Planetary/Cometary Submillimeter-Wave Instruments on Ultra-Small Platforms

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CubeSats are shoe box size satellites with low-mass, low available power, and until recently had limited communication and instrumentation capability. The size of the CubeSats are referred in the unit of ‘U’, where one ‘U’ is a cube with 10 cm x 10 cm x 10 cm dimensions.

Until recently, the development of CubeSats and its related instrumentation was primarily confined to undergraduate university research. However, in recent years, the national space agencies have been actively looking into CubeSats and SmallSats as useable platforms to supplement main missions as well as using them for standalone scientific missions. In some cases, they are being used to provide a communication relay platform for the missions where direct to earth (DTE) links are not always feasible. A case in point is the Mars Cube One (MarCO) [1] where two CubeSats were used to provide communications with the main space craft and ground control during high risk maneuvers and critical events during the recent Insight landing.

In general, a small 6U will have approximately 2U available (the rest of the space is used for solar cells for power generation, star tracker for guidance, attitude control, and other electronics) for low-power, low-mass, yet highly capable scientific payload. These CubeSat based flights will not only enable advancing proof of concept instruments to higher technology readiness level (TRL) by flying them in relevant environment, but also will allow to have multiple targeted flights with scientific data returns. Due to budget constraints, flying large missions are becoming more and more challenging. CubeSat and SmallSat platforms will provide the avenue to more scientific missions as they are much cheaper than large missions.

Developing scientific payloads CubeSat platform poses a host of challenges. First, the instrument needs to be highly compact due to the lack of available space. Second, it has to be ultra-low power due to the severe restrictions on DC power availability. And finally, one has to be innovative in the design of the antennas as traditional high gain reflector antennas (for scientific payload as well as for data communication) are not practical. Design and development of aperture deployable antennas and other innovative structures are gaining a lot of attention in this regard.

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We are currently developing fully functional submillimeter-wave standalone scientific instruments as technology demonstrations on 6U CubeSats. Specifically, we are developing a low-mass and low-power 500-600 GHz high-resolution spectrometer instrument on a 6U CubeSat platform capable of remotely measuring water isotopes on comets. The instrument’s 18 cm diameter aperture consists of a novel low-profile leaky-wave lens based antenna with waveguide feed integrated on the CubeSat. A microelectromechanical system (MEMS) based calibration switch [2] is integrated with the receiver front-end along with low-power CMOS based backend spectrometer circuits. This allows the overall instrument mass and power to be in the range ideal for implementation on ultra-small platforms such as CubeSats. Fig.1 shows the schematic of the concept.

In this presentation, we will provide the design and implementation of the 500-600 GHz spectrometer instrument with details of innovative packaging solutions, antenna technology, and low-power backend solutions suitable for CubeSat and SmallSat platforms.

The research described herein was carried out at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA, under contract with National Aeronautics and Space Administration.

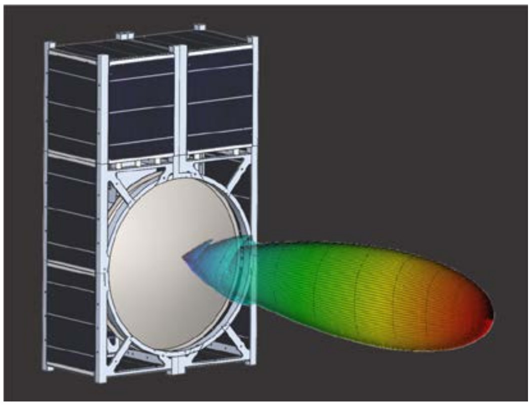

Fig. 1: Conceptual schematic of a submillimeter spectrometer instrument on a CubeSat Platform.

References

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[2] T. Reck et al., “A 700-GHz MEMS Waveguide Switch,” *IEEE Trans. THz Sci. Tech.*, vol. 6, no. 4, pp. 641-643, July 2016.

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