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C4Or1A-01: High-Fidelity Modeling of the Continuous Adiabatic Demagnetization Refrigerator for PRIMA

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The 5-stage continuous adiabatic demagnetization refrigerator (CADR) on the Probe far-Infrared Mission for Astrophysics (PRIMA) is designed to provide continuous cooling at two temperatures: 100-120 mK for the focal planes of the imaging instrument (PRIMAger) and multi-band spectrometer (FIRESS), and at 1.0-1.2 K for parts of the optical train. The CADR will use a James Webb Space Telescope-like 4.5 K Joule-Thomson cryocooler as its heat sink to provide 700 microW of lift at 1.0 K and 9 microW of lift at 100 mK. The JT cryocooler cools other cryogenic components, allowing only 10 mW of the expected 53 mW total cooling power to be allocated to the CADR's operation. Meeting both the required cooling power and temperature stability requirements is challenging given how close the CADR must operate to practical limits of thermodynamic efficiency. In order to assure such operation is possible, a high-fidelity model of the system has been assembled, based on the performance of identical components flown on Astro-H/Hitomi and the X-Ray Imaging and Spectroscopy Mission (XRISM). The model and predicted performance of the CADR will be presented.

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