Results from the Quarter-Scale THAI-SPICE balloon flight: Implications for athermalizing balloon-borne telescopes

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Abstract

THAI-SPICE (*Testbed for High Acuity Imaging – Stable Photometry and Image-Motion Compensation Experiment*) is a NASA-funded balloon project with three main goals: to characterize the thermal environment in the stratosphere in order to athermalize balloon-borne telescopes, to test a solid-state motion compensation device and to determine *in-situ* wavefront errors on a balloon-borne telescope. We report on results from the 16-OCT-2019 flight in which we flew a quarter-scale version of the full-size THAI-SPICE payload. This payload was instrumented with thermal sensors to assess the fidelity of thermal models and determine the relative importance of radiation vs. convection/ advection as cooling mechanisms in the stratosphere. Radiative cooling at ~35 km was expected to dominate other mechanisms, but we found that radiative cooling and atmospheric thermal coupling were comparable effects.

The Quarter-Scale Payload

The THAI-SPICE quarter-scale payload was roughly the size of a dormitory refrigerator (Fig. 1) and weighed 71.5 lb (32.5 kg). We intend to launch a full-scale payload in September 2020, a 1500-lb science payload with a 50-cm aperture telescope, an orthogonal-transfer CCD (OTCCD) and a wavefront sensor. The quarter-scale flight (QSF) was intended to serve as a thermal dry run for the full-scale flight: it had a non-operational scale-model telescope and quarter-scale sun-shields and earth-shields. The QSF was instrumented with 16 thermal sensors and an infrared camera that imaged the back of the primary mirror. Data from these instruments were recorded at 1 Hz from the time that the payload was powered (at 6:07 AM MDT on 16-OCT-2019) until after termination (13:07 MDT). Launch took place at 7:56 MDT.

Fig. 1. The Quarter-Scale payload undergoing thermal testing in the NASA/CSBF chamber.

Thermal Results

Two thermal sensors were placed on an aluminum panel that was heated with a known source. The difference between those sensors and ones nearby is diagnostic of radiative cooling vs. thermal coupling to the atmosphere. Data from the pre-launch period showed that atmospheric coupling dominates radiative cooling on the ground. Data from float altitudes show that cooling from the two processes are comparable.

Conclusions

The THAI-SPICE project is intended to enable diffraction-limited performance by balloon-borne telescopes. The QSF lets us model thermal fields and gradients: results from the QSF let us validate modeling software (like *Thermal Desktop*) and design athermal balloon OTAs and enclosures.