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Freeze-out of the Richtmyer-Meshkov instability

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It is known that for some values of the initial parameters that define the Richtmyer-Meshkov instability, the normal velocity at the contact surface vanishes asymptotically in time. This phenomenon, called freeze-out, is studied here with an exact analytic model. The instability freeze-out, already considered by previous authors [K. O. Mikaelian, Phys. Fluids **6**, 356 (1994), Y. Yang, Q. Zhang, and D. H. Sharp, Phys. Fluids **6**, 1856 (1994), and A. L. Velikovich, Phys. Fluids **8**, 1666 (1996)], is a subtle consequence of the interaction between the unstable surface and the corrugated shock fronts. In particular, it is seen that the transmitted shock at the contact surface plays a key role in determining the asymptotic behavior of the normal velocity at the contact surface. By properly tuning the fluids compressibilities, the density jump and the incident shock Mach number, the value of the initial circulation deposited by the reflected and trasmitted shocks at the material interface can be adjusted in such a way that the normal growth at the contact surface will vanish for large times. The conditions for this to happen are exactly calculated, by expressing the initial density ratio as a function of the other parameters of the problem: fluids compressibilities and incident shock Mach number. This is done with the aid of a linear theory model developed in a previous work [J. G. Wouchuk, Phys. Rev. E **63**, 056303 (2001)]. The evolution of different cases (freeze-out and non freeze-out) are studied with some detail. The distance traveled by the interface ripple before it stops growing can be also calculated. A comparison with previous works is also presented.