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A COMPACT MEMS-BASED FABRY-PÉROT INFRARED SPECTROMETER FOR PLANETARY SURFACE EXPLORATION

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Thermal infrared spectroscopy provides essential information on the mineralogical and physical properties of planetary surfaces through diagnostic emissivity features such as the Christiansen feature, Reststrahlen bands, and transparency features. However, the implementation of thermal infrared spectrometers on small satellites, landers, and rovers remains challenging due to strict constraints on mass, power, and system complexity. This contribution presents the development and laboratory validation of a compact Fabry-Pérot infrared point spectrometer optimized for resource-constrained Solar System exploration missions.

The instrument operates in the thermal infrared wavelength range between 7.5 and 10.5 μm and employs an electrically tunable MEMS-based Fabry-Pérot filter (FPI) in combination with an

uncooled thermopile detector. Spectra are generated in the time domain by scanning the FPI using electrostatic actuation, eliminating the need for moving macroscopic parts or cryogenic cooling. The spectrometer design builds on heritage from thermopile-based radiometers flown on previous planetary missions and integrates optics, filter, detector, and thermal monitoring into a compact, vacuum-compatible sensor head.

Laboratory characterization and spectral calibration using a cavity blackbody, collimator, and narrowband reference filters were performed under thermal vacuum conditions. The measurements demonstrate a usable spectral resolution / of approximately 30 across the operating wavelength range, sufficient to resolve broad spectral features of rock-forming minerals relevant for planetary geology and in-situ resource utilization studies. The current breadboard design achieves a sensor head mass of approximately 105 g and an estimated total instrument mass of about 300 g including electronics. Owing to its compactness, low power demand, and modular architecture, the presented Fabry–Pérot spectrometer concept is well suited for future planetary landers, rovers, and CubeSat-class missions targeting the Moon, Mars, and small bodies. Future developments could include the use of multiple Fabry–Pérot filters and detector channels to extend the effective free spectral range of the instrument, enabling broader spectral coverage and simultaneous multiband measurements while preserving the compact and low-resource architecture.