Toward the First Study of Chemical Reaction Dynamics of Mu with pumped molecules: Stimulated Raman Pumping and the Mu+H_2* (v=1) Reaction

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The use of Stimulated Raman Pumping (SRP) is known to be an effective tool for the preparation of infrared inactive molecules into a vibrational excited level in the ground electronic state [1]. We propose to use SRP to produce H_2* in its v= 1 state in order to measure the reaction rate of Mu with H_2*, the first measurement of its kind of Mu reactivity with laser-pumped molecules. Due to the ultra-light Mu atom mass, the results will provide a truly unique test of current reaction rate theory on the highly accurate H_3 PES [2]. An earlier study of the reaction rate of Mu with H_2 in its ground state also provided an important test of reaction rate theory at the time [3].

The major difficulty in this experiment, compared to the standard SRP process, where the excitation mostly happens over a very limited size (microns), is to ensure a homogeneous excitation over a large volume (few cm^3) while achieving a high partial pressure of H_2* (3-12 torr). These constraints arise from the requirements of superposition of the muon beam with the laser beam and the expected rate constant for the Mu + H_2*(v=1) $\rightarrow$MuH + H reaction [3]. This also mandates the need of additional moderator gas (Ar or Xe) to the hydrogen (total pressure $\sim$ 30 bar) to give a sharp enough stopping distribution of the muon beam in the target cell, and it imposes strong requirements on durability and the simplicity of the system. Important to the success of the experiment as well are MC simulations of the muon stopping distribution to ensure optimum overlap with the laser pulse.

The experiments will be carried out using the ISIS pulsed muon beam at the RIKEN/RAL facility. The 2^{nd} harmonic of a Nd:YAG laser (Continuum) is used as the source of SRP of H_2*.The laser energy is varied from $\sim$100 mJ/pulse to 500 mJ/pulse at a 25Hz rate and pulse duration of $\sim$ 8 ns, to vary the amount of pumped H_2*. Several test experiments of were carried our at UBC (LASIR lab), with a similar laser (10 Hz, 3ns pulse), in order to test different excitation schemes as well as the best geometry for the reaction cell. An efficiency of conversion of laser pump radiation (532 nm) to the 1^{st} Stokes radiation (683 nm) of up to 70% was achieved, giving $\sim$ 6 torr of pumped H_2*(v=1) over 5 cm^3. Novel methods for obtaining higher excitation of the v=1 state of H_2* will be discussed. The first experimental results are expected from July beam time at Port 2 of the RIKEN/RAL Facility and will be presented.

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