

From Boiling to Cryogenics: The Role of Two-Phase Flow in Sustainable Aviation

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Abstract:

Global energy demand and the urgent need to reduce environmental impact are driving radical changes in aerospace research. Novel aircraft designs, alternative fuels, and advanced propulsion concepts, ranging from battery-powered systems to hydrogen-based engines, are being developed to decarbonize aviation.

The transition to sustainable flight, however, introduces new thermal and phase-change challenges. Future aircraft will generate high heat loads and employ cryogenic propellants that tend to evaporate, complicating safe storage and fuel delivery. Managing these conditions requires a fundamental rethinking of thermal and fuel management strategies.

Here, we highlight how research in two-phase flow and thermal management, originally developed in the contexts of electronics cooling and nuclear energy systems, provide powerful insights for enabling future aviation systems. In particular, the study of boiling heat transfer, critical heat flux limits, and cryogenic phase-change dynamics become directly relevant to next-generation aircraft.