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C1Po1D-01: Research on an efficient Joule-Thomson throttling refrigeration system based on cold compression cycle

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2K-class or 4K-class mechanical Joule-Thomson (JT) throttling refrigeration system is crucial to cool far infrared detector or extremely high sensitivity and resolution detector，such as SQUID（Superconducting quantum interference device），SNSPD（superconducting nanowire single photon detector）
A novel efficient precooled JT throttling refrigeration system is currently under development. In this system, JT cooler is pre-cooled by a GM refrigerator or a pulse tube refrigerator.The compression unit of JT cooler which drives the circulating mass helium, is at low temperature and directly coupled to the cold head of the pre-cooling cooler. Compared to traditional throttling refrigeration system, this design eliminates the need for multi-stage heat exchangers, simplifies the system architecture, and enhances the efficiency.
The linear motor components driving the compression unit is arranged in an environment of ambient temperature and pressure. The heat generated by the linear motor during operation is dissipated through air cooling or water cooling methods. The linear motor is connected to the compression unit by a connecting rod made of materials with low thermal conductivity and high strength, reducing heat loss.
The operating mass helium is isolated from the linear motor through a bellows, preventing the low-temperature operating mass from shuttling between the ambient-temperature motor, which would lead to heat loss.
Compared to traditional throttling refrigeration systems, this innovative system can still achieve rapid cooling without the need for a bypass valve. simplifying the structure and enhancing reliability.
A mathematical model is established in this work to reveal the cooling capacity characteristic based on thermodynamic analysis method. At present, the JT system experimental platform has been built and the corresponding performance tests are being carried out.

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