II. 2. Development of Optical System for RI Polarizing System

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We have proposed a new technique to polarize unstable nuclei by a cross polarization method¹). The aim of this study is to find a possibility to produce a polarization of unstable nuclei better than 10%. The highly polarized unstable nuclei would be useful in the study of nuclear structure as well as material science.

A polarization of unstable nuclei is produced by the following three steps: an optical excitation to produce a population difference in the photo-excited triplet state²,³), a transfer of the population difference to protons by a cross polarization⁴,⁵) and a polarization transfer from protons to unstable nuclei. To attain a high polarization of unstable nuclei, the population difference and the population on the triplet state should be maximized because the population difference is used as a source of the polarization. For efficient optical excitation, the laser power should be intense as long as stimulated emission is not dominant. Moreover, the pulse width should be longer than the lifetime of the excited singlet state (19.5 ns) and shorter than the lifetime of the triplet state (26 µs).

We use a Nd:YAG laser as a light source for the optical excitation. The laser has a power of 100 mJ/pulse, 5 ns-pulse width and the repetition rate of 20 Hz. The pulse width is thus much shorter than the required pulse width, although the power is sufficiently high. To obtain a longer pulse width, we have designed and constructed an optical system shown in Fig. 1. The laser beam from the Nd:YAG laser is divided by a beam splitter (BS1). A laser beam passes directly to the second beam splitter (BS2), while the other laser beam travels in a delay line (DL1). Each beam is hence travel by different lengths before merge them again at BS2. The laser beam has then twice the pulse width of the original laser beam, if the delay time is adjusted to be almost the same width as the original laser pulse. We used three delay lines to obtain a longer pulse width.
Figure 2 shows a time profile of laser pulses measured with a photodiode seen in Fig. 1. The violet line shows a time profile of an original laser pulse and the blue line shows that of laser pulse after travelling the optical system. By using the optical system, the pulse width has successfully been extended from 4.4 ns to 34 ns. The resultant pulse width is longer than the lifetime of the excited singlet state.

References


Figure 1. A schematic view of the optical system for extending a laser pulse. The system consists of beam splitters for dividing the laser beam and mirror pairs for delay lines. A time profile of laser pulse is measured with a photodiode.

Figure 2. A time profile of laser pulse detected by the photodiode. The gain of the photodiode, i.e. the vertical scale is different for each measurement. The origin of the time axis corresponds to the time that the Q-switch of Nd:YAG laser begin work.