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Fast ion acceleration in a foil plasma heated by a multi-picoseconds high intensity laser

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Abstract;
Recently, high power lasers with kilo-Joule energy such as LFEX, NIF-ARC, LMJ-PETAL, and OMEGA-EP are becoming available. In a LFEX experiment at ILE Osaka University, an efficient proton acceleration reaching 30 MeV was observed at the peak laser intensity level of 10^18 W/cm^2. Owing to the large spot size of 70 micro-m FWHM, the target foil expands one-dimensionally during the multi-picosecond pulse duration time, which yields the electron heating beyond the ponderomotive scaling. In such a long time scale, the conventional isothermal model cannot describe the expansion of plasmas and the resulting target normal sheath acceleration (TNSA) of ions.
We here study the electron heating mechanism in the multi-ps laser interaction with a solid thin foil plasma based on the particle-in-cell simulation. Electrons are found to recirculate around the expanding plasma for many times, which results the electron heating beyond the ponderomotive scaling. We further developed a non-isothermal plasma expansion theory that takes the time dependence of electron temperature into account. By assuming that the time scale of electron temperature evolution is slow compared with the time scale of plasma expansion, we derived a non self-similar solution in the first order approximation. The time evolution of ion maximum energy obtained by the non-isothermal theory can explains that observed in the simulation.