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Literature Seminar

When: November 3, 2022
Time: 2:30 p.m.
Location: CBLL-16

Rovibrational Spectroscopy of Molecules using Cavity-Enhanced Double-Resonance Methods

Abstract:

The advent of improved astronomy facilities and technologies, most recently including the James-Webb Space Telescope, which was launched in the December of 2021, has long been accompanied by laboratory measurements of optical spectra used as fingerprints to identify different molecules found in space. However, some molecules of astrochemical importance contain coupling that perturbs the spectra of the molecule. For instance, methane, a molecule of interest in astronomy due to its roles in the atmospheres of hot exoplanets and on the surface of Titan, the largest moon of Saturn, features many near-degenerate states and has strong coupling, such that the molecule cannot be adequately modeled by perturbation theory. These vibrational energy level groups, called polyads, are comprised of rotational structures that are inaccessible or unresolvable when using single-photon spectroscopic methods. Methods that use two-photon excitation schemes can drastically improve the resolution of these rovibrational (rotational-vibrational) transitions by removing broadening due to the Doppler Effect and can be used to investigate the hot bands, the feature on spectra of high-temperature celestial bodies. Furthermore, double-resonance spectroscopic techniques can simplify the recorded spectra and facilitates spectroscopic analysis. In this talk, I will describe the development of cavity-enhanced double-resonance (CEDR) spectroscopy techniques and the most recent progress in the field, including the utilization of optical frequency combs as the light source for absorption spectroscopy. This talk will describe three different setups in research groups, which take advantage of CEDR to access previously unexplored states of molecules and compare the results to previous high-resolution scans of the explored states. These experiments and their successors provide resolved spectra of molecules that have astrochemical interests and can be used to test the models for near-degenerate states of molecules.

References:

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3. Karhu, J.; Nauta, J.; Valnio, M. Double Resonant Absorption Measurement of Acetylene Symmetric Vibrational States Probed with Cavity Ring down Spectroscopy. *J. Chem. Phys* **2016**, *144* (244201). https://doi.org/http://doi.org/10.1063/1.4954159.
4. Hu, C.-L.; Pereavlov, V. I.; Cheng, C.-F.; Hua, T.-P.; Liu, A.-W.; Sun, Y. R.; Tan, Y.; Wang, J.; Hu, S.-M. Optical-Optical Double-Resonance Absorption Spectroscopy of Molecules with Kilohertz Accuracy. *J. Phys. Chem. Lett.* **2020**, *11*, 7843–7848. https://doi.org/https://dx.doi.org/10.1021/acs.jpclett.0c02136.
5. Foltynowicz, A.; Rutkowski, L.; Silander, I.; Johansson, A. C.; de Oliviera, V. S.; Axner, O.; Sobon, G.; Martynkien, T.; Mergo, P.; Lehmann, K. K. Sub-Doppler Double-Resonance Spectroscopy of Methane Using a Frequency Comb Probe. *Physical Review Letters 126* (063001). https://doi.org/10.1103/PhysRevLett.126.063001.