Search for a parity violation effect in chiral molecules: old dream and new persepctives

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Parity violation (PV) effects have so far never been observed in chiral molecules. Originating from the weak nuclear force, PV should lead to a frequency difference in the rovibrational spectra of the two enantiomers of a chiral molecule. However the smallness of the effect represents a very difficult experimental challenge. The measurement of PV in molecules is interesting for a range of subjects across the board. It is a probe of the weak interaction and would thus serve as a test of the standard model of physics. But it has also been suggested to be connected to biomolecular homochirality, a strong quantity imbalance observed on earth between left- and right-handed biomolecules. We have been working towards measuring this difference using Ramsey interferometry in the mid-infrared (at around 10 μm) using ultra-narrow line width CO_2 lasers referenced to atomic clocks in Paris via an optical link. We expect to reach a fractional sensitivity of around 10^{-15} ($\sim$ 10 mHz) on the frequency difference between enantiomers [1].

We present the results of preliminary investigations conducted on methyltrioxorhenium (MTO), an achiral test molecule whose chiral derivatives have recently been synthesized and are estimated to have a $\sim 10^{-14}$ level PV effect [2]. We report on the high-resolution spectroscopy of MTO [3,4], both in a cell and in a supersonic beam (Fig. 1). This work has enabled us to identify several key elements of the current experiment needing improvement prior to making a PV measurement. The first is the lack of tunability of our CO_2 lasers. We present our on-going work towards the replacement of the CO_2 lasers with quantum cascade lasers (QCLs) [5] the very latest mid-infrared laser technology which offer broad and continuous tuning. Secondly, the current molecular beam source only yields a modest flux for species such as MTO which are solid at room temperature. We plan to overcome this by developing a buffer-gas-beam source and report on our latest efforts to implement buffer-gas cooling on polyatomic species such as MTO.

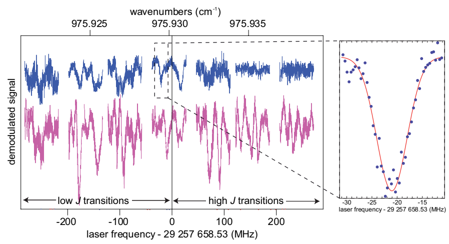

Figure 1: *Linear absorption spectroscopy of a MTO-seeded supersonic jet, in the vicinity the R(20) CO_2 laser line frequency (0 MHz on the bottom axis). Lower pink curve: translational temperature ≥ 5 K. Upper blue curve: translational temperature ~ 1 K. The inset is a zoom on a single line.*

References

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