Improving Implicit Non-local Electron Transport in 2D DRACO Simulations

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Abstract: An improved implicit algorithm (iSNB) based on Schurtz, Nicolai and Busquet algorithm[1,2] for nonlocal electron transport is presented. On the numerical side, efforts have been made to make numerical approximations consistent throughout the iSNB algorithm, resulting in robustness. On the physics side, simulations provide strong incentive to further modify key parameters within the SNB theory, namely the 'mean free path'. An example 2D polar drive simulation to study mean free path modifications is presented. This research was supported by the University of Rochester Laboratory for Laser Energetics.

Improved Implicit Algorithm

On every timestep in DRACO…

1. Solve the following equation for $T^{(k)}$:

$$\rho C_v \frac{T_e^{(k)} - T_e^n}{\Delta t} = \nabla \cdot K_{SH}^n \nabla T_e^{(k)} + S_{ext}^n + S_{nl,correction}^{(k-1)}$$

k = iteration index, $S_{nl,correction}^{(0)} = 0$

Compute for use in Step #4
$\nabla \cdot K_{sh} \nabla T_e \approx \boldsymbol{A}_{divQ} \boldsymbol{T}_e$
This way of computing $-\nabla \cdot \boldsymbol{Q}_{sh}$ is accurate up to the error of the differencing scheme and works for any scheme.

2. Solve the following equation for H_g:

$$-\nabla \cdot \frac{\lambda_g'}{3} \nabla H_g + \frac{H_g}{\lambda_g} = \nabla \cdot \frac{K_{SH}^n \nabla T_e^{(k)}}{24} \int_{\beta_{g-1}}^{\beta_g} \beta^4 e^{-\beta} d\beta$$

$\beta_g = E_g / kT$ $\quad g = 1,2,3 \ldots G$

Computation similar to above.
$\nabla \cdot \eta_g K_{sh} \nabla T_e = \nabla \cdot K_g \nabla T_e \approx \boldsymbol{A'}_{divQ} \boldsymbol{T}_e$
Only difference between $\boldsymbol{A}_{divQ}$ and $\boldsymbol{A'}_{divQ}$ is that K_{sh} is replaced by $\eta_g K_{sh}$ wherever former is used in $\boldsymbol{A}_{divQ}$ formulae.

3. Check the convergence criterion:

$$\sum_{g=1}^{G} \frac{H_g}{\lambda_g} \cong \sum_{g=1}^{G} \frac{H_g}{\lambda_g}\Big|_{last\ iteration}$$

Note: Do not check for convergence in low density areas

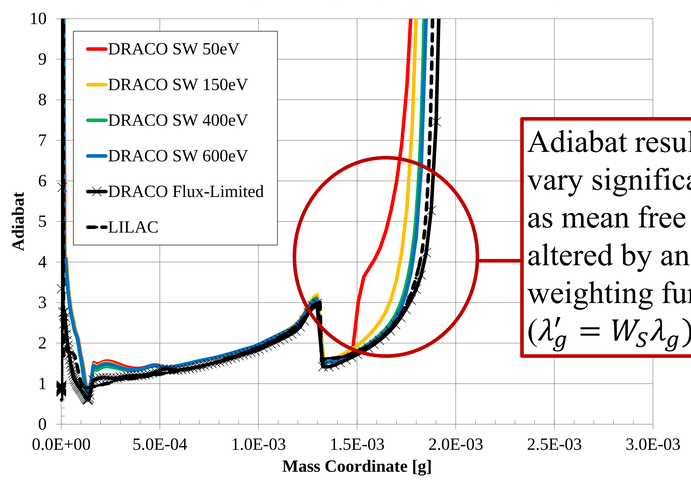
4. If no convergence, compute $S_{nl,correction}^{(k)}$:

$$S_{nl,correction}^{(k)} = \sum_{g=1}^{G} \frac{H_g}{\lambda_g} - \nabla \cdot K_{SH}^n \nabla T_e^{(k)}$$

Then go back to step #1 and repeat with next iteration of k (i.e. $k \to k+1$).
Else, stop iteration and set

$$T_e^{n+1} = T_e^{(k)}$$

Results can also be improved by varying the mean free path formula



Adiabat results vary significantly as mean free path is altered by an S-weighting function ($\lambda_g' = W_S \lambda_g$).

Discussion

- Consistent numerical approximation of divergences for steps #2 and #4 lead to algorithm robustness
- Mean free paths are the only physical parameters
  - Location of temperature fronts and preheat levels depend on mean free paths
  - Mean free paths depend on detailed electron transport physics
  - Combination of above provides strong incentive to explore modification of current mean free path formula

Conclusion

iSNB has been made more robust. Work is now solely focused on improving results by means of modifying mean free paths. It is believed that by having more realistic mean free path formula (i.e. not relying on an 'S-Weight' function), better agreement with experiment can be achieved.

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References

[1] Schurtz, Nicolai and Busquet, "A nonlocal electron conduction model for multidimensional radiation hydrodynamics codes", Phys. Plasmas 7, 4238(2000).
[2] Private communications with M. Marinak and G. Zimmerman, LLNL.

Related Talk – UO4.00007, J.A. Delettrez *et al*: Effect of Nonlocal Electron Transport on the Symmetry of Polar-Drive Experiments