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## Toward precision spectroscopy of trapped chiral molecular ions for fundamental physics

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The success of trapped molecular ion precision spectroscopy in eEDM searches motivates the extension of the platform to more complicated polyatomic species to test the Standard Model (SM) and search for new physics. The prediction that weak force parity violation (PV) breaks the symmetry between the left and right-handed chiral molecules has eluded detection for decades in a field dominated by neutral species. Crucially, comparison between the two chiralities of the molecule isolates all PV interactions, which arise from the SM and beyond. Despite the potential, the lack of theory on chiral molecular ions makes it challenging to select a species to initiate the experiment. Importantly, the ideal candidate, must be prepare-able at internally cold temperatures and have efficient detection avenues.

We have found several intriguing candidates, the most promising of which is CHDBrI<sup>+</sup>. Using ab initio theory, we predict a ~2 Hz shift between L and R molecules for the C-H bend vibrational transition at 9  $\mu\text{m}$ , where the transition's linewidth is >10x narrower than the shift [1, 2]. CHDBrI<sup>+</sup> has reasonable wavelengths for cold preparation through state-selective, near-threshold photoionization of neutral CHDBrI and is also promising for detection via photodissociation [1].

Our plan is to extract the PV signature from a mixed chirality ensemble of trapped CHDBrI<sup>+</sup>, using vibrational Ramsey spectroscopy that is embedded within the 3-wave mixing (3WM) framework [3]. So far 3WM has been demonstrated using microwaves to separate molecules according to their handedness using asymmetry of the chiral molecules' transition dipole moment components. We propose to extend these ideas to differential precision spectroscopy between the two chiralities, which is critical to suppress noise and sources of systematic uncertainty.

We will discuss our progress in this young experiment.

### References:

- [1] "Chiral molecule candidates for trapped ion spectroscopy by ab-initio calculations: from state preparation to parity violation" Landau, Eduardus, Behar, Wallach, Pašteka, Faraji, Borschevsky, Shagam, arXiv:2306.09788 (2023)
- [2] "Vibrationally Induced Large Parity Violation Effects in CHDBrI<sup>+</sup> – A Promising Candidate for Future Experiments" Eduardus, Shagam, Landau, Faraji, Schwerdtfeger, Borschevsky, Pašteka, arXiv:2306.09763 (2023)
- [3] "Simultaneous Enantiomer-Resolved Ramsey Spectroscopy Scheme for Chiral Molecules" Erez, Wallach, Shagam, arXiv:2206.03699 (2022)

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