Optical frequency standards based on slow molecules in hollow-core fibers

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Both high intensity and long interaction length is needed for saturation spectroscopy of weak molecular transitions. The narrow core of hollow-core photonic bandgap fibers (HC-PBG fibers) allows for high intensity maintained over a distance limited basically by the practical problem of filling gas into the fiber.
In previous experiments, the minimum linewidth of the saturated absorption signal for acetylene confined in a HC-PBG fiber was set by the rate of collisions between the molecules and the inner wall of the fiber. According to the definition, the saturation intensity of a molecular transition is the intensity that makes the frequency of Rabi oscillations equal to the molecular decoherence rate. At low pressure the main source of decoherence is wall collisions, and since slow molecules have a smaller wall collision rate and hence smaller saturation intensity than molecules at the average speed, the slow molecules can be "selected" by using low intensity and low pressure.
We have observed the selection of slow molecules in a HC-PBG fiber and we discuss the potential for optical frequency standards based on saturated absorption in a hollow core fiber.

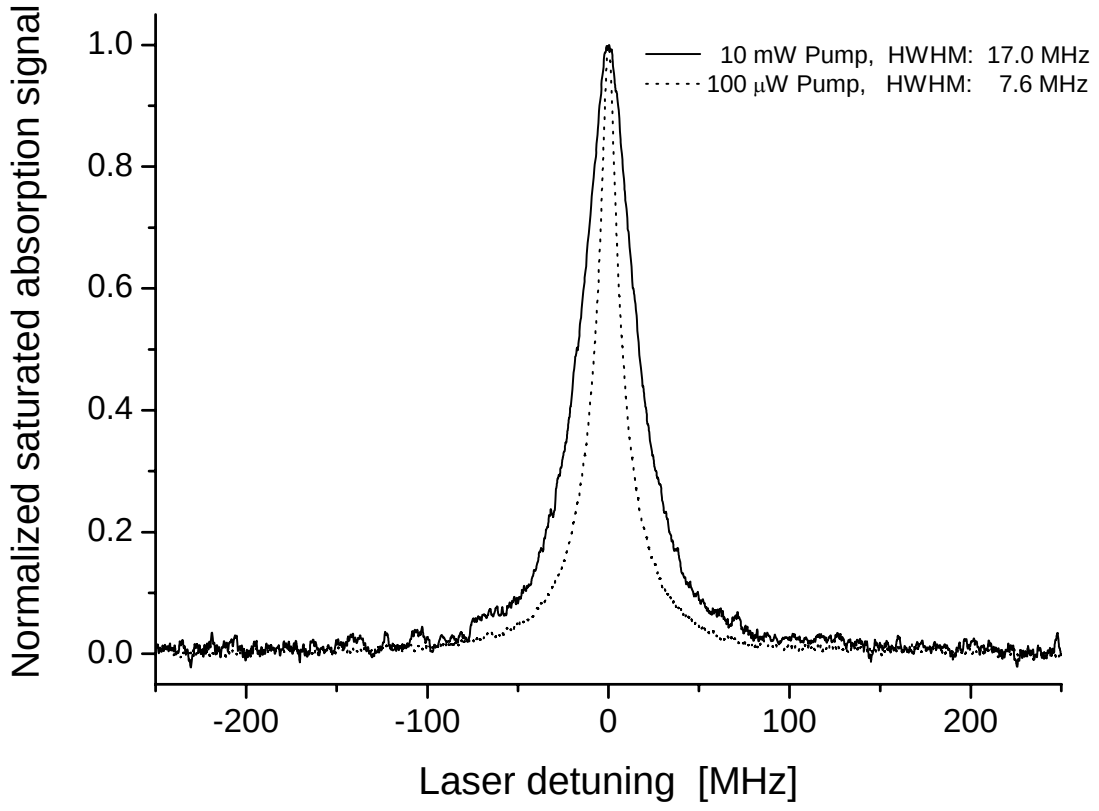

Figure: Observation of line-narrowing when reducing the optical power well below the 23 mW saturation power of the thermal acetylene gas.