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Exploring the Early Solar System: Cometary Chemical Fingerprints: A Study of Comet C/2022 E3 (ZTF) via Near-Infrared Spectroscopy

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Comets are small, icy remnants from the solar system formation (4.5 billion years ago). Their interior composition should reflect the composition and conditions presented in the mid-plane of the protoplanetary region where (and when) they formed. These small objects predominantly reside in two major reservoirs, the Oort cloud and the Kuiper belt. Comets coming from the Oort cloud have long orbital periods while comets from the Kuiper belt have short orbital periods (< 200 years). An overarching goal in astronomy is to understand the conditions presented in the planetary region in the early solar system. Since comets lack a known mechanism of self internal heating, any processes that have changed their composition should only affect a few meters deep, which is believed to be excavated over a course of a perihelion passage into the inner parts of the solar system. As comets get closer to the Sun, solar irradiation causes their ices to sublime, leaving a formation of a freely expanding atmosphere (coma). Depending on the science interest, astrophysicists use different techniques for data collection, a common one being spectroscopy. Using iSHELL spectrograph at the NASA-Near-Infrared Telescope Facility (IRTF), we examine the primary chemical composition (e.g., H2O, CO, CH4, C2H6, C2H2, H2CO, NH3, CH3OH, OCS, and OH) of cometary coma in bright comet C/2022 E3 (ZTF).

Our preliminary results indicate the H2O production rate of ~3.4E28 (molecules per second), which corresponds to the rotational temperature of 86 (K). Cometary atmospheres are dense enough that molecules in the inner coma are thermalized by collision (Local Thermodynamic Equilibrium), thus 86 (K) is a physical parameter of coma. We compared the production of the rest of species with that of water (in %) and our results indicated that comet E3 was typical (close to average) in mixing ratios of all volatile species. By mapping the intensity of light with distance from the nucleus we were able to examine the spatial distribution of volatiles and dust in E3’s coma which were consistent with production directly from the nucleus.