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Performance study of hybrid space cryocoolers working at liquid helium temperature

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The hybrid space cryocooler consists of a Stirling or pulse tube cryocooler, serving as a precooler, and a J-T loop. With the high efficiency, compact structure, long service life, and remote cold head which can be isolated from vibration or electromagnetic interference, it has been employed by several space missions to provide the liquid helium temperature environment for the detectors. These space missions are briefly reviewed and the performance comparison of the hybrid cryocoolers is given. It is shown that the cryocooler for SPICA mission has the highest COP and lowest precooling power needed in the J-T loop per unit mass flow. Further analysis, based on the cryocooler for SPICA mission, shows that the appropriate lower precooling temperature, higher pressure ratio and higher recuperator effectiveness are the keys to improve the performance of the J-T loop. According to the current performance level of the precoolers and the linear compressors of the J-T loops, the precooling temperatures and pressures of the J-T loop are discussed to optimize the overall efficiency of the hybrid cryocooler. The results show that a better performance of the cryocooler can be obtained with the optimized parameters.

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