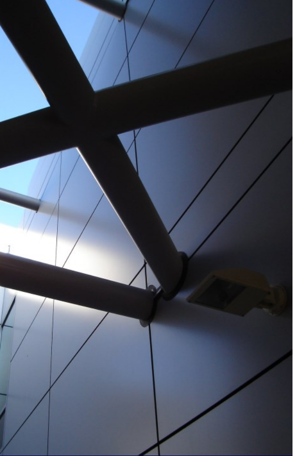

MECHANICAL ENGINEERING
DISSERTATION DEFENSE

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of

Ariana Nushin Sabzeghabae

Monday, June 6, 2022,
10AM Pacific time

Investigation of Laser-Induced Cavitation and Non-linear Optical Response of Plasmonic Nanoparticles Solutions

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

Laser-induced cavitation (LIC) is the formation of an explosive vapor bubble as a consequence of a highly focused laser pulse into a liquid medium. This bubble is capable of inducing damage to the nearby environment, which is beneficial for many applications such as cancer therapy and cavitation peening. The severity of the LIC damage depends on the physical properties of the fluid and light interaction with the particles. The inclusion of plasmonic nanoparticles, such as gold nanorods (GNR) and Titanium Nitride nanoparticles (TiN NP) in the liquids greatly enhances the nucleation of LIC bubbles, becoming an important research interest. The plasmonic nanoparticles increase the absorption, therefore reducing the laser energy requirements and lowering the chance of undesired damage to non-targeted areas. In this thesis, the effect of plasmonic nanoparticles on the bubble dynamics and their nonlinear optical interaction were investigated to find optimal materials for photothermal applications, such as cancer therapy or biosensing, but also their use for laser ablation and sensor protection.

In our initial studies, the inclusion of GNR in water reduced the energy requirements for LIC formation and increased the pressure wave intensity. The decrease in surface tension after the addition of GNR motivated us to compare the effect of surface tension and viscosity on LIC dynamics for bubbles formed in water-ethanol, water-glycerol, and water-GNR solutions. Despite many advantages of GNR, these particles exhibit low thermal stability in the nanosecond infrared regime. Our comparative study on GNR and TiN NP solutions allowed a better understanding of the higher thermal stability of TiN NP after cavitation exposure and its superior nonlinear absorption coefficient compared to GNR. We also reported the impact of TiN nanoparticle concentration and agglomeration on the third-order optical nonlinearities of the solutions. The final section of the thesis focuses on the optical and material properties of other biomedical materials such as Zirconium Nitride nanoparticles and implants. Overall, this thesis deepens our knowledge of the optical, photoacoustic, and photothermal properties of new alternative materials and expands on materials' interactions with lasers for advancing applications such as drug delivery, targeting, and photothermal therapy.