Production of ultra cold Rydberg gases for cold atom engineering

R. Shiozuka, A. Takamine, and H. Maeda

Dept. of Phys. & Math., Aoyama Gakuin Univ., Fuchinobe, Sagamihara, Kanagawa
252-5258, Japan

riki.shiozuka@gmail.com ; hmaeda@phys.aoyama.ac.jp

A high-lying Rydberg atom has been one of the research subjects which recently provides hot topics since it exhibits blockade excitation effects [1] and many-body effects because of its high polarizability. On the typical timescales of Rydberg experiments of a few microseconds, ultra cold atoms move only a fraction of the typical spacings between adjacent atoms, which has led to the expression of frozen Rydberg gases. Hence the dynamics of cold dense sample of Rydberg atoms is predominated by atomic interactions. We are planning to reveal the reaction mechanism and control the reactions between such cold particles from studying the strong inter-atomic interaction with precisely and systematically varying trap conditions aiming for cold atom engineering. Another curious topic is the ultra cold plasma physics since an ultra cold Rydberg gas can spontaneously evolve into a cold plasma [2]. We also plan to investigate the dynamics of cold plasma produced from the Rydberg gases such as the study of the propagation of electromagnetic wave in the cold plasma in anticipation of application to astrophysics.

For the purpose of production of such a cold Rydberg gases, we firstly developed a magneto-optical trap (MOT) system for cooling and trapping of rubidium atoms and recently succeeded in the observation of a cloud of trapped rubidium atoms. In parallel we have designed and developed a laser system of 480 nm for exciting of rubidium atoms from \(^{5p_{3/2}}\) state to \(^{nS/nd}\) states (\(n \sim 30 - 50\)). It is composed of a Littrow-type external-cavity diode laser at 960 nm followed by a taper-amplified diode laser and a resonant bow-tie cavity where 480 nm light is produced via quasi-phase-matched second harmonic generation in a periodically poled KTP crystal. We will show the details of our experimental system for the study of ultracold Rydberg gases and some preliminary results.