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**Ultrashort elastic and plastic shock waves in Aluminum**

NAIL INOGAMOV, Landau Institute for Theoretical Physics of RAS, VASILY ZHAKHOVSKY, University of South Florida, CARTER WHITE, Naval Research Laboratory, IVAN OLEYNIK, University of South Florida, VLADIMIR FORTOV, Joint Institute for High Temperatures of RAS — Ultrashort shock waves in aluminum films generated by femtosecond laser pulses were studied using two-temperature hydrodynamics and molecular dynamics methods. We observed double wave breaking characterized by an independent formation of leading elastic and trailing plastic shock waves. Both the amplitude and speed of the plastic shock decrease quickly in time due to hydrodynamic attenuation, while the elastic shock front slowly decays during propagation. When the pressure in the plastic front becomes equal to the pressure in the elastic zone, the plastic wave disappears. Therefore, the distance between elastic and plastic fronts first decreases, then increases, with time. The elastic shock uniaxially compresses the crystal to very high pressures and extreme shear stresses comparable in magnitude to the aluminum shear modulus. For a short time, the crystal within the elastic zone remains in a metastable state, that lies on an extension of the elastic branch of the Hugoniot beyond the Hugoniot elastic limit. Our theoretical results explain the seemingly puzzling experimental findings, where high-pressure elastic shock waves were observed with pressures up to 12 GPa.

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