Observation of a Velocity Domain Oscillation in a Radiative Shock Expansion

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Shocks and blast waves are ubiquitous features readily observed in many astrophysical phenomena (e.g. supernova remnants) and high-energy-density environments. The rapid development of high-power laser systems over the last two decades has made it possible to systematically study such structures on a laboratory scale.

Clustered gases are an exceedingly interesting target medium for such studies as they exhibit extremely efficient absorption (~90%) when subjected to high-intensity laser radiation compared to an unclustered gas (<1%) [1]. Accordingly, a clustered gas allows for a substantial deposition of energy into the target medium even with 'table-top' scale laser systems, creating a low-average-density but high-temperature plasma that evolves into a shock as the hot plasma expands into the ambient cold gas. As such, this is a perfect medium for studying the dynamics of high-Mach-number shocks.

Cylindrical shocks are launched by coupling a 1.4 ps, ~10 J, 1054 nm laser pulse into an extended cluster medium resulting in initial energy densities of $\sim 10^5$ Jcm^{-3}. Varying the material Z of the cluster gas provides control over the impact of radiation on the subsequent shock evolution. This is confirmed through the observation of increased shock deceleration and radiative preheat in argon and krypton compared to hydrogen as well as shell-thinning and an enhanced compression. Using time-resolved propagation data from single-shot streaked Schlieren measurements in krypton [2], we observe temporal modulations on the shock velocity, which we attribute to the thermal cooling instability.

References

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