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Nonlocal electron energy transport and flux inhibition in laser produced plasmas in one and two dimensions[1]

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As the mean free path of the heat conducting electrons in laser produced plasmas can, at certain points, be greater than the temperature gradient scale length, the classical, local model can be invalid. More energetic electrons can advance ahead of the main heat front and preheat the fusion target. Also, experiments show that the main heat front does not propagate as rapidly as classical theory would predict, so there is heat flux inhibition. This latter effect is usually treated by limiting the flux to some arbitrary fraction f of the free streaming flux; f's have ranged from 0.03 to 0.3. However the choice of flux limit is arbitrary and the choice affects plasma temperature, which in turn affects thresholds for laser plasma instabilities; too low a limit has given too high a temperature and false optimism regarding instability threshold. We have developed a velocity dependent Krook model for nonlocal electron energy transport. It shows preheat and flux limitation are not separate effects, but are two sides of the same coin. The model gives an analytic solution for the nonlocal electron energy flux, and it is relatively simple and inexpensive to incorporate in a fluid simulation run at the ion time scale. It shows that in some sense, preheat is subtracted from the main electron energy flux, thereby giving rise to flux limitation. We have developed the theory and compared it with Fokker Planck simulations of simple configurations. We have incorporated the model into our code FAST2D and used it to model foil acceleration and evaluate and compare a number of competing physical effects in one and two dimensions, and compared with experiments. We have investigated the effect on spherical implosions, especially the effect on corona temperature, pressure, fuel adiabat and preheat, and ultimately gain.

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