Pulse Tube Cryocooler at 4 K: Customization for Sensitive Cryoelectronic Applications in “Dry” Low Noise Cryostats

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Introduction

Pulse tube cryocooler system

Cryogen free
Closed cycle system
"Dry" cooling at liquid helium temperatures [1,2]
Remote configuration for low vibration
Galvanic insulation against EMI

Intrinsic Thermal and Mechanical Variations

All regenerative cryocoolers suffer from thermal and mechanical variations of the cold head due to the periodic pressure wave of compressed and expanding gas inside the tubes.

Mechanical vibrations
periodic elastic deformation ("breathing") of the thin-walled tube with the pressure oscillation \( p \) : wall thickness \( d \)

\[
\Delta L = \frac{E \cdot d^3}{2 \cdot \alpha \cdot p} \quad \text{[m]} \quad \text{(E: Young's modulus)}
\]

Temperature variations
from periodic expansion (adiabatic) of the working fluid (He)

\[
\Delta T = \frac{c_p \cdot T \cdot \Delta p}{\rho \cdot C_p} \quad \text{[K]} \quad \text{(c_p: specific heat capacity of helium)}
\]

Mechanical Vibration of PTD 406 C in Measurement and Simulation

Cooling power of PTC in non-vertical operation

Cooling power of both stages of PTD 406C cold head operated with a 240 W tube refrigerator (P = 4.5 K)

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