INTEGRATED QUANTUM SCIENCE AND TECHNOLOGY

University of Stuttgart Germany

| **Probing chemical reactions using optical cavities \| 2YR** | **Start Date: December 1st 2015** |
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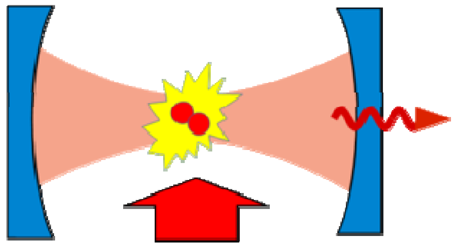

**Abstract:** In recent years, the preparation of ultracold atomic samples, e.g., Bose-Einstein condensates (BECs) has enabled first studies of chemical reactions such as molecule formation on a very fundamental level: The relative motion between unbound ultracold atoms is so slow that only s-wave scattering is relevant. Molecules in a well-defined rotational and vibrational quantum state can thus be formed and used for further studies, e.g., of their collisional properties. One important reaction process is photoassociation where strongly bound molecules can be formed from a weakly bound dimer (Feshbach molecule) in a two-photon process. So far, the reaction detection was slow and indirect via atom losses.

At Ulm, we want to exploit the strong vacuum fluctuations inside of an optical cavity to stimulate the transition to a desired molecular quantum state of $Rb_2$. At the same time, a photon will be emitted into the cavity mode heralding the reaction event in real time and with high efficiency, see Figure 1. Moreover, we want to use the cavity for non-destructive detection of ultracold $Rb_2$ molecules and their internal state. Photon scattering that could change the molecular state would be suppressed. This would be a direct detection method, where the molecules could be used for subsequent experiments.

The Köhn group in Stuttgart develops accurate quantum-chemical methods and will provide highly accurate calculations to describe the interaction of the atoms and molecules with the laser field. Highly accurate computations of molecular bound states and optical parameters will be benchmarked against the experimental data from Ulm. First predictions for the creation of $Rb_3$ trimers in the experiment will be done.

**Recent results:**

- *Experimental setup (Ulm):*
  - *Novel UHV science chamber for integrating the microcavity*
  - *New experiment control system*
- *Theory (Stuttgart): Identification of a possible target state for photoassociative $Rb_3$ formation.*

**Publications:**

**Further Collaborators:**
Prof. Dr. Johannes Hecker Denschlag (Ulm)
Prof. Dr. Alexander Kubanek (Ulm)