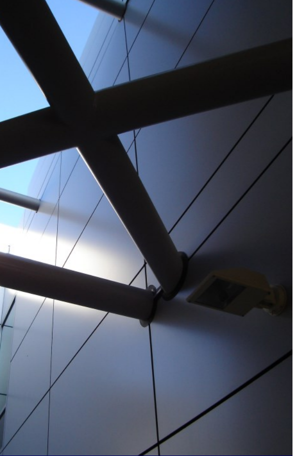

MECHANICAL ENGINEERING
DISSERTATION DEFENSE

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of

Vicente Robles

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Manipulation of Laser-Induced Cavitation Bubbles for Microfluidic and Micro-Targeting Applications

Doctor of Philosophy, Graduate Program in Mechanical Engineering
University of California, Riverside, June 2022
Dr. Guillermo Aguilar, Chairperson

Cavitation is a micron-scale process in which short-lived vapor bubbles form and collapse, giving way to intense, localized effects in the surrounding liquid. The phenomenon of cavitation was first noted to cause undesired damage on nautical equipment via erosion from strong emitted shock-waves as well as microjets that form when cavitation collapses near solid boundaries. More recently, cavitation studies have sought to exploit this process as a multitool for applications such as microfluidic pumping, and surface cleaning among other uses. However, several cavitation mechanisms continue to contribute to mechanical failure via surface erosion, thermal damage and collateral impacts expanding beyond the intended targeted regions. While fluid and optical properties may influence the formation threshold of cavitation, the physical surroundings such as interfaces and boundaries have more control on the collapse dynamics which is the primary effect utilized for said applications. An overwhelming number of investigated applications use a single cavitation event near a static structure to initiate jet formation, but this limits the available control to the stand-off distance, the non-dimensional distance between the bubble and solid. Two studies are presented which demonstrate how laser-induced cavitation impact can be controlled effectively or avoided entirely.

First, a detailed study investigates how varying the temporal and spatial separation of two interacting cavitation bubbles can affect the resulting jet speed. The double bubble system is found to generate fast jets capable of perforating soft materials with a minimized surface damage compared to a single bubble impact. A novel experimental proof of concept is reported to use this system for needless injection without the need for clean room fabrication of micronozzles as is required by previous works. A second experimental study reports the use of simple casted gas entrapping microstructures to influence the migration of cavitation collapse. The entrapped air pockets act as compressible interfaces and expand during the primary cavitation event and repel the bubble away from the surface. This process can be employed as a method to mitigate cavitation erosion or enhance agitation in low Reynolds number flows in an on-demand and localized manner. The final section briefly explores characterization of thermocavitation, a second form of cavitation formation via energy deposition by continuous wave irradiation.