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C2Or2D-02: Sorption Compressor Developments for Vibration-Free JT Cryocoolers

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The ETpathfinder (ETPF) is a scaled prototype of the Einstein Telescope gravitational wave observatory, developed to validate and advance the technologies required for next-generation detection. It features two Fabry–Perot Michelson interferometer arms cooled by liquid nitrogen (LN_2), with one arm requiring additional cooling to approximately 10 K. Because third-generation laser-interferometry detectors demand minimal vibration for precise measurements, the University of Twente has proposed a modular "cryochain"design. This configuration combines sorption-based compressors and Joule–Thomson (J–T) cold stages in a parallel cascade at 40 K (neon), 15 K (hydrogen), and 8 K (helium), yielding cooling powers of 2.5 W, 0.5 W, and 0.05 W, respectively. A key factor in ensuring the cryocooler's compactness and performance is the sorption compressor, which comprises multiple sorption cells and additional passive components. The design and operation of these sorption cells require thorough investigation and optimization to achieve the targeted cooling efficiency. Recent predictive models of the sorption process offer valuable insights into factors such as pressure dynamics and thermodynamic cycles, informing critical design decisions for improved efficiency and reduced vibration. Crucially, these optimizations can also be adapted for low-vibration cryocooling in space-based systems and satellite applications, where minimizing disturbance is equally vital. Collectively, these developments establish a pathway for implementing a robust, low-vibration sorption cryocooler, representing a significant stride toward meeting the stringent requirements of high-sensitivity measurement applications.

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