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Leveraging Real Fluid Effects as a Tool for Power Flow Measurements in 4 K Cryocooler Regenerator

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The real fluid properties of helium have a major impact on the thermodynamics of pulse tube and Gifford-MchMahon cryocoolers operating near the critical point, i.e., below about 30 K and pressures around 1 MPa. These real fluid properties limit the available cooling power at the lowest temperatures (below approximately 6 K), but they can also be leveraged to absorb a significant additional heat load in the 8 K to 15 K temperature range. This additional cooling capacity has been leveraged in several applications, but a deep understanding of the physical processes and the best approach to leverage them are lacking. We have densely instrumented the second stage of a two-stage pulse tube refrigerator to closely investigate the details of these thermo-fluid processes with a goal of validating physical models and developing design tools to integrate this additional cooling to best support lower-temperature cryogenic refrigeration stages. We discuss the design of the experiment, present preliminary data, and discuss initial interpretations of the results in the context of thermodynamic models of these processes.