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C1Po1B-01: In-line and coaxial configuration performances of Stirling pulse tube cryocoolers for spaceflight

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Cryocoolers are critical components in space missions, providing the necessary cooling to maintain the functionality of sensitive instruments operating at cryogenic temperatures, such as superconducting devices and infrared detectors. This paper explores the design and application of Stirling and Stirling pulse tube cryocoolers (SPTCs) for spaceflight, emphasizing the trade-offs between different configurations and their suitability for specific mission requirements. Two primary configurations are analyzed: in-line and coaxial. The in-line design offers more simplicity and reduced fluid mechanical complexity but poses challenges in integration due to its linear geometry and lack of access to the cold head for detector integration. In contrast, the coaxial design is more compact, making it advantageous for detector coupling, although it introduces turbulence that can impact thermodynamic efficiency and cooling power. The study highlights critical design considerations, including minimizing vibrations, enhancing thermodynamic efficiency, and ensuring reliability over extended mission durations. Examples of these configurations utilized in space-based instruments are analyzed and underscore the importance of design innovations, such as dual-opposed compressors and advanced thermal linking, in addressing challenges like thermal noise and reliability. Future cryocooler development must focus on reducing mass, improving integration into space instruments, and enhancing energy efficiency, which are demonstrated to be achievable through configuration modifications. Addressing these challenges will enable the next generation of cryogenic systems to meet the stringent requirements of long-duration space missions.

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