# マイクロ波分子減速に向けた低温低速 PbO 分子ビーム源の開発

（富山大理）○榎本勝成・吉原隆之昌・米澤大介・小林かおり・松島房和・森脇喜紀

# Development of a cold and slow PbO beam towards microwave Stark deceleration

(Univ. of Toyama) K. Enomoto, T. Yoshihara, D. Yonezawa, K. Kobayashi, F. Matsushima, and Y. Moriwaki

Control of the translational motion of molecular beams is a fundamental technique for molecular physics and spectroscopy with a long history. Recently, various cooling or deceleration methods have been invented aiming for the generation of trapped ultracold molecular gases. We are also developing a “microwave Stark decelerator”, which utilizes the ac Stark effect of polar molecules with a microwave standing wave enhanced in a cylindrical superconducting resonator [1]. In this talk, we will present the current status of this project, especially focusing on the cold and slow beam source, which is required to decelerate the molecular beam to the zero velocity using this microwave Stark decelerator.

We have produced a cold and slow PbO beam source using the helium buffer-gas cooling method, similarly to Ref. [2]. Inside a cell attached to a liquid helium bath, a solid PbO target was ablated by a pulsed laser (532 nm, about 4 ns duration). The PbO molecules produced were then cooled by a cold helium gas in the cell, and a cold PbO beam was obtained from a small hole of the cell. Excitation spectra of PbO molecules in the cell are shown in Fig. 1. When the cell was cooled down to 9 K, we obtained a PbO beam whose mean velocity was about 140 m/s. We have measured the yield of the PbO molecules as a function of the pulsed laser fluence (energy per area). PbO molecules of the order of $10^{9}$-$10^{10}$ were generated with the fluence of 0.5-2 J/cm$^{2}$. When the laser fluence was higher than about 2 J/cm$^{2}$, plasma glow was observed and the molecules were not generated efficiently (Fig. 2).

We have also made and examined a superconducting resonator which will work as the decelerator. Its inner length is 458 mm and the inner radius is 6.3 mm. It was made from copper and the inner surface was electroplated with an alloy of Pb and Sn, whose critical temperature is 7 K. The resonator was cooled directly with liquid helium, and its quality factor was measured via the resonance linewidth and the decay time of the standing wave. The quality factor was about $10^{6}$ for a microwave at 18 GHz, and we estimate that the kinetic energy of about 10 K can be removed from the PbO beam for 10 W microwave input power to the resonator.

[1] K. Enomoto *et al.*, Appl. Phys. B **109**, 149 (2012).
[2] S.E. Maxwell *et al.*, Phys. Rev. Lett. **95**, 173201 (2005).

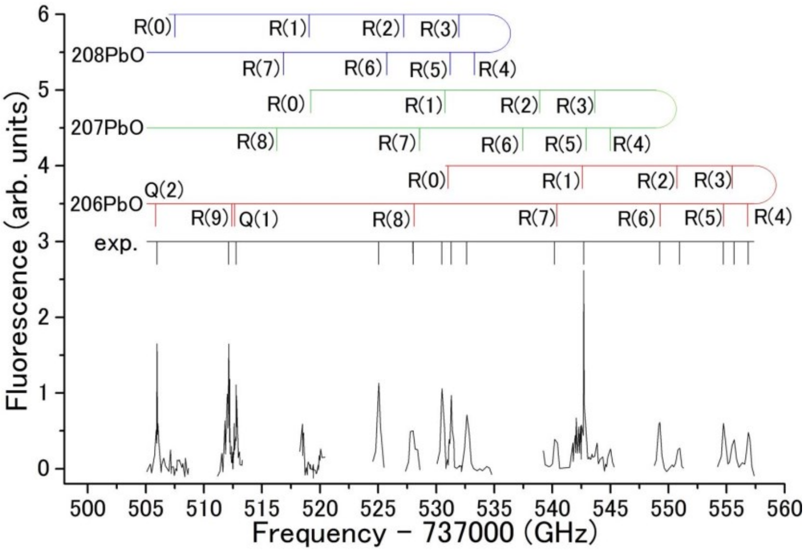

Fig. 1: Excitation spectra of PbO molecules at the liquid nitrogen temperature. Expected resonance frequencies for each isotope are also shown.

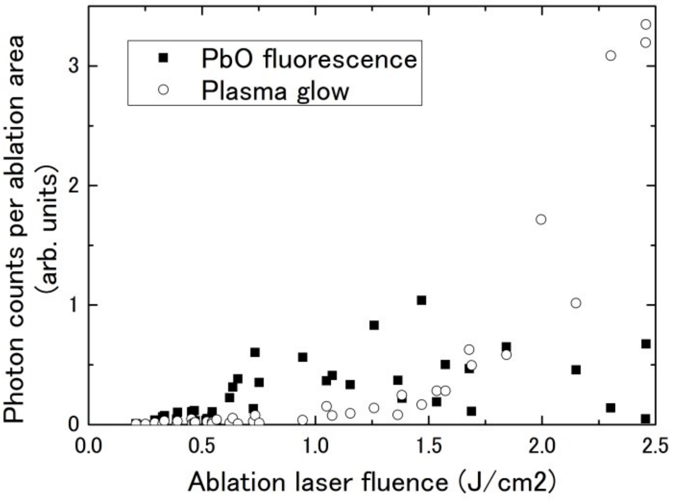

Fig. 2: Fluorescence of PbO and plasma glow as a function of the pulsed laser fluence.