Relaxation mechanism of the Rb polarization in a strong magnetic field

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Recently, a novel method for production of a polarized $^3He^+$ ion beam, i.e. the electron pumping, has been experimentally verified.[1] In this method, a Rb metal is vaporized up to the thickness of 5.0×10^{14} atoms/cm^2. This thickness is much larger than the case used for an ordinary optical pumping polarized ion source. Such a large thickness is needed for allowing multiple electron capture and stripping collisions between polarized Rb atoms and an incident $^3He^+$ ion. We observed a $^3He^+$ nuclear polarization of 7.5 % with a Rb polarization of 20 %. The smallness of the obtainable nuclear polarization is due to the smallness of the Rb polarization. The smallness of the Rb polarization might be induced by the relaxation process of the Rb vapor with a large thickness under a strong magnetic field. However, there has been no attempt to study the relaxation mechanism at such an extreme condition. In this paper we will discuss the relaxation mechanism of the Rb polarization observed by means of the time differential measurement.

A schematic view of an experimental apparatus is shown in Fig.1. A Rb metal was vaporized ($0.5-5.0\times10^{14}$ atoms/cm^2) in the Rb cell in a 2-T magnetic field.[2] A Rb vapor was optically pumped by a 795-nm laser light extracted from a 4 W Ti:Sapphire laser excited by a 25 W Ar ion laser. The pumping laser was periodically swiched by using a combination of the Pockels cell and a polarizer. The Rb thickness and the Rb polarization were determined by means of the Faraday effect.[3] The Rb polarization was measured with a precision better than 1%.

The relaxation rate of the Rb polarization is considered as a sum of the wall relaxation rate and the depolarization rate due to the effusion of the polarized Rb vapor out of the cell. An example of the experimental results is shown in Fig.2. The two components, i.e. the fast and slow components, were clearly observed. The slow component was represented as a sum of the wall relaxation and the depolarization due to the effusion of the polarized Rb vapor out of the Rb cell. From the observed relaxation rate, we found that the wall relaxation was suppressed by a strong magnetic field of more than 2 T, and the depolarization due to the effusion effect was considered as the most dominant effect in a strong magnetic field. On the other hand, the fast component was considered as the diffusion rate of the highly polarized Rb atom from the region of pumping laser to the probe laser. The detail discussion will be presented elsewhere.[4]

References

[1] M. Tanaka et al., RCNP Annual Report 1998.
[2] RCNP Annual Report 1996, p.132.
[3] RCNP Annual Report 1997, p.258.
[4] K. Yonehara et al., to be submitted to Phys.Rev.A.

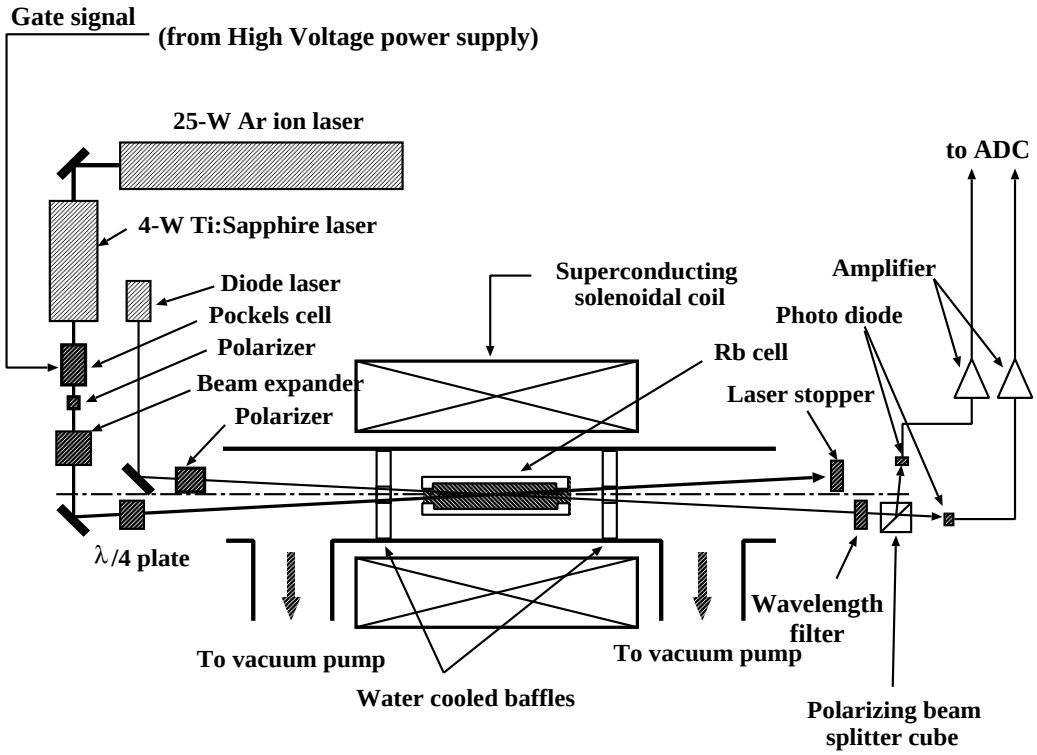

Figure 1: A schematic view of an experimental apparatus for the time differential measurement of Rb polarization is shown.

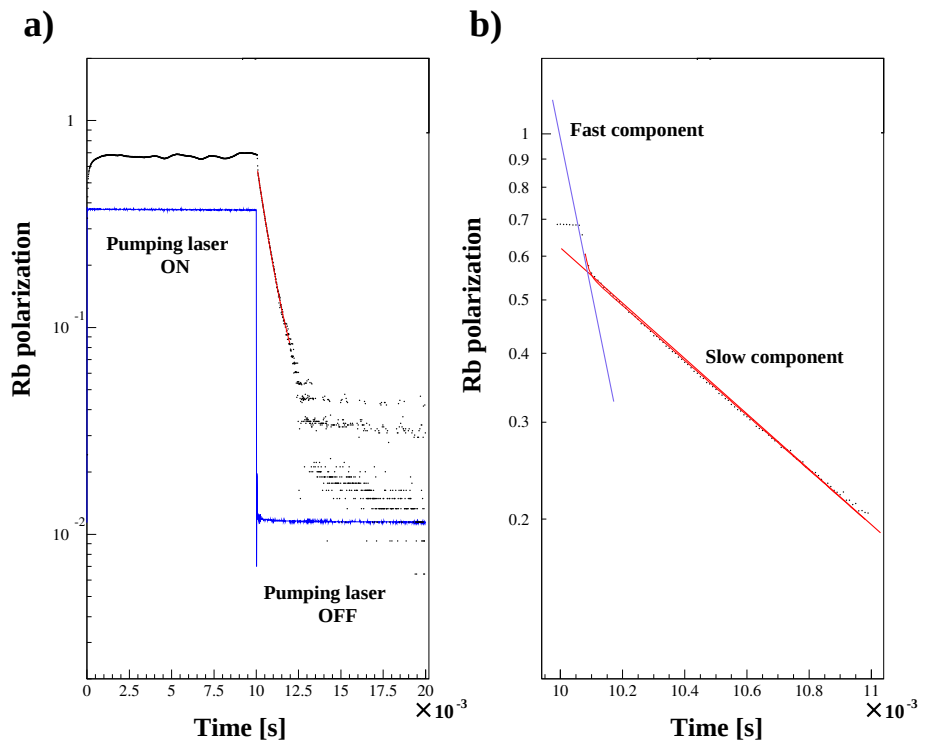

Figure 2: An example of the time differential measurement of a Rb polarization is plotted with the gate signal of the pumping laser.