The dust environment of distant Long Period Comets: a study in support to ESA Comet Interceptor space mission

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Introduction. The dust environment of comets pertaining to different dynamical and physical families and groups provides key information to investigate the formation processes and evolution of pebbles that formed planetesimals at different heliocentric distances, and to check if cometary nuclei are built-up by pebbles formed in different regions of the solar protoplanetary disk [1].

Up to now, only a handful of comets has been visited in-situ by space missions and they are all Short Period Comets (SPCs), with the only exceptions of comet 1P (Halley-type): 19P, 9P, 81P, 103P and 67P, the target of the successful Rosetta mission, are comets that repeatedly traveled in the inner part of our Solar System. To understand the higher complexities of planet-building in the primordial solar nebula, we must examine comets during the first inbound orbital branch and at high heliocentric distances.

Comet Interceptor ESA space mission. The very next future in the field of cometary science will be the new ESA cometary mission, Comet Interceptor (CI). For the first time ever, a space probe will investigate *in-situ* a Long Period Comet (LPC), possibly dynamically new, or even an Interstellar Comet (IC), thus a surely less evolved object than SPCs.

CI will be very likely launched before its target is discovered: it will wait in a parking orbit around the Sun-Earth L2 point, where it can station-keep with very little fuel, until a reachable target is selected. The spacecraft will depart from L2 to encounter the comet at a distance from the Sun of $\sim$ 1 au, following a cruise period of up to 3 years. Even with this strategy, the target comet must be discovered inbound at a relatively large distance, in order to give sufficient time to characterize its orbit and activity levels, and for the spacecraft to reach the encounter position.

Ground-based observations of distant comets in support to CI mission. To account for the CI safety, to plan at best fly-by trajectory and to optimize the payload observation planning, it is necessary to learn about LPCs activity from ground-based observations and then, more in particular, to characterize at best the selected target just after the discovery. To this aim, we started a Long Term Observing Program in support to the selection of the CI target selection. The main scientific aim of this activity is to monitor how the activity of Dynamically New Comets (DNCs) evolves with respect to heliocentric distance, to: (a) better understand the processes driving distant cometary activity; (b) make predictions on the future behavior of possible CI targets to be discovered in the next decade. Beyond the so-called “water line” (~ 4 au), solar heating is not high enough to trigger their activity by H_2O ice sublimation [2], and the coma and tail formation is driven by ices that are more volatile than water-ice (namely carbon monoxide, molecular oxygen, methane, ethane and carbon dioxide [3]).

First results of the project: The Copernico 1.82 mt telescope (Cima Ekar, Asiago, Italy) and the Telescopio Nazionale Galileo TNG 3.5 mt telescope (La Palma, Canary Islands, Spain) are involved in the project. High-res images of LPCs’ tails are being collected in the frame of dedicated TNG observing programs, in order to study the physical parameters driving the distant cometary activity (in particular the dust loss rate). LPCs comae photometry is being pursued within observing programs at the Copernico telescope, in order to define how the LPCs dust loss rate evolves while comets move along their orbit. The observation programs started in February 2022: the dust environment of the observed comets is expected to mimic quite well the environment of the putative CI target at discovery, i.e., when it will still not have experienced enough heating to trigger the more canonical water-driven activity.

We will present the main aims of the project together with the preliminary results obtained on a sample of DNCs observed when at heliocentric distances beyond 4 au, up to almost 9 au.

References: [1] Fulle M., 2021, MNRAS 505, 3107. [2] Fulle M. et al., 2020, MNRAS 493, 4039. [3] Fulle M. et al., 2022, MNRAS 513, 5377