ANOMALOUS INVERSE BREMSSTRAHLUNG HEATING OF LASER-DRIVEN PLASMAS

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In the literature it is often quoted that collisional absorption of laser light in plasma via electron-ion collision (inverse bremsstrahlung, IB) should decrease with the laser intensity as $I_0^{-3/2}$ or with the electron temperature as $T_e^{-3/2}$. This conventional picture of IB is explained by assuming a ponderomotive velocity ($v_0 = E_0/\omega$) independent Coulomb logarithm $ln\Lambda = 0.5ln\left(1 + \left(b_{max}^2/b_{min}^2\right)\right)$ in the expression of electron-ion collision frequency ν_{ei}, where $b_{max} = v_{th}/max\left(\omega, \omega_p\right)$, and $b_{min} = Z/v_{th}^2$ are maximum and minimum cut-off distances of the colliding electron from the ion; ω, ω_p are laser and plasma frequency, and $v_{th} = \sqrt{T_e}$ is the thermal velocity of an electron. Clearly, $ln\Lambda$ does not depend on the laser field strength E_0 which is not justified. On the contrary, we propose a total velocity $v = \sqrt{v_0^2 + v_{th}^2}$ dependent $ln\Lambda(v)$ and show that ν_{ei} and corresponding fractional laser absorption (α) initially increases hand in hand with increasing intensity, reaches a maximum value, and then fall according to the conventional scenario. It may be objected that, such an anomalous increase in ν_{ei} and α is partly due to the artifact introduced in $ln\Lambda(v)$ through the maximum cut-off distance $b_{max} \propto v$ [1]. To answer this, similar anomalous increase of ν_{ei} and α versus I_0 (in the low temperature and under-dense density regime) are shown here [2] with more accurate quantum and classical kinetic models (e.g., Dawson-Oberman model) of ν_{ei} without using $ln\Lambda$, but a proper choice of the total velocity dependent inverse cut-off length $k_{max} \propto v^2$ (in classical case) or $k_{max} \propto v$ (in quantum case). For a given $I_0 < 5 \times 10^{14} W cm^{-2}$, ν_{ei} versus T_e also exhibits so far unnoticed identical anomalous increase as ν_{ei} versus I_0, even if the conventional $k_{max} \propto v_{th}^2$, or $k_{max} \propto v_{th}$ (without v_0) is chosen. However, for higher plasma temperature >15 eV and under-dense density, the anomalous growth of ν_{ei} and α disappear in all cases. The total velocity dependent k_{max} in kinetic models, as proposed here, is shown to explain anomalous increase of α with I_0 measured in some earlier laser-plasma experiments. This work may be important to understand collisional absorption in the under-dense pre-plasma region due to low intensity pre-pulses and amplified spontaneous emission (ASE) pedestal in the context of laser induced inertial confinement fusion.

[1] M. Kundu, Phys. Plasmas 21, 013302 (2014).
[2] M. Kundu, Phys. Rev. E 91, 043102 (2015).