R005-P28
ポスター３：11/6　AM1/AM2 （9:00-12:30）

#兵藤　初美 1), 斎藤　徳人 2), 津田　卓雄 1), 渡部　蓮 1), 野澤　悟徳 3), 川端　哲也 3), 川原　琢也 4)
(1 電通大,(2 理化学研究所基幹研,(3 名大・宇地研,(4 信州大・工

Sodium saturation spectroscopy using distributed feedback lasers

#Hatsumi Hyodo1), Norihito Saito2), Takuo Tsuda1), Ren Watabe1), Satonori Nozawa3), Tetsuya Kawabata3), Takuya Kawahara4)
(1UEC,(2ASI, RIKEN,(3ISEE, Nagoya Univ.,(4Faculty of Engineering, Shinshu University,

Sodium (Na) resonance scattering lidar is a means of laser remote sensing capable of measuring temperature and wind velocity in the mesospheric and lower thermospheric (MLT) region (the altitude range from 80 to 110 km). To perform such lidar observation, it is important to tune the laser frequency to a resonance line of Na for accurate measurements of the Doppler broadening (related to the temperature) and Doppler shift (related to the wind velocity) in the Na resonance fluorescence spectrum. The Na saturation spectroscopy can produce fine structures ($<$10 MHz), called Lamb dips and crossover peaks, in the Na resonance fluorescence spectrum, and these structures can be used as the absolute frequency standards for accurate laser frequency control. Narrow linewidth distributed feedback (DFB) lasers have the potential for several applications, e.g., telecommunication and trace molecular gas detection. In addition, the DFB lasers have advantages as stable and compact laser systems. Generally, to obtain a Na D2 resonance light (589 nm) by use of DFB lasers, nonlinear frequency conversion, i.e., sum frequency generation (SFG) or second harmonic generation (SHG), is needed. As a result of this kind of wavelength conversion (with 20 mW DFB lasers), the obtained output power, however, becomes normally a few μW, which is normally not enough to induce saturation in the Na saturation spectroscopy experiments. Therefore, the previous study performed the Na saturation spectroscopy experiments using the amplified 589 nm light source composed of a configuration of master oscillator fiber amplifier and a high-efficiency wavelength conversion module, which is a waveguide periodically poled lithium niobate.

In this study, we have developed a new optical system for Na-saturation spectroscopy using a low-output power 589 nm light source with a few μW obtained in SFG by mixing two DFB lasers, without the fiber amplifier and the high-efficiency wavelength conversion module used in the previous study. First, based on the theory of Na hyperfine structures, we modeled Na transitions inside of the Na vapor cell in Na-saturation spectroscopy experiments and investigated the Na saturation by changing the model parameters. As the result, we found the importance of the beam waist size of the laser (i.e., the 589-nm coherent light), which can affect the laser intensity as well as the advection rate. Then, based on the theoretical investigations, we developed an efficient optical system, in which we added lenses to increase the intensity in the Na cell. With the increase in the intensity, the Na D2 hyperfine structures such as Lamb-dips and crossover-peaks were successfully observed with an input power of 6 μW. In further experiments, we optimize the tuning method of the laser frequency and the cell temperature, the measurements, and the data analysis of measured data. These experiments can be compared with theoretical calculations by the developed model, and thus we evaluate the performance of our Na saturation spectroscopy for further improvements.

In the presentation, we will present experimental results from the developed optical system along with theoretical calculations from the developed model, and then discuss the current performance of our Na-saturation spectroscopy experiments.