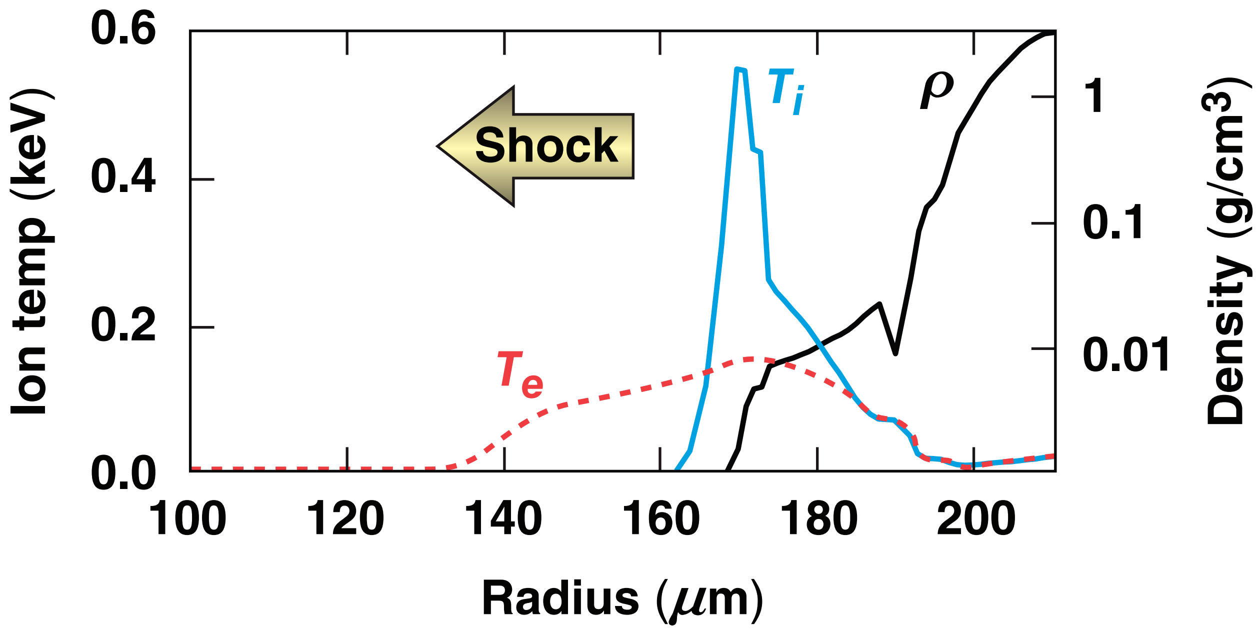
Nonlocal Ion-Heat Transport in ICF Implosions



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Summary

Nonlocal ion-heat transport significantly modifies shock propagation and could affect compression conditions

UR LLE

- With nonlocal ion-heat transport
  - the shock front is more diffuse
  - material ahead of the shock is preheated
- Hydrodynamic shock heating, using artificial viscosity, produces temperature structure that is not consistent with the ion mean free paths
- One model that produces self-consistent temperature profiles with nonlocal heat transport and shock heating shows significant modifications of peak-compression conditions
  - peak density is ~25% lower
  - peak temperature is ~2 times higher

A multigroup treatment for the ion-distribution function is used to treat the energy dependence of the mean free path

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- Ions are tracked in different directions from each interface for each energy group.
- They move in straight lines through the computational grid.
- Energy is deposited in each cell according to the mean free path.
- Ion heating is coupled to the hydrodynamics.

$$\left[\begin{array}{c}\text{Change}\\ \text{in energy}\end{array}\right] = \left[\begin{array}{c}\text{Hydro}\\ \text{heating}\end{array}\right] + \left[\begin{array}{c}\text{Nonlocal}\\ \text{ion heating}\end{array}\right]$$

Ion transport is calculated using a Krook approximation for ion–ion collisions

- Ions are created in a Maxwellian distribution and absorbed according to their mean free path.

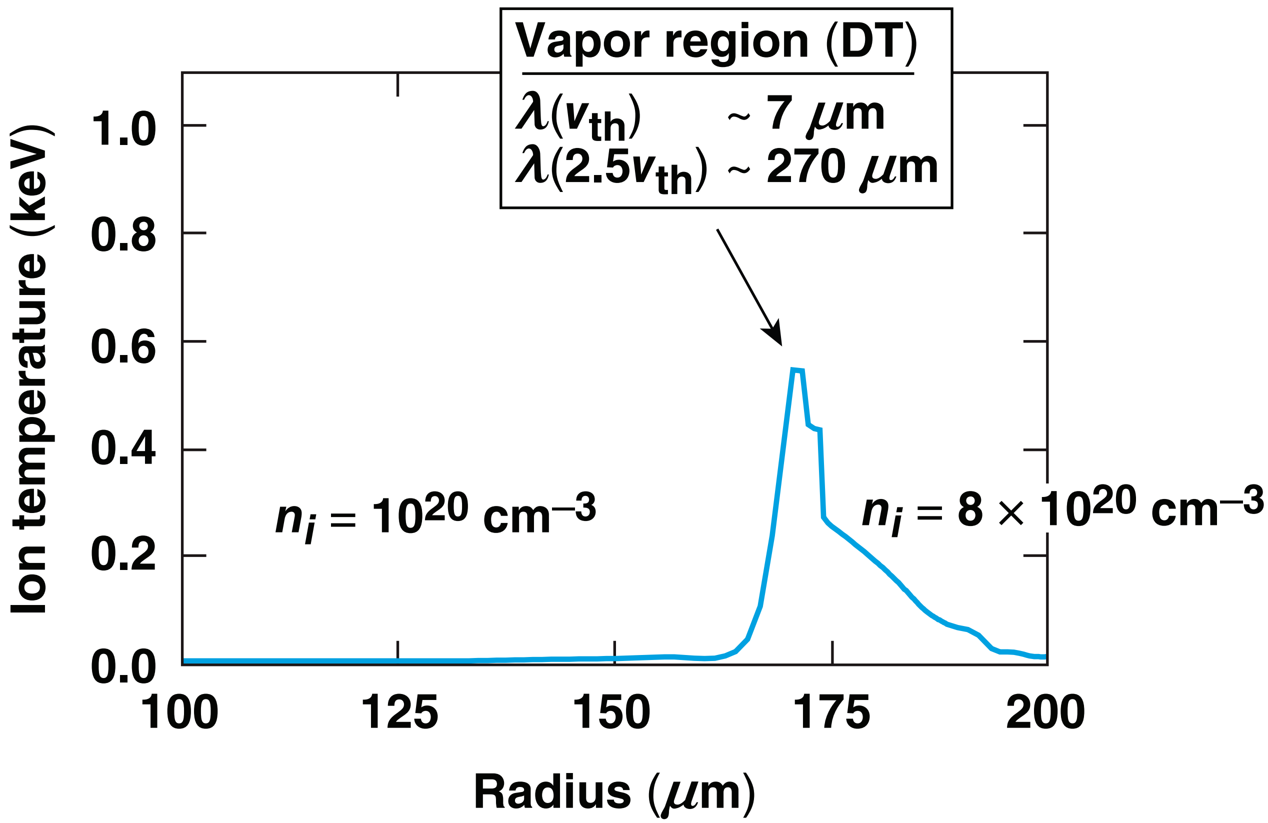
$$\mu v \frac{\partial}{\partial x} n(x, v, \mu) = -\frac{n(x, v, \mu) - n_{mb}(T, v)}{\tau(v)}$$

$$\lambda(v) = v\tau(v) = \lambda_{th}\left(v/v_{th}\right)^4$$

- Heat flux is obtained by integration over the distribution function

$$q = \int \left(\frac{1}{2} m v^2\right)(v\mu)\, n(x, v, \mu)\, v^2\, dv\, d\mu$$

The mean free path is large for ion energies characteristic of heat flow in the vapor region of the target



TC7569

Direct implementation of nonlocal heat transport produces even higher temperatures and longer mean free paths

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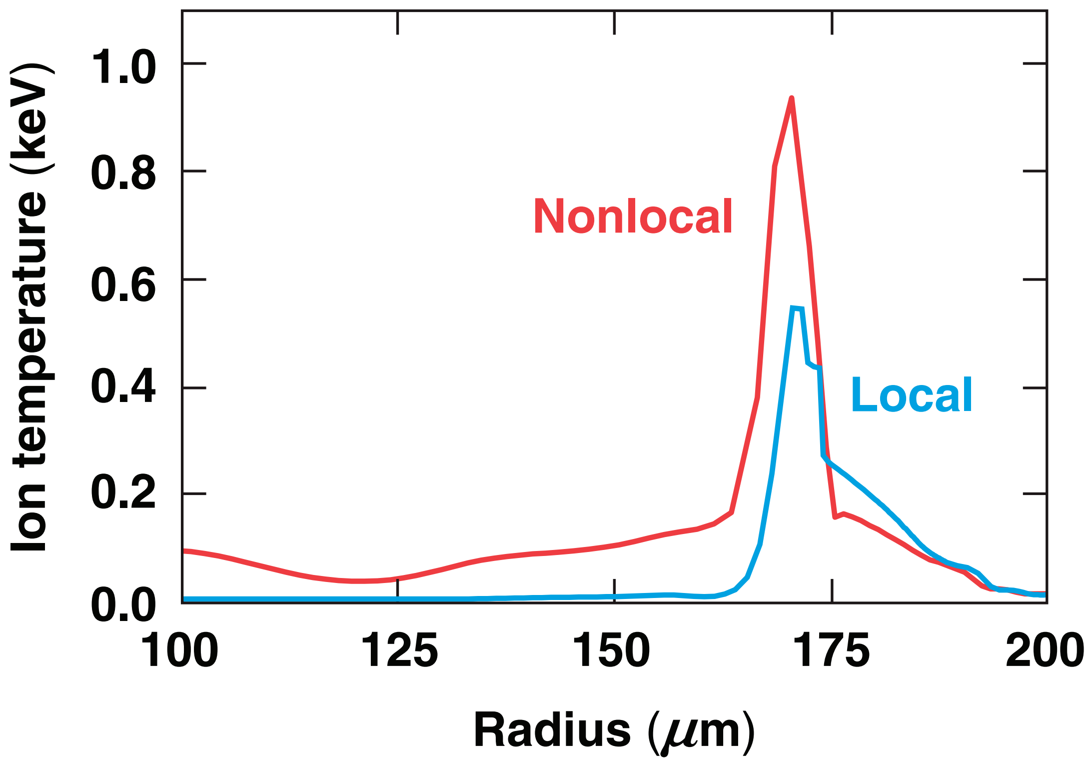
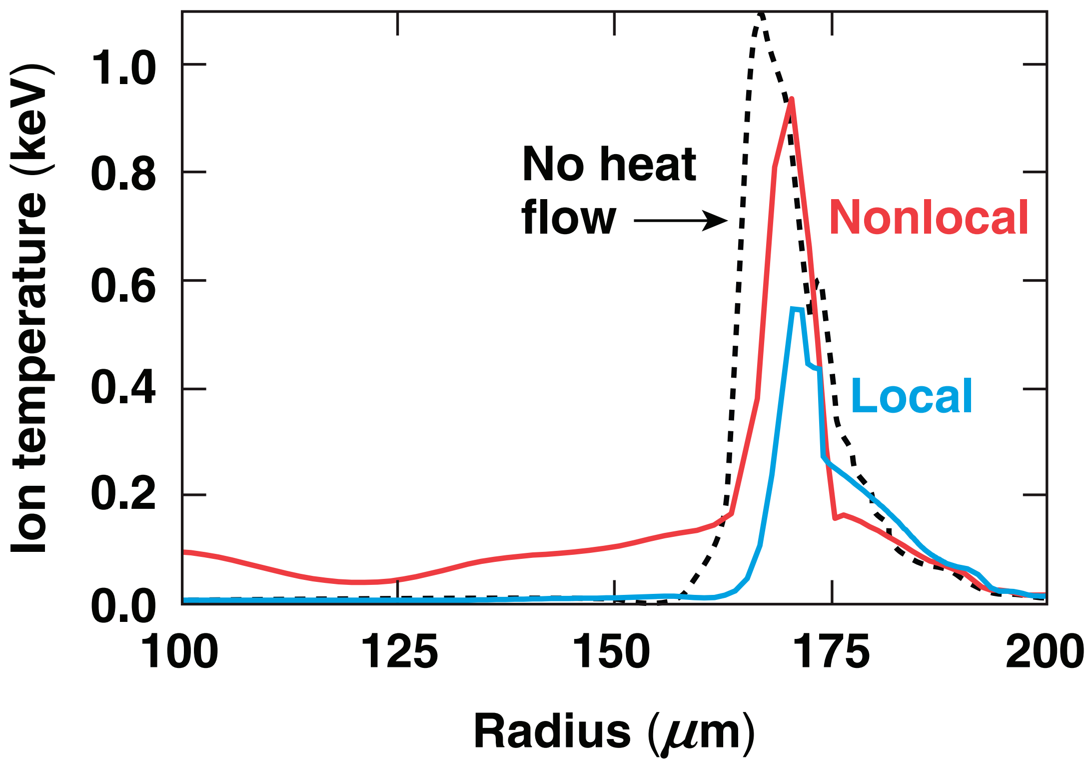
- Heat flow out of the shock front is greatly reduced due to incomplete “tail filling” for nonlocal transport



TC7570

The nonlocal result is similar to no heat flow

- The temperature at the shock front is dominated by shock heating; heat conduction is decoupled



TC7571

Artificially filling the tail of the ion-distribution function results in temperatures more consistent with mean free paths

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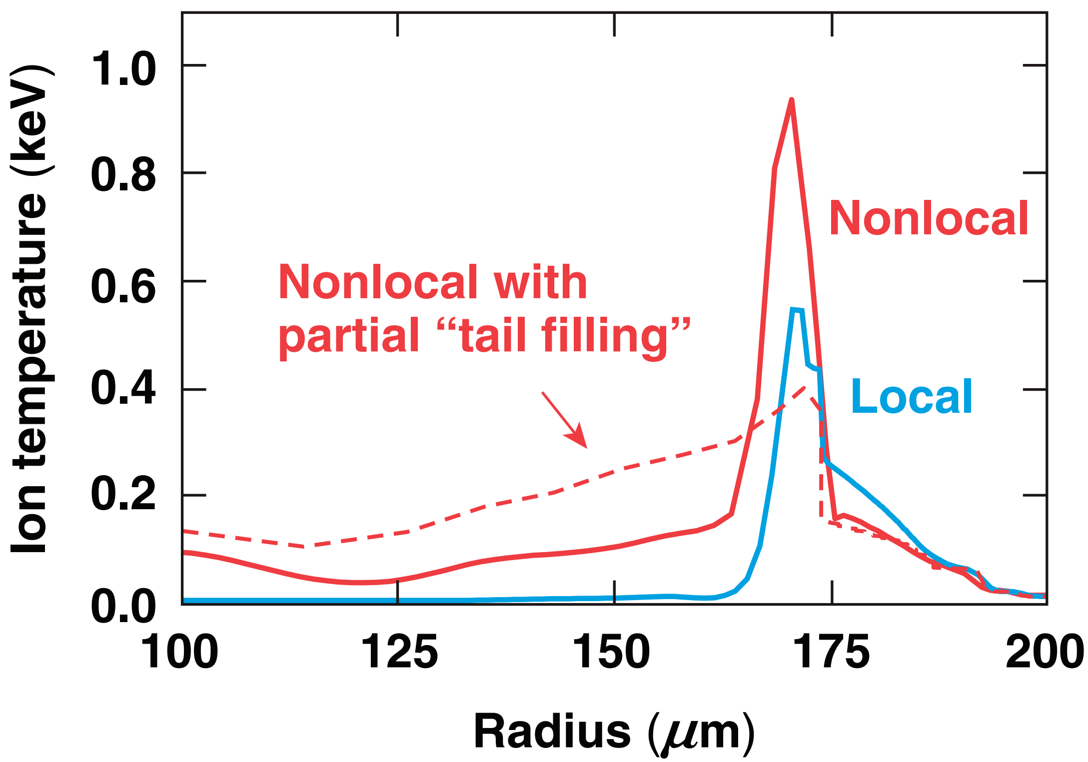
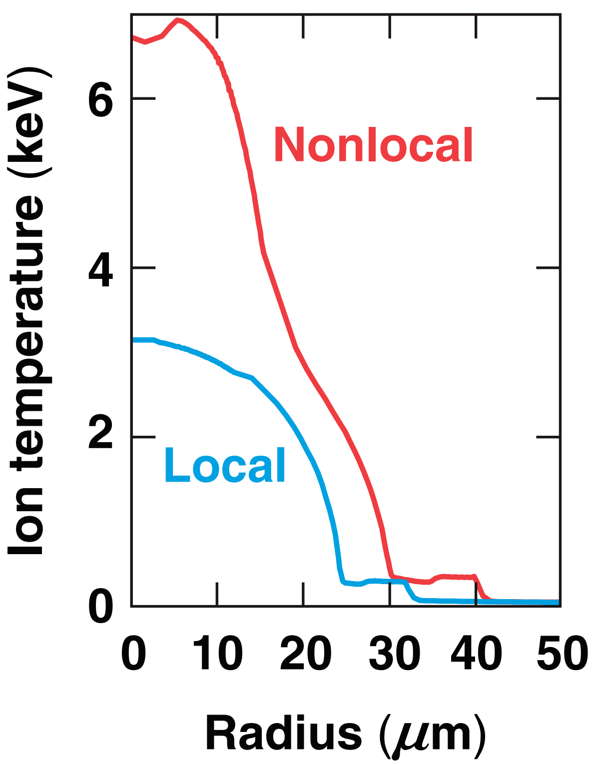
- Long mean-free-path ions transport heat into the shell and preheat ahead of the shock

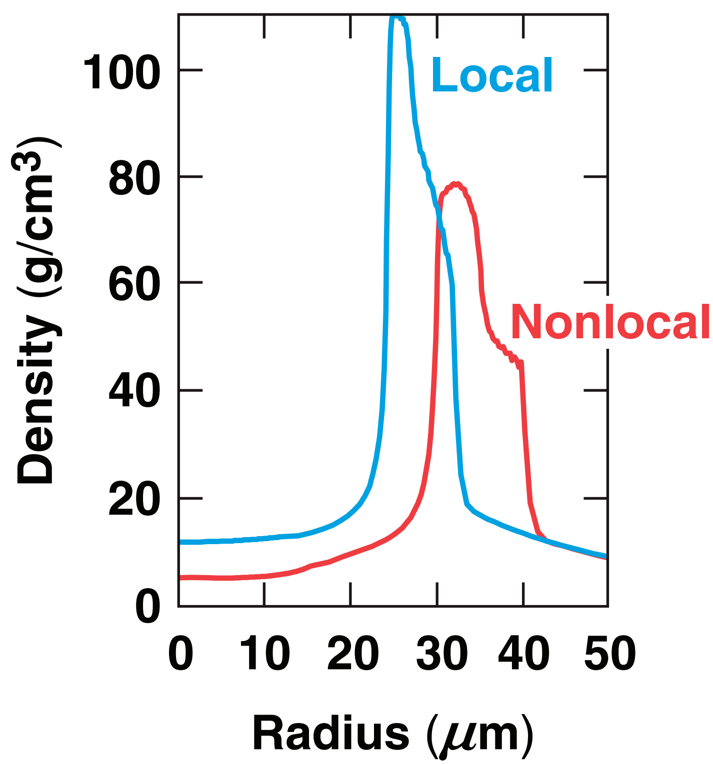


TC7572

Nonlocal transport with "tail filling" significantly affects conditions at peak compression

- Nonlocal compression delayed by 300 ps





TC7573

Summary/Conclusions

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A consistent model that couples nonlocal ion transport with shock heating is required