Joint Physics Dept-MtSE Seminar

April 22th, Monday

Ablation of Liquids with X-ray Lasers: From Enabling MHz-rate Measurements to Uncovering New Physics

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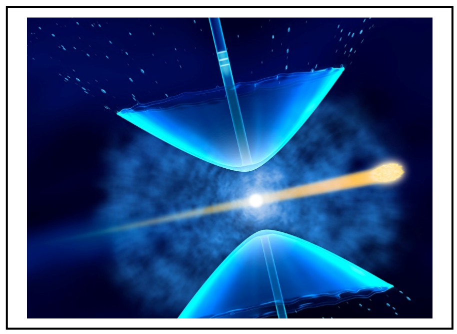
(Condensed Matter/Materials Physics, Host: Tyson)

Time: 11:45 am - 12:45 pm with 11:30 am tea time
Room: ECE 202



X-ray free-electron laser facilities (XFELs) operating at angstrom wavelengths are the most advanced X-ray sources available to scientists today. They generate ultrafast and extremely intense X-ray pulses that enable a new range of physical investigations in bulk materials, at the molecular length and time scales. A critical feature of XFELs is their ability to record data from samples that are eventually destroyed by the high X-ray intensity. This destruction requires the delivery of many identical samples for single-shot measurements, for example by embedding the samples in liquid microjets. The second-generation XFELs have megahertz repetition rates and require equally rapid sample delivery methods. To determine if liquid jets can handle MHz X-ray pulses, we investigated the dynamics of XFEL-induced liquid jet explosions, using time-resolved optical microscopy. This study resulted in the prediction of the jet parameters needed for MHz-rate measurements, which enabled the first successful experiments at the European XFEL. But equally important, it uncovered the spectacular shock physics and fluid dynamics of X-ray laser ablation in liquids. Compared with ablation by optical lasers, the tighter focusing and the linear absorption of X-rays lead to simpler dynamics that can be controlled at smaller length scales. XFEL pulses generate short-lived and highly symmetrical shock waves that can be used to access new physical regimes. We found that shock reflections in liquid microdrops can be used to reach previously inaccessible metastable states of liquid water at negative pressures. We also generated in liquid jets ultrasounds with unprecedently high intensities, close to the limit where the concept of sound waves cannot be used anymore because a single wave oscillation is enough to cavitate the liquid.