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Ion acceleration by laser plasma interaction from liquid cryogenic microjets*

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Processes that occur in extreme conditions, such as in the center of stars and large planets, can be simulated in the laboratory using facilities such as SLAC National Accelerator Laboratory and the Jupiter Laser Facility (JLF) at Lawrence Livermore National Laboratory (LLNL). These facilities allow scientists to investigate the properties of matter by observing their interactions with high power lasers. Ion acceleration from laser plasma interaction is gaining greater attention today due to its widespread potential applications, including proton beam cancer therapy and fast ignition for energy production. Typically, ion acceleration is achieved by focusing a high power laser on thin foil targets through a mechanism called Target Normal Sheath Acceleration. Based on research and recent experiments, we hypothesized that a pure liquid cryogenic jet would be an ideal target for this type of interaction, capable of producing the highest proton energies possible with todays laser technologies. Furthermore, it would provide a continuous, pure target, unlike metal foils which are consumed in the interaction and easily contaminated. In an effort to test this hypothesis and investigate new, potentially more efficient mechanisms of ion acceleration, we used the 527 nm split beam, frequency-doubled TITAN laser at JLF. Data from the cryogenic jets was limited due to the flow of current up the jet into the nozzle during the interaction, heating the jet and damaging the orifice. However, we acheived a pure proton beam with an indiciation of a monoenergetic feature. Furthermore, data from gold and carbon wires showed surprising and interesting results. Preliminary analysis of data from two ion emission diagnostics, Thomson parabola spectrometers (TPs) and radio chromic films (RCFs), suggests that shockwave acceleration occurred rather than target normal sheath acceleration, the standard mechanism of ion acceleration. Upon completion of the experiment at TITAN, I researched the possibility of transforming our liquid cryogenic jets into droplet streams. This type of target should solve our problems with the jet as it will prevent the flow of exocurrent into the nozzle. It is also highly effective as it is even more mass-limited than standard cryogenic jets. Furthermore, jets break up spontaneously anyway. If we can control the breakup, we can synchronize the droplet emission with the laser pulses. In order to assist the team prepare for an experiment later this year, I familiarized myself with the physics and theory of droplet formation, calculated values for the required parameters, and ordered the required materials for modification of the jet. Future experiments will test these droplet streams and continue towards the goal of ion acceleration using cryogenic targets.

* General Audience Abstract

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