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C1Po3D-04: Transient Heat Transfer in Superfluid Helium from Localized Heating Spots on Spherical Surfaces

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The transient heat transfer in superfluid helium (He II) from curved surfaces presents unique features that differ significantly from planar geometries. We numerically investigate this process by solving the two-fluid model coupled with Vinen's equation for vortex-line density, focusing on how surface curvature affects the propagation of the second sound wave. The numerical model is first validated against experimental data through comparisons with previous planar heater results, showing good agreement in temperature profiles and second sound behaviors. Analyzing cases of curved surfaces reveals distinct wave propagation patterns. When a heat pulse is applied, a second sound wave emerges and propagates away from the curved surface, accompanied by a rarefaction tail. The counterflow between superfluid and normal fluid components shows direction-dependent characteristics, with the wave's relatively velocity distribution, which provides insights into the energy transport mechanism. Our results demonstrate that curvature significantly influences both the magnitude and direction of energy transport. By analyzing different characteristic regions (10%, 50%, and 90% Energy Region), we identified different impacts of curvature on wave propagation angles. To quantify these effects, we establish dimensionless parameters using flat surface cases as a reference, enabling systematic analysis of curvature-dependent phenomena. These findings provide fundamental insights into the heat transfer of He II from curved surfaces, which also offer valuable guidance for optimizing the heat transfer process in curved geometries cooled by He II.
Keywords: Superfluid helium, Heat transfer, Second sound wave, Curved surface.

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