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Linking ice and dust in comets to the building processes of our Solar System

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Because comets are considered fossils of the early solar system, comparing their composition to that found in planet-forming disks surrounding young solar analogues (10^4 - 10^6 years old) provides a unique insight into the physical, chemical, and evolutionary processes that shaped our planetary system (Mumma & Charnley 2011; Ceccarelli et al., 2023).

Here, we present the statistical analysis of a database of molecular abundances in 35+ comets from infrared (2-5 µm) high-resolution ground-based spectroscopy (Lippi et al., 2024). We do not observe statistically significant differences between comets from different dynamical classes (e.g., Jupiter family/short period vs. Oort Cloud/long period comets), implying that the comet material has not changed considerably after formation. We identify the existence of temperature-activated processes in the coma that may affect the abundance of given species (e.g., H2CO), depending on the observing conditions. When comparing the database results to those from the ESA-Rosetta mission, we find that 67P/Churyumov-Gerasimenko is not representative of the average comet population, highlighting the importance of avoiding using this target alone as the major reference when comparing comets and planet-forming regions.

Finally, we tested the comet database against recent findings in star-formation research, (e.g., Booth et al., 2021, Podio et al. 2020), showing for example that [CH_3OH]/[H_2CO] and [NH_3]/[CH_3OH] ratios in comets, Class 0 hot-corinos, and inner regions of Class II disks are consistent, indicating an inheritance scenario for these species.

Further steps of our research will integrate the database with: (i) cometary dust properties observed in the mid-infrared (e.g., Harker et al., 2023), (ii) new chemical aspects of planet-forming systems and comets from state-of-the art facilities (e.g., ALMA, JWST) including isotopes (e.g., $^{34}S/^{32}S$, $^{33}S/^{32}S$, Booth et al. 2024, D_2CO/H_2CO, Podio et al. 2024, HDO/H_2O, Cordiner et al., 2025, submitted), and (iii) dust growth and grains chemistry (e.g. Fe, Mg, Al, K) in accretion flows from the surrounding envelopes (Bianchi et al. 2023, Codella et al. 2024, Sabatini et al. 2024, Podio et al., 2024).