On the Numerical Simulation of Plasma Flows with Mixing

Remi Sentis [1], C. Baranger [1], G. Carré [1], D. Paillard [1].
[1] *CEA/Bruyeres - BP 12 - 91680 Bruyères - F*

In the simulation of multicomponant plasma flows at very high temperature (for instance in the plasma produced by laser beams), mixing of two different fluids can occur. A classical model for such phenomena consists in a system of six equations which corresponds to the conservation of mass, momentum and energy for each fuid, besides an equation for the electronic energy. The two fluids are assumed to occupy the same volume and the global pressure is the sum of the pressure of the two fluids. If the friction coefficient σ^0 between the two fluids (which depends on the internal energy) is assumed to be large enough, we can made a simplification of this model owing to a closure concerning the enthalpies of the two fluids. The resulting model consists of the classical conservation equations of mass, momentum and energy for the averaged fuid coupled with an equation for the concentration c and an equation for the relative kinetic energy K. If one denotes $\rho, \mathbf{u}$, ε the density, the averaged velocity and the averaged internal energy, the concentration obey the non linear diffusion equation

$$\rho D_t c - \nabla . \left(c(1-c) \frac{D^0}{\sigma^0} \varepsilon \nabla c \right) = 0. \tag{1}$$

where D_t is the Lagrange derivative (with velocity $\mathbf{u}$) and D^0 is a bounded smooth function of c. Moreover, the kinetic energy K obey an equation of the following type

$$\rho D_t K + 2\rho K \nabla . \mathbf{u} + 2\sigma^0 \rho^2 K = \text{source term}. \tag{2}$$

To solve this system, one uses a classical numerical Lagrange scheme of Wilkins type ; the new variables c, K are evalueted at the center of each cell ; for the momentum equation the mixing pressure $2\rho K$ is added to the material pressure. The diffusion equation (**??**) is solved by an iterative way. Notice that if the initial value c^{in} of c is a Heavyside function, then it remains an unstable solution of (**??**).

In the framework of Inertial Confinement Fusion, we will present numerical results for a case where two fluids with a large relative velocity collide. After some time, a mixing between the two fluids occurs. We sees that when the mixing model is taken into account, the value of the density is quite lower from the one obtained with the pure mono-fluid model.

References.

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