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C2Po1C-03 [11]: Sensitivity analysis on miniaturize pulse tube boundary layer losses

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Miniaturized cryocooler systems are among the key components of state-of-art infrared sensing small satellites (SmallSats). To achieve small size, these cryocoolers need to operate at high frequencies, e.g., 200 to 300 Hz range. High frequency leads to lower compression and expansion swept volumes and hence a smaller cryocooler. Previously we showed that pulse tube cryocoolers have high boundary layer losses for small size pulse tube diameters, which results in low thermodynamic efficiency. In this follow-up study we present a sensitivity analysis on the pulse tube boundary layer losses which investigate the effects of the bounding temperatures, pulse tube aspect ratio, operating frequency and pulse tube diameter. Computational fluid dynamics (CFD) is used for this sensitivity analysis. The results allow us to find the threshold conditions beyond which a miniature pulse tube cryocooler can no longer be effective for use at high frequencies.

Primary author: GHAVAMI, Ali (Georgia Tech)

Co-authors: KIRKCONNELL, Carl (West Coast Solutions); Dr GHIAASIAAN, Mostafa (Georgia Institute of Technology)

Presenter: GHAVAMI, Ali (Georgia Tech)

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