Evolution of irregular shock structures in supersonic co-flows

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This work examines the interaction of a shear layer separating two uniform supersonic streams of Mach numbers M_1 and M_2 with an oblique shock approaching at an incident angle σ_i. The development considers the outer problem of oblique–shock impingement on a supersonic vortex sheet of infinitesimal thickness, for which the region of existence of regular shock refractions with downstream supersonic flow is delineated in the parametric space (M_1, M_2, σ_i). Regular solutions involving three shocks waves, or two shocks plus a rarefaction wave are readily obtained by solving the jump conditions across these waves and imposing mechanical equilibrium in the post-shock shear wave. Neumann-Henderson plots are also used to characterize the family of solutions involving regular and non-regular configurations. Theoretical tools and high-fidelity DNS are employed to resolve the evolution of the complex structures present in the flow. The massively-parallel finite-difference code CREAMS is being used to solve the unsteady, two-dimensional set of compressible Navier-Stokes equations for multicomponent gas mixtures. The code accurately reproduces the expected regular interactions and provides the evolution of non-regular unstable configurations, as the one displayed in Fig. 1. A stability criterion is derived in terms of the parametric space and the initial conditions, then providing useful information to be later employed in more complex scenarios that may involve reacting gases.

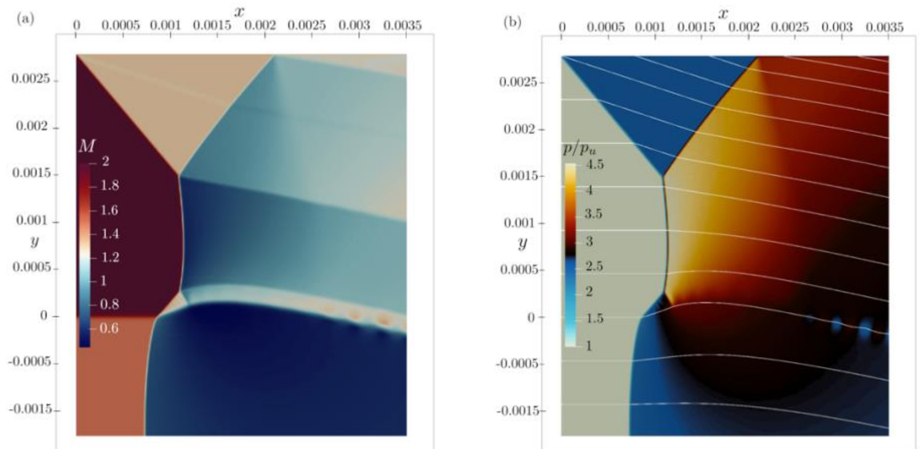

Figure 1: Irregular interaction between an oblique shock and a supersonic shear layer. An unstable configuration is found with subsonic regions, reflected shocks, expansion waves and downstream evolution of the mixing layer.

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