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Radiative shock theory, experiments, and connections to astrophysics

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This work concerns both radiative shocks (RS) in astrophysics and in laboratory. Accurate RS models are attempted to understand stellar evolution where they are always involved. Two extreme types of RS can be considered: in optically thin and thick medium. A third type is an intermediate regime. In astrophysics, observed RS arise generally in optically thin material. Thus, radiation escapes without interaction with the surrounding gas and it can be modeled by a cooling function Λ. In this case only the post-shock region is structured by the radiation cooling. We have solved the hydrodynamic equations including $\Lambda \propto \rho^{\varepsilon} P^{\zeta} x^{\theta}$ for arbitrary values of $\varepsilon,\ \zeta,\ \theta$. Moreover introducing this cooling function in hydro-code HADES, we are able to simulate astrophysical shocks under optically thin conditions and recover analytical calculations. Our models are validated by confrontation with experimental results. We performed RS experiments using LULI2000 laser facility, in which the plasma is more or less optically thick. Consequently, these high-Mach number RS present a radiative precursor. Specific radiation hydrodynamic codes, including radiative terms (flux, pressure, energy density), are used to examine the structure of this kind of RS. In addition, we obtain analytical solutions describing the post-shock structure of RS growing both in astrophysical environment and in laboratory. Therefore, we can study this region experimentally and compare its structure with astrophysical shocks. This theoretical work is motivated by new very high-power experimental facilities, as LIL (France) for which we propose to probe the downstream zone. Experimental results related to the cooling in the downstream flow will allow to validate and to check our astrophysical code HADES. Finally, we attempt to predict the precursor length of steady laboratory RS, using now Λ as a radiation flux propagating towards the upstream flow in the precursor.