MECHANICAL ENGINEERING

The Department of Mechanical Engineering presents:

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Enhanced Cooling for High Heat Flux Applications Using Droplet Impact and Optical Cavitation

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Dr. Guillermo Aguilar, Chairperson

Demand for increased heat fluxes in high-power thermal management applications drives research into improved cooling techniques. Liquid and two-phase cooling methods provide cost-effective and potent means of heat extraction. Sprays of atomized liquid, in particular, deliver very high heat flux due to large cooling surface area, rapid evaporation, and continuous delivery of fresh cold liquid to the target. Sprays are difficult to model and study due to the inherent complexity of highly dynamic two-phase flows and the wide range of factors which influence the cooling effects. A detailed study of the impact of liquid droplets, alone and in sequential trains, onto a variety of impact surfaces is presented, with examination of the fluid properties, impact characteristics, and environmental conditions that govern the dynamics of the liquid after impact and the overall cooling effect. The interaction of successive droplets in a train is found to dramatically influence heat transfer, depending on the frequency of impacts.

As a spray is used to cool a target surface, a liquid film will often develop. A thermal boundary layer develops within the liquid film, reducing the effective cooling rate by isolating hot liquid near the surface. Agitation will minimize the thermal boundary layer, restoring the heat flux. Optical cavitation presents a unique method of non-intrusively breaking down the thermal boundary layer. By inducing cavitation within the layer, near the surface, the growth and collapse of the bubble will draw cool liquid from outside the boundary layer and deposit it near the surface. To achieve this effect, the optical and fluid conditions that contribute to cavitation are explored, in particular looking at the growth and collapse dynamics and the sequences of bubbles resulting from irradiation by a continuous wave laser. Novel experimental observations of asymmetric collapse phenomena are reported, and among the first measurements of cavitation frequency for continuous wave laser irradiation are reported.