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EFFECT OF THE ELECTRON THERMAL CONDUCTIVITY ON THE STATE PARAMETER DISTRIBUTIONS IN PELLET WAKES

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Introduction

The evolution of pellet clouds generated by moving neutral particle sources in magnetically confined thermonuclear plasmas is studied by means of a numerical time-dependent quasi-three-dimensional code [1]. This 2-D+1 code consists of a 2-D resistive MHD model applicable to the poloidal plane of a plasma torus, supplemented by a Lagrangian module for the expansion of the cloud along the magnetic field lines. A massive neutral particle source representing a pellet traverses the plasma and continuously releases cold and unionized particles. Its motion is confined to a poloidal plane, which is thus considered to be a symmetry plane of the model.

The 2-D conservation equations supplemented by Maxwell's equations, Ohm's generalized law, and a number of rate equations are solved for the symmetry plane. To each mesh point of the Eulerian grid in the poloidal plane, a toroidal 'flux tube' is attached. The field-aligned expansion of the ablated substance in these flux tubes and the corresponding change of the state parameters are taken into account in a Lagrangian approximation.

The results of a series of computations are presented here in which the neutral particle source strength is a prescribed input parameter and the anomalous thermal conductivity of electrons in the direction perpendicular to the magnetic field is varied. The effect of $\chi_{e\perp}$ on the parameter distributions in the pellet wake is discussed.

Initial parameters

The initial state parameters of the recipient plasma as well as the applied toroidal magnetic field are assumed to be uniform. The initial plasma parameter values are as follows: electron density $n_e = 10^{20}\ m^{-3}$, electron temperature $T_e = 0.5$ keV, toroidal magnetic field $B_z = 1.5$ Tesla. In the computations the poloidal plane is represented by a rectangular x-y plane of dimen-

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sions ($0.601m \times 0.401m$). with (301×201) mesh points. The neutral particle source('pellet') is represented by a circle of radius 2 mm. It has a constant velocity and is depositing particles at a given constant rate ('ablation rate'). The neutral particles are deposited proportionally to the area of the circle that is mapped onto the rectangular grid that represents the poloidal plane.

The initial position of the neutral source is at (0.201m, 0.201m), the source velocity has only one component which is parallel to the x-axis and has a value of 1500 m/s. The ablation rate is $4 \times 10^{23} s^{-1}$, and the particles are ablated with an initial temperature of 450 ^0K,

Results and Conclusions [1]

Figures 1a and 1b are plots of the magnetic field B_z along the path of the neutral source at the four time instances of 20, 40, 80, and 120 μs for anomalous electron thermal conductivities $\chi_{e\perp} = 1m^2/s$ and $\chi_{e\perp} = 400m^2/s$ respectively. The thin vertical lines represent the locations of the pellets at the respective times. Figures 2a and 2b are contour plots of the magnetic field strength at $120\mu s$ computed with $\chi_{e\perp} = 1m^2/s$ and $\chi_{e\perp} = 400m^2/s$ respectively. The LHS circle on the contour plots represents the initial pellet position, and the RHS circle the position of the pellet at $120\mu s$. Figures 3a and 3b are contour plots of the pressure at $120\mu s$, again with $\chi_{e\perp} = 1m^2/s$ and $\chi_{e\perp} = 400m^2/s$ respectively. Figures 4a and 4b are contour plots of the temperature at $120\mu s$ with $\chi_{e\perp} = 1m^2/s$ and $\chi_{e\perp} = 400m^2/s$. The magnetic field minimum and the pressure maximum computed with $\chi_{e\perp} = 1m^2/s$ lag behind the pellet location by about 3 cm. Only the minimum of the temperature coincides, approximately, with the location of the pellet. In the case where $\chi_{e\perp} = 400m^2/s$, the locations of all computed minimums/maximums practically coincide with the pellet location.

Some previous calculations [2] had shown that, in order to reproduce experimentally observed radiation patterns in deuterium pellet plasmas, e.g. *the lengths of the radiating filaments along the magnetic field lines*, the conductive heat transport in the $B_\perp$ direction must be increased by a factor of about 400 compared to the case of 'standard' anomalous diffusivity of 1 m^2/s. Apparently, the same can be concluded on the basis of the present results.

The dependence of the computed wake patterns on the assumed $\chi_{e\perp}$ values may be useful, in combination with measured distributions, in the analysis of the effective thermal transport processes in pellet-fuelled plasmas.

References

[1] Lalousis, P., Lengyel, L.L., et al., Paper submitted for publication.

[2] Lengyel, L.L., Schneider, R., et al., Paper submitted for publication.

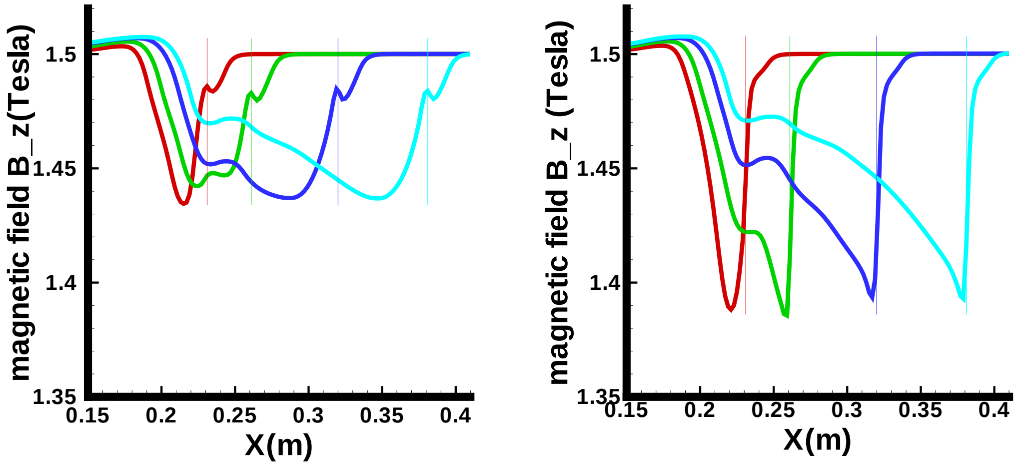

Figure 1: Magnetic field strenght B_z along pellet path, at time 120, 40, 80, and 120μs computed with **(a)** $\chi_{e\perp} = 1m^2/s$, and **(b)** $\chi_{e\perp} = 400m^2/s$.

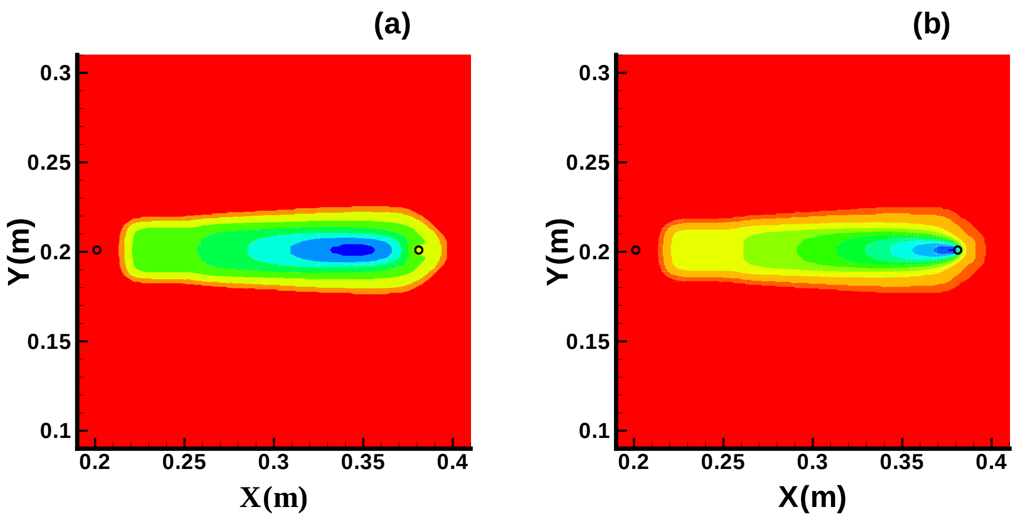

Figure 2: Two-dimensional contour plots of the magnetic field distributions at 120μs computed with anomalous thermal conductivity value of **(a)** $\chi_{e\perp}$ = 1 m^2/s (colour scale 1.44 to 1.50 *Tesla*) and **(b)** $\chi_{e\perp}$ = 400 m^2/s (colour scale 1.40 to 1.50 *Tesla*).

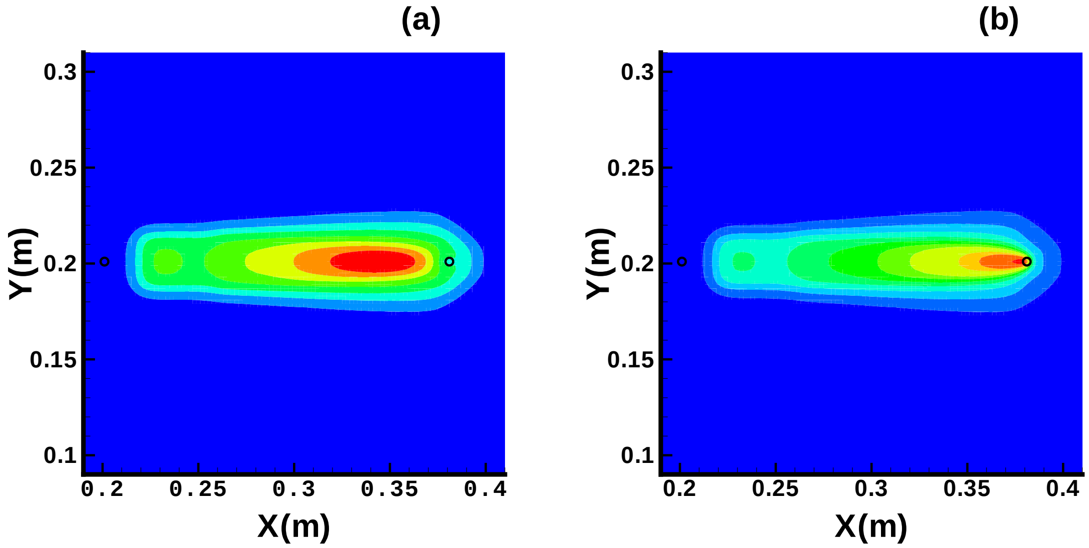

Figure 3: Two-dimensional contour plots of the pressure at $120\mu s$ computed with anomalous thermal conductivity value of **(a)** $\chi_{e\perp}$ = 1 m^2/s (colour scale 0.2×10^5 to $0.8 \times 10^5 Nm^{-2}$). and **(b)** $\chi_{e\perp}$ = 400 m^2/s (colour scale 0.2×10^5 to $1.3 \times 10^5 Nm^{-2}$).

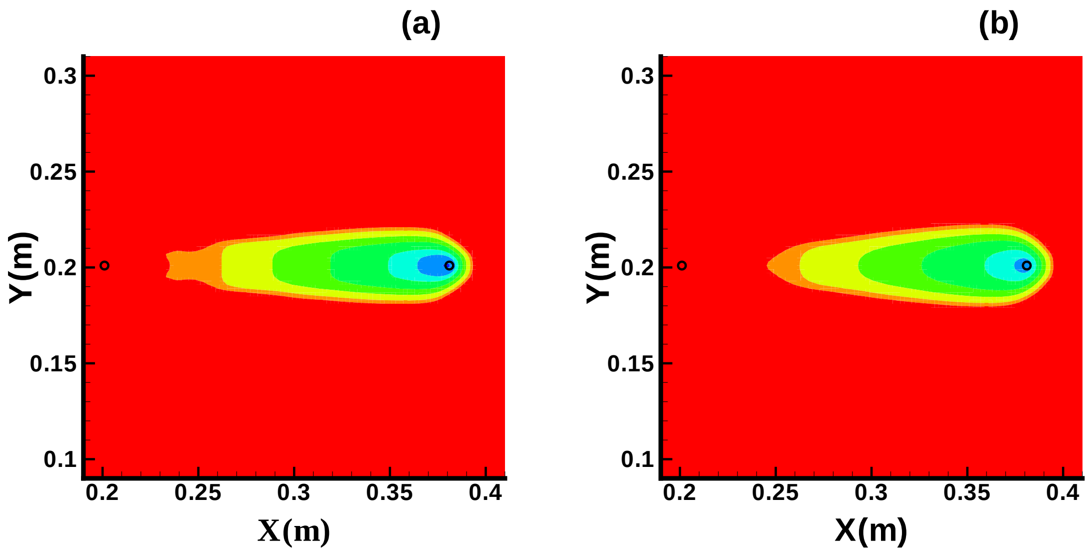

Figure 4: Two-dimensional contour plots of the temperature at $120\mu s$ computed with anomalous thermal conductivity value of **(a)** $\chi_{e\perp}$ = 1 m^2/s (colour scale 10ev to 450ev). and **(b)** $\chi_{e\perp}$ = 400 m^2/s (colour scale 30ev to 450ev).