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Development of a sorption-based Joule-Thomson cooler for the METIS instrument on E-ELT

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METIS, the Mid-infrared E-ELT Imager and Spectrograph, is one of the proposed instruments for the European Extremely Large Telescope (E-ELT) that will cover the thermal/mid-infrared wavelength range from 3- 14 µm. Its detectors and optics require cryogenic cooling at four temperature levels, 8 K for the N-band detectors, 25 K for the N-band imager, 40 K for the L/M-band detectors and 70 K for the optics. To provide cooling below 70 K, a vibration-free cooling technology for the METIS instrument based on sorption coolers is developed at the University of Twente in collaboration with Airbus Defence and Space Netherlands B.V. (former Dutch Space B.V.). We propose a sorption-based cooler with three cascaded Joule-Thomson (JT) coolers of which the sorption compressors are all heat sunk at the 70 K platform. A helium-operated cooler is used to obtain the 8 K level with a cooling power of 0.4 W. Here, three pre-cooling stages are used at 40 K, 25 K and 15 K. The latter two levels are provided by a hydrogen-based sorption cooler, whereas the 40 K level is realized by a neon-based sorption cooler. In order to prove the theoretical designs, three demonstrators were built and tested: 1. Full-scale helium JT cold stage; 2. Down-scaled helium sorption compressor; 3. Close-to-full-scale neon sorption JT cooler. In this paper, we present the design of these demos and we discuss the experimental results obtained so far, the lessons that were learned from these demos and the future development towards a real METIS cooler.

Primary author: Mr WU, Yingzhe (University of Twente)

Co-authors: Dr BENTHEM, Bruin (Airbus Defence and Space Netherlands); Mr VERMEER, Chris (Foundation SuperACT); Mr HOLLAND, Harry (University of Twente); TER BRAKE, Marcel (University of Twente, The Netherlands)

Presenter: TER BRAKE, Marcel (University of Twente, The Netherlands)

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