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C3Po1F-01: Conceptual design of a lab-scale low-noise He-II liquefier using a pulse-tube cryocooler with a Joule-Thomson cycle

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The Einstein Telescope (ET) is a 3rd generation gravitational wave detector planned in Europe, combining a low-frequency (LF) and a high-frequency (HF) laser interferometer. Cryogenic operation of ET-LF in the temperature range of 10 K to 20 K is essential to suppress the suspension thermal noise (STN), which dominates the detection sensitivity at frequencies below 10 Hz.

The ERC project GRAVITHELIUM aims to investigate the suitability of static He-II for the heat extraction from the cryogenic core optics in ET-LF. It requires a low-noise He-II supply unit that can provide 400 mW of cooling capacity at 1.8 K via a 5 m long transfer line. Using a pulse-tube cryocooler in combination with a Joule-Thomson cycle, an in-depth process analysis and optimization is conducted. Significant improvements to the process efficiency are achieved by a novel heat exchanger technology, the so-called foil-frame counterflow heat exchanger (FFCFHX), which allows for large heat transfer areas while maintaining low kinetic pressure losses.

The contribution also contains the characterization of the transient cool-down process, which happens in two phases: The cool down of the He-II supply unit and the transfer line using a supercritical helium flow, and the final cool-down via pumping on the liquid helium tank. The results show that He-II temperatures can be reached in less than one day, depending on the cool-down behavior of the experimental cryostat.

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