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From microjoules to megajoules and kilobars to gigabars: probing matter at extreme states of deformation[1]

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Over the past 3 decades there has been an exponential increase in the newly emerging field of matter at extreme states of deformation and compression. This has been due to the confluence of new experimental facilities, new experimental techniques, new theory, and new multiscale simulation techniques. Regimes of science and research hitherto thought out of reach in terrestrial settings are now being accessed routinely. High energy lasers and pulsed power facilities are accessing high pressure macroscopic states of matter, and next generation light sources combined with smaller drive lasers are probing the quantum response of matter at the atomistic level. Combined, this gives multiscale experimental access of the properties and dynamics of matter from femtoseconds to microseconds and from kilobars to gigabars of pressure. There are a multitude of new regimes of science and research that these new developments make possible. Examples include planetary formation dynamics, asteroid and meteor impact dynamics, space hardware response to hypervelocity interplanetary dust impacts, reactor component response to prolonged exposure to radiation damage, advanced research into light weight armor, and capsule dynamics in inertial confinement fusion (ICF). I will review highlights and advances in this rapidly developing field of science and research, touching on experiments at a wide range of facilities (NIF, Z, Omega, Jupiter, Trident, Vulcan, Orion, LULI, LIL, Gekko, Shenguang, LCLS, DCS). I will also review a wide variety of sophisticated new experimental techniques being developed and new developments in theory and multiscale modeling.

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