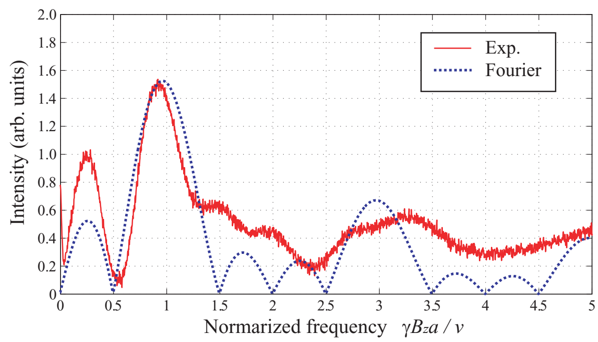

Figure 1. The typical MIR spectrum for v = 408 m/s

References

[1] A. Hatakeyama *et al.* 2005 *Phys. Rev. Lett.* **95** 253003

[2] Y. Nagata *et al. J. Phys. B* accepted

[1]E-mail: yugo.nagata@rs.tus.ac.jp