Progress in the Zurich experiment on parity violation in chiral molecules

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Because of the space inversion symmetry of the electromagnetic force, the ground state energies of the enantiomers of chiral molecules would be identical by symmetry in conventional quantum chemical theory. Including also the parity violating weak nuclear force, they are, however, predicted to be different by a very small parity violating energy difference $\Delta_{pv}E$ in the sub-feV and low feV range. This small effect from the ’electroweak quantum chemistry’ has so far never been measured and such experiments constitute a major challenge of physical-chemical stereochemistry with possible importance both for the fundamental physics in the standard model of elementary particles and for the evolution of biomolecular homochirality in the origin of life as reviewed in [1, 2].

An important step in our approach following [3] has been the proof of concept for the experimental stability of parity states (tested with the achiral molecule NH_3 [4]) demonstrating the possibility to detect values of $\Delta_{pv}E$ as small as 100 aeV (or larger). Our current efforts concentrate on developing techniques to measure and analyze mid-IR vibration-rotation-tunneling spectra (around 3000 cm^{-1}) of one of our mid-sized chiral candidate molecules with low vapor pressure (listed e.g. in Tab. 2 of Ref. [2]). Here, we report improved cw-laser cavity ring-down spectroscopy [5, 6, 7] referenced to a frequency comb combined with a slit jet expansion and partial pressures below 1 mbar sufficient for highly resolved absorption spectra of aniline with our new setup. We report also the spectrum of benzene spanning ranges of more than 10 GHz in the mid-IR with complexity similar to the spectroscopy of our chiral candidate molecule, 1,2-dithiine.

[1] M. Quack, G. Seyfang, G. Wichmann, *Proc. Nobel Symposium*, **2023**, 167, 209−268.
[2] M. Quack, G. Seyfang, G. Wichmann, *Chem. Sci.*, **2022**, 13, 10598−10643.
[3] M. Quack, *Chem. Phys. Letters.*, **1986**, 132, 147−153.
[4] P. Dietiker, E. Milogyadov, M. Quack, A. Schneider, and G. Seyfang, *J. Chem. Phys.*, **2015**, 143, 244305.
[5] M. Snels, V. Horká-Zelenková, H. Hollenstein and M. Quack, in Handbook of High−resolution Spectroscopy edited by M. Quack and F. Merkt (Wiley, Chichester, New York, **2011**), vol. 2, chap. 27, pp. 1021−1067.
[6] Y. B. He, M. Hippler and M. Quack, *Chem. Phys. Lett.*, **1998**, 289, 527534.
[7] G. Wichmann, E. Miloglyadov, G. Seyfang and M. Quack, *Mol. Phys.*, **2020**, 118, e1752946.