Effect of Gravity Orientation on the Thermal Performance of Stirling-type Pulse Tube Cryocoolers

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The effect of angular orientation on the off-state conduction of pulse tube cryocoolers has been previously explored, as has the effect of orientation on the thermal performance of low-frequency (~1 Hz) GM-style pulse tube refrigerators. The significant effects that have been found are well explained by the presence of free convection that builds up in the hollow pulse tube when the hot end of the pulse tube is not higher than the cold end. This paper extends the investigation of angular orientation effects to the refrigeration performance of high frequency (~40 Hz) Stirling-type pulse tube cryocoolers typical of those used in long-life space applications.

Strong orientation effects on the performance of such cryocoolers have recently been observed during system-level testing of both linear and U-tube type pulse tubes. The level of effect can be large enough to prevent meeting system operational requirements during ground testing when the hot end of the pulse tube is not in an upward orientation.

To quantify the angular dependency effects, data have been gathered on both U-tube and linear type pulse tubes of two different manufacturers as a function of orientation angle and cold-tip temperature. This paper discusses both the observed orientation effects during cryogenic system-level testing as well as the detailed results of the parametric pulse tube measurements.

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