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New experimental capabilities and theoretical insights of high pressure compression waves[1]

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While some high pressure, compression wave research seeks ever high pressures($>$10 Mbar), the exciting developments of high pressure research for gas-gun generated compression waves have spawned novel compression experiments as well as new theoretical insights into compression wave dissipation. The first half of the discussion covers the unique gradient density impactor (GDI) developed at LLNL, that has just matured into a viable tool to examine the material response along and significantly away from the principal paths of the Hugoniot and isentrope. This gives direct access to hot planetary isentropes or cyclic paths to understand hysteretic response at moderately high pressures ($<$5 Mbar). Recently, significant material design challenges pertaining to material control, planarity, parallel layers, and reproducibility have been overcome in the manufacturing of these impactors used to create (within 2μs) compression waves. These compression waves consist of the standard monotonic compression and of unique non-monotonic compression waves, which widens the field of research to include previously inaccessible parts of the thermodynamic phase diagram for a given material. These developments will be addressed in conjunction with hydrodynamic simulations discussing several interesting experiments that have taken place in the pursuit of understanding the high-pressure phase diagram of water and of understanding high-pressure strength. Closely connected to these compression experiments, in general, is the interpretation of the recorded particle velocity histories and the assumptions used to quantify those results, e.g. stress versus density. Therefore, a second theoretical discussion of solitary wave structure is given suggested by recent experimental observations. Dissipative and dispersive effects are expected to exist in general, however, these effects are not usually discussed within the context of the Korteweg-de Vries(KdV)-Burgers equation, thus, leading to a possible quantification of these effects. Specifically, observed ramped-pressure drives generate coherent structures consistent with solitons in the weakly dissipative limit, that evolve into a dissipative, localising kink structures coalescing into larger kinks. A simulation based on experiment evolves via the KdV equation these structures between two Lagrangian points. The aim being to quantify the dissipation and dispersion that develops in high-pressure compression waves.

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