ASSESSING 27 MOLECULES FOR SENSITIVITY TO PROTON-TO-ELECTRON MASS VARIATION: STRENGTHS AND LIMITATIONS OF A HIGH-THROUGHPUT APPROACH

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Astrophysical molecular spectroscopy is an important method of searching for new physics through probing the variation of the proton-to-electron mass ratio, $\mu$, with existing constraints limiting variation to a fractional change of less than $10^{-17}$/year. To improve on this constraint and therefore provide better guidance to theories of new physics, new molecular probes will be useful. These molecular probes must have spectral transitions that are observable astrophysically and have different sensitivities to variation in the proton-to-electron mass ratio.

This talk will focus on the development of a high-throughput methodology to calculate the sensitivities of transitions in diatomic and polyatomic molecules with established spectroscopic models. The calculations required are straightforward; reproducing the line list with a slight increase in nuclear masses and comparing the original and mass-shifted energies and transition frequencies. The major challenge was in matching the quantum states in the original and mass-shifted data as the quantum number descriptions were not always preserved when the state was heavily mixed - unfortunately precisely those states likely to have high sensitivities to $\mu$ variation. These challenges were far more severe in polyatomics than diatomics.

Our results found that even a conservative intensity cut-off of $10^{-30}$ cm/molecule at 100 K (astrophysically relevant interstellar conditions) removed almost all transitions with high sensitivity to $\mu$ variation. There were no new clear transitions of interest were identified in the 22 diatomic and 5 polyatomic molecules investigated, with the low-frequency diatomic parity changing and polyatomic inversion transitions having the strongest sensitivities.

In the diatomics we investigated, high sensitivity was observed in low-frequency rovibronic transitions arising from accidental near-degeneracy between electronic states were observed, but these have very low intensity (as the states involved were high in energy) and thus not likely to be observable astrophysically. This insight allows screening of diatomics without spectroscopic models for sensitivity to $\mu$ variation; we conclude that no diatomic known extragalactically is likely to have transitions with high sensitivity to $\mu$ variation.