# Fluorescence detection and double resonance spectroscopy using $^{85}$Rb beam for the development of OROCHI

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Nuclear structure study using atomic laser spectroscopy has revealed the nuclear spins and moments of a wide variety of nuclei with high accuracy in the past decades. However, in order to apply these methods to nuclei with a production rate of less than 100 pps, a highly sensitive method is strongly desired.

To establish such a method, we are developing a laser spectroscopic method for a smaller number of atoms in superfluid helium (He II) to study their nuclear structure. We call this method OROCHI (Optical RI-atom Observation in Condensed Helium as Ion-catcher). In OROCHI, superfluid helium works as an effective stopper for highly energetic ion beams. Most of the immersed ions (nearly 100%) in He II are neutralized in the stopping process and are stopped as atoms. In addition, the center wavelengths of the absorption and emission spectra of the atoms in He II have an large difference because of the effect of the surrounding He II[1)] We can detect emitted photons from the stopped atoms with an extremely low background using wavelength separation. From the features of He II mentioned above, OROCHI should achieve a highly sensitive detection of the fluorescence from atoms.

So far, we have shown the validity of the principle of our method by observing both laser-MW (microwave) and laser-RF (radio frequency) double resonance spectra using a $^{84-87}$Rb beam[2)] However, we also found that the reduction of the stray laser light was not sufficient. Therefore, the applicable ion beam intensity was limited. In order to apply OROCHI to rare isotopes whose production rate is less than 100 pps, we have upgraded the fluorescence detection system to reduce the stray laser light more effectively[3)]. Last December, we conducted an online experiment using an $^{85}$Rb beam to confirm the validity of our development.

Figure 1(a) schematically shows the experimental setup. The $^{85}$Rb ions delivered from RIPS were injected into He II and stopped at the center of the cryostat. In order to measure the ion beam intensity, we counted the number of injected Rb ions using two photomultiplier tubes (PMTs) and a plastic scintillator. The stopped atoms were subjected to a laser light whose wavelength corresponds to the Rb D1 line in He II, namely 780 nm[1)] The fluorescence from the atoms was collected through two lenses and focused on the entrance of an optical fiber. The exit of the optical fiber was connected to the entrance of a monochoromator that was used to select 794-nm emission light. Finally, the fluorescence was detected using PMT. Figure 1(b) shows the detected photon intensity variation due to the switching of the ion beam and laser. The ion beam intensity and the irradiated laser power were approximately $10^4$ pps and 400 mW, respectively. This result confirms the fluorescence detection using the upgraded system and effective background suppression. In addition, we also successfully observed laser-RF double resonance spectra by applying both a switching magnetic field and an RF field whose frequency was scanned. As shown in Fig. 1(c), the detected photon count rate clearly decreases with the production of the spin polarization when the magnetic field is ON. The degree of the polarization is approximately 35% which was comparable to that obtained in the previous experiment[2)]

We are now analyzing these data to estimate the lower limit of the applicable beam intensity.

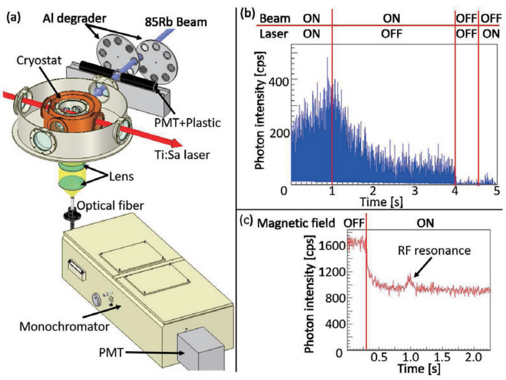


Fig. 1. Experimental setup and obtained result. (a) Experimental setup. (b) Variation of the detected photon intensity due to the switching of the ion beam and the laser. (c) the RF resonance spectrum.

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References

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