COMETS – Comets Observation & Mapping Enhanced THz Spectrometer at 210-580 GHz: Objectives and Development Status

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Comets are one of the most intriguing and fascinating objects of the Solar System not only because of their potential for providing information on conditions in the pre-Solar and Solar Nebula, but also for their possible connections with the origin of life on Earth. They are indeed among the most primitive least processed bodies, and hence they may provide reliable information on the composition and thermo-dynamical conditions in the Solar Nebula. Understanding the nature of the cometary nucleus, outgassing from the nucleus, and development of the comet coma is essential to understand the evolution of comets over time, and how primordial the materials they expose are. The Microwave Instrument on the Rosetta Orbiter (MIRO), through its high spatial and high spectral resolution observations has been able to identify morphological features as small as 5 m on the comet nucleus and correlate them with regions of outgassing. Outgassing rates from the nucleus for a number of molecules including water could be measured directly with MIRO [1].

However MIRO had a very important limitation: A single-pixel receiver topology which made it impossible to map the comet before it significantly rotates. In fact, retrieving thermal properties of the nucleus requires maximal coverage of the nucleus as function of location and time of day. In addition, the cometary coma are extremely asymmetric, especially close to the nucleus, making the retrieval of coma properties strongly model-dependent and computationally intensive, particularly when each point is acquired at different times (and thus rotational phase). A "straight forward" solution to these limitations is to use multi-pixel systems for instantaneous and efficient mapping of the cometary comas. But for planetary science missions, where the power budget and compactness of the instrument is crucial to be considered a part of the baseline payload, this mapping capability was not feasible until now.

As a response to this problem, we are developing COMETS (Comets Observation & Mapping Enhanced THz Spectrometer), the first multi-pixel broadband all-solid-state submillimeter-wave heterodyne spectrometer & radiometer to enable instantaneous mapping of cometary comas and surfaces with very high-spectral resolution ($\lambda/\Delta\lambda \sim 10^7$). COMETS will feature a 16-pixel dual-band 210-245 GHz/500-560 GHz array receiver integrated on a single front-end channel for continuum & spectroscopic measurements, including instantaneous mapping of water, H/D ratios, and other key molecular species (see Fig. 1).

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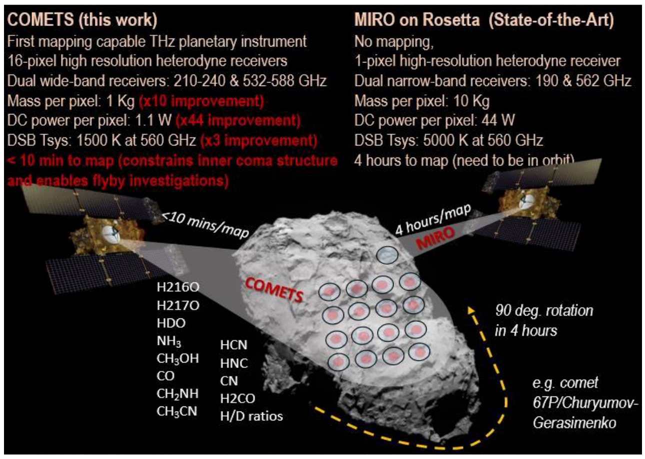

Fig. 1. COMETS overview - Comets Observation & Mapping Enhanced THz Spectrometer at 210-580 GHz (16-pixel array).

The receiver front-end consist of a combination of fundamental/subharmonic mixers and Schottky diode based frequency multiplied local oscillators [2], introducing a new design concept that increases the bandwidth of traditional frequency multipliers by a factor of two, allowing to combine the two-bands on a single channel. This simplifies considerably the instrument optics. A novel dual-band leaky-wave micro-lens array antenna [3] has been designed to provide the same beam width for both bands so that the high and low frequency pixels are collocated in the field of view, allowing identical foot-prints in the comet. Based on tests performed on a 2-pixel proof-of-concept version, the current-base estimate (CBE) of the dc power consumption of COMETS is ~54 W for the 16-pixel array. This is already lower than MIRO's numbers. An overview of COMETS science, overall instrument architecture design and preliminary receiver results will be discussed at the conference.

References

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