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Land of Gas and Dust: Exploring Bursting Pockets on Comet 67P

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Dust and gas outbursts are recurring phenomena in comets, playing a crucial role in shaping their comas. A large set of outbursts on comet 67P/Churyumov-Gerasimenko during its perihelion in 2015 has been presented in Vincent et al. (2016), demonstrating the comet's high activity while ESA's Rosetta spacecraft orbited it. Recent findings (Müller et al., 2024) indicate two distinct outgassing patterns for such outbursts: water-driven events, marked by rapid changes in coma composition over minutes to hours, and CO₂-driven events, characterized by slow, prolonged increases in highly volatile species over hours to days. These divergent gas composition patterns suggest different trigger mechanisms. Notably, cliff collapses expose fresh ice, leading to water enhancement, while perihelion outbursts often coincide with significant density increases of CO₂. It has been proposed that these CO₂-driven events originate from subsurface gas-filled cavities, whose walls have been sealed by earlier refreezing of CO₂ migrating from warmer regions, and hence elevating the cavity pressure required for bursting.

To have gas pockets with significant pressure buildup, the porous structure of the comet interior must be sealed. Refreezing of CO₂ emerges as a plausible mechanism (Filacchione et al., 2016). Research indicates that CO₂ sublimates long after water ceases sublimation on the comet's outbound orbit from areas no longer exposed to sunlight (Läuter et al., 2019, Combi et al., 2020). Sublimating gas that is dispersed in all directions encounters colder temperatures towards the comet interior, promoting refreezing and creating a volatile-enriched ice layer (Prialnik et al., 2022). This mechanism may account for the extended orbital frost cycle and potentially also drive a diurnal refreezing process, fostering gas pocket formation in volatile rich regions over shorter time scales. Laboratory experiments affirm CO₂'s ability to coat surfaces and to create impermeable layers with considerable tensile strength, sufficient to confine gas in pockets under pressure (Portyankina et al., 2019; Prialnik et al., 2022). Experimental data suggest CO₂ ice tensile strength ranges between 2 and 6 MPa (Kaufmann et al., 2020) and thus slightly higher than the tensile strength of water ice (Litwin et al., 2012).

This study focusses on the CO₂-driven events, analysing gas production data measured with the ROSINA/DFMS mass spectrometer. Analyzing the same dataset as in Müller et al. (2024), we focus

on events attributed to CO₂-driven outbursts. Employing a simple gas distribution model, we explore the behavior of pressurized gas containers and approximate gas cavity pressure, contrasting it with CO₂ ice tensile strength. By this approach, we aim to shed light on the formation and characteristics of gas pockets on cometary surfaces.

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