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Linear stability analysis of self-similar solutions for ablation fronts in ICF

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The stability of an ablative flow is of importance in inertial confinement fusion (ICF). Here we exhibit a family of exact self-similar solutions of gas dynamics equations with nonlinear heat conduction for semi-infinite slabs of perfect gases. Such self-similar solutions arise for particular but realistic initial and boundary conditions—boundary pressure and incoming heat flux follow time power laws—and are representative of the early stage during the ablation of a pellet heated with a laser, *i.e.*, a shock wave propagates upstream of a thermal front. Following the work of Boudesocque-Dubois *et al.* (2000), these solutions are computed using a dynamical multidomain Chebyshev pseudo-spectral method (Abéguilé *et al.*, 2003). A wide variety of ablation configurations may thus be obtained. Linear stability analyses of such time dependent solutions are performed by solving an initial and boundary value problem for linear perturbations. The numerical methods are based on a dynamical multidomain Chebyshev pseudo-spectral method and an operator splitting between a hyperbolic system and a parabolic equation (Boudesocque-Dubois *et al.*, 2003; Abéguilé *et al.*, 2003). Here, focusing on the laser imprint problem, we have considered boundary heat flux perturbations and obtained space-time evolutions of flow perturbations for a wide range of wavenumbers. By contrast with steady low Mach number models for ablation front, we obtain that: (a) maximum perturbation amplitudes in the thin ablation layer are reached for transverse wavenumber $k_\perp = 0$; (b) the damping of ablation front perturbations is clearly related to thermal diffusion; (c) ablation front perturbations seem to persist although the transverse wave number increases.

References

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