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## C3Po1D-08: A three-stage high-frequency pulse tube cryocooler obtaining a low temperature down to 2 K

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Limited by real gas effects which stick out in the critical temperature range, it is a challenge for high-frequency pulse tube cryocoolers to obtain the liquid helium temperature or below. The influence of real gas effects on the cold-end refrigeration performance of a low-temperature regenerator working in the liquid-hydrogen to liquid-helium temperature ranges was investigated primarily by theoretical analysis and simulation in this paper. Besides, the critical parameters hindering the achievement of liquid-helium temperature were given, and the design and optimization direction of the high-frequency regenerator working at 4 K was pointed out. A three-stage high-frequency pulse tube cryocooler was designed, built, and tested. The composite refrigeration process uses a single-stage 77 K cooler to pre-cool a two-stage gas-coupled high-frequency pulse tube cryocooler. The no-load temperature has been reduced to 2.4 K using  $^4\text{He}$  as the working gas, and a cooling power of 26 mW at 4.2 K was obtained.

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