TIME-DOMAIN MW SPECTROSCOPY: FUNDAMENTAL PHYSICS FROM MOLECULAR ROTATION

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In the past, it was a great triumph of Dirac's theory to predict the fine structure in the energy levels of the simplest atom. Nevertheless, even the relativistic Dirac theory did not completely describe the spectrum of the electron in an H-atom. However, at that time, attempts to obtain accurate information through a study of the Balmer lines have been frustrated by the large Doppler width in comparison to the small shifts. Obtaining more accurate information was the key to provide a delicate test of the relativistic wave equation as well as finding confirmation for line shifts due to coupling of the atom with the radiation field and any non-Coulombic interaction. Then, the advances in microwave (MW) techniques resulted in new physical tools, making it possible to observe the small energy difference of terms that were degenerate in Dirac's theory. This, as well as the small deviation of the electrons gyromagnetic ratio g_e from the value 2, provided an excellent test for the validity of quantum electrodynamics (QED).
At present, the electron electric dipole moment (e-EDM) is a particularly good place to find, as proposed by Purcell and Ramsey, a new source for P and T violation that may, in fact, be linked to the matter-antimatter asymmetry of our Universe and - in a wider sense be responsible for our existence. Since the Standart Modell's (SM) prediction is negligible, any observed $d_e \neq 0$ is direct evidence for "New Physics" beyond the SM. Many supersymmetric theories in extension to the SM, indeed, predict an e-EDM within two orders of magnitude from the current limit $|d_e| < 1.6 \times 10^{-27} e \cdot cm$. However, this limit[a] was published already in 2002, nine years ago. Since then, no progress was made. As at the time when Dirac's equation was put to test, attempts to obtain accurate information through a spectroscopic study are mostly frustrated by the large Doppler width in comparison to the small shifts. Again, obtaining more accurate information will be the key to provide a delicate test to the proposed theories, potentially making the discovery long awaited for: the e-EDM. And again, employment of an MW method to hunt down a tiny effect, obscured by the linewidth inherent to other techniques, can serve as a new tool for the study of the even smaller shifts in an e-EDM sensitive rotational transition, making it possible to observe the tiny energy difference of terms that are degenerate without an e-EDM.

[a]B. C. Regan, E. D. Commins, C. J. Schmidt, D. DeMille *Phys. Rev. Lett.* **88**, 071805 (2002).