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Vibration-free cooler for the METIS instrument using sorption compressors

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METIS is the 'Mid-infrared ELT Imager and Spectrograph'for the European Extremely Large Telescope that will cover the thermal/mid-infrared wavelength range from 3 –14 micron. Starting from a pumped nitrogen line at 70K, it requires cryogenic cooling of detectors and optics at 40K (1.4 W), 25K (1.1 W), and 8K (0.4 W). A vibration-free cooling technology for this instrument based on sorption coolers is under development at the University of Twente in collaboration with Dutch Space. We propose a sorption-based cooler with three cascaded Joule-Thomson coolers of which the sorption compressors are all heat sunk at the 70K platform. A helium-operated cooler is used to obtain the 8K level with a cooling power of 0.4 W. Here, three pre-cooling stages are used at 40K, 25K and 15K. The latter two levels are provided by a hydrogen-based cooler, whereas the 40K level is realized by a neon-based sorption cooler. Based on our space-cooler heritage, our preliminary design used sorption compressors equipped with gas-gap heat switches. These have maximum efficiency, but the gas-gap switches add significantly to the complexity of the system. Since in METIS relatively high cooling powers are required, and thus a high number of compressor cells, manufacturability is an important issue. We, therefore, developed an alternative cylindrical compressor design that uses short-pulse heating establishing a thermal wave in radial direction. This allows to omit the gas-gap heat switch. The paper discusses modeling, validating experiments, and the consequences in the design of the METIS cooler.

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