Influence of electron shell effects on compressibility of substances in strong shock waves

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The maximum pressures and temperatures in substances are achieved in dynamic experiments via relative compressibility methods [1]. Obtaining information on thermodynamic properties of a substance under study by such methods requires knowledge of the equation of state for another substance, which is taken as a reference material.
Quantum-statistical models [2] are successfully used to construct equations of state in a wide range of temperatures and densities. The influence of the discreteness of the spectrum of bound states leads to oscillatory behavior of thermodynamic functions at sufficiently high temperatures (i.e. electron shell effects). But, at the present time, available experimental data for this region of parameters are insufficiently accurate, contradict one another or have been obtained by relative methods, which make it impossible to measure unambiguously the magnitude of the shell effects.
In the present work, we construct equations of state for Al, Cu, Mo, Fe, Pb and SiO_2, which are widely used as standards in the framework of the impedance-matching technique. The calculated equations of state are used to derive the Hugoniots, double shock adiabats and isentropes of unloading, which are required to yield relative dependencies of shock wave velocities. We estimate the magnitude of shell effects by consideration of the difference between results of the quasi-classical (the Thomas–Fermi model with modifications) and quantum-mechanical (the Hartree–Fock–Slater model) calculations with experimental data for different pairs of the investigated substances.
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