ROTATIONAL SPECTRA IN SERVICE OF PARTICLE PHYSICS: ZEEMAN & HYPERFINE EFFECTS

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Motivated by the ongoing search for the parity violating effects originated by an electron electric dipole moment (e-EDM) or a nuclear anapole moment, the rotational spectra of heavy atom diatomic radicals like, e.g., $^2\Pi_{1/2}$ PbF are studied at the unrivalled resolution offered by supersonic-jet Fourier transform microwave spectroscopy. Obtaining accurate information on such relativistically behaving systems will be the key to provide a delicate test to the proposed theories in extension to the Standard Model of Physics.

Employment of an MW method to hunt down these tiny effects, easily obscured by the line width inherent to other techniques, in rotational transitions is a promising approach to observe the tiny energy difference of terms that are degenerate without parity violation. Already before an experiment sensitive to parity violation, the exceptional resolution of the microwave time-domain technique can be exploited to provide accurate tests on the quantum chemical predictions that are part of the calculation of the anticipated e-EDM or anapole moment sensitivity of a given species since nuclear quadrupole and magnetic hyperfine effects in the rotational spectra are closely related.

In our current experiment, transitions can be observed with 0.2 kHz accuracy for unblended lines over a range of 2 – 26.5 GHz. The observation of field dependent spectra (in magnetic fields up to 4 Gauss) allows for the determination of the two body fixed g-factors, $G_\perp$ and $G_\parallel$ which can then be compared with recent theoretical values.

While $^2\Pi_{1/2}$ and $^3\Delta_1$ electronic states ease the requirements for precise B-field control in nuclear-spin independent (NSI) e-EDM sensitive experiments because of small molecular g-factors, diatomic molecules in $^2\Pi_{1/2}$ and $^2\Sigma_{1/2}$ states can exhibit nuclear-spin dependent (NSD) parity non-conservation (PNC) effects that are enhanced by a factor of 10^5 due to the mixing of close rotational states of opposite parity. The nuclear anapole of heavy nuclei, which couples the un-paired electron's spin to toroidal currents inside the nucleus, provides the dominant contribution to the nuclear-spin-dependent (NSD) parity-violating effect in atoms and molecules.

YbF provides the current e-EDM upper limit. Although it is more sensitive to magnetic fields than $^2\Pi_{1/2}$ PbF, the nuclear quadrupole hyperfine structure of $^2\Sigma_{1/2}$ ^{173}YbF constitutes a direct probe on the electric field gradient and thus can help characterize the critical electric field at the heavy atom nucleus. We will report on 14 GHz transitions and global multi-isotopolog fit including the vibratioinal ground and first excited state for the main and 3 of the less abundant even isotopologues of YbF as well as the dual nuclear spin ^{207}PbF analogue ^{171}YbF, important steps towards observing ^{173}YbF.