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**Deformation and material dynamics under ultrafast compression**

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For decades, dynamic compression experiments have been used to determine the equation of state of materials, and examine material deformation at high strain rates. Within the last 15 years, ultrafast optical methods have been used to characterize deformation at strain rates in excess of $10^{10}$/s. Recently such experiments have found broad consistency with empirical laws formulated at orders of magnitude lower strain rates, but have also discovered intriguing phenomena on short time scales, such as elastic stress orders of magnitude beyond the yield strength. These experiments explore the ultimate limits of material relaxation via deformation, and the results suggest exciting possibilities for practical and scientific application of ultrafast compression, including nonequilibrium material synthesis, determination of the equation of state with a small scale experiment, and the investigation of ultrahigh density with a table top laser. Here we will talk about our experiments on the ultrafast deformation of metals, including aluminum and iron, and the ultrafast compression of deuterium.