Cryogenic Design for the SAFARI Test-Setup Calibration Source

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Abstract

In a European consortium led by SRON Netherlands Institute for Space Research, the SpicA Far-infraRed Instrument (SAFARI) is being developed. The SAFARI [1] Imaging Spectrometer working in the far-infrared wavelength range is to fly on the joint JAXA-ESA SPICA [2] mission (SPace Infrared telescope for Cosmology and Astrophysics). The instrument is actively cooled to ~4.5 Kelvin and cooling power is limited to a few mW. To perform absolute calibration of the instrument a calibration source is needed that covers the full dynamic range of the detectors in the SAFARI bands with accurate knowledge of both the power level and its spectral distribution.

The calibration source [3] design is shown in Figure 1. A 'hot source' black body cavity (3) is heated up to 150K to provide the desired radiation. The bi-stable shutter mechanism (2) can be used to provide a flash function and to close the aperture to allow other measurements during the warm-up and cool-down time of the hot source, increasing the efficiency of the test-setup. The iris mechanism (4) will be used to fine-tune the absolute power output of the calibration source, and can create an arbitrary power versus time function so the response of the detectors to time varying signals can be verified. Finally the radiation is redistributed inside an integrating sphere (1) that is thermally anchored to 1.7K to provide a flat output for the instrument with negligible background to the instrument. A thermal break (5) separates the 1.7K integrating sphere from the 4.5K environment. The design of the calibration source is now past the conceptual stage and the actual hardware is being made and tested.

Here we will present the COMSOL Multiphysics® analysis of the elements of the calibration source. COMSOL Multiphysics® was used to optimize the heat-leakage and stiffness of the thermal suspensions of the Hot Source and Integrating sphere. For the bi-stable shutter latching mechanism, the magnetic field and latching force were calculated for different angles of the mechanism, by performing a parametric sweep in combination with the LiveLink™ for Pro/ENGINEER®. The Iris mechanism was optimized for minimal power dissipation with COMSOL Multiphysics® by sweeping the air-gap size and the number of windings on the coil (Figure 2). The first tests of actual hardware of the Hot Source, Shutter and Iris showed that the measurements match the results predicted by the COMSOL Multiphysics® modeling very well.

Reference

[1] Brian Jackson et al. “The SPICA-SAFARI Detector System: TES Detector Arrays With Frequency-Division Multiplexed SQUID Readout” IEEE Transactions on Terahertz Science and Technology, 2, 1–10 (2011)
[2] Bruce Swinyard et al. “The space infrared telescope for cosmology and astrophysics: SPICA A joint mission between JAXA and ESA.” Experimental Astronomy, 23, 193–219 (2008)
[3] Wouter Laauwen et al. “Development of a Calibration Source for SAFARI on ground Calibration.” 22nd ISSTT Proceedings (2012)

Figures used in the abstract

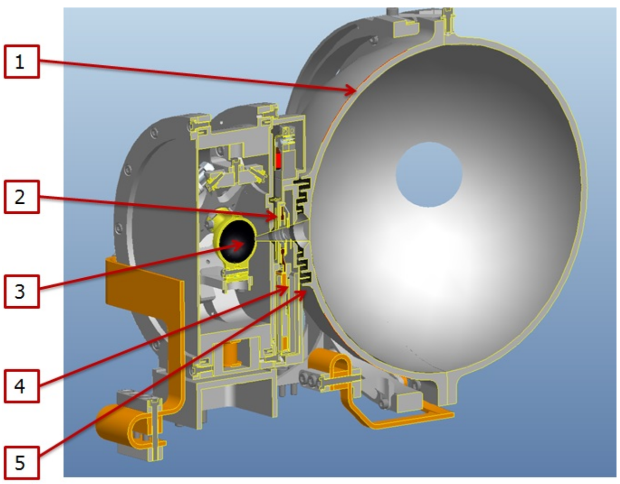

Figure 1: Calibration source design. See the text for a description of the different parts of the calibration source that were modelled in COMSOL Multiphysics®.

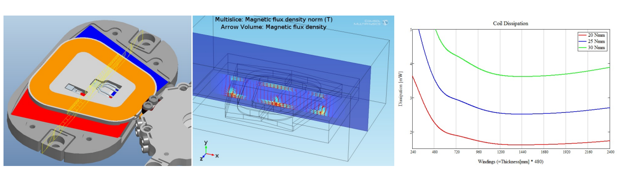

Figure 2: The actuator of the iris mechanism. Left: CAD Model of the actuator ('hard-disk' / arc type voice coil motor). Middle: Magnetic model of the actuator in COMSOL Multiphysics®. Right: The minimum dissipation was found at a coil thickness of 2.5mm and 1200 windings.