In this issue

Laser-driven shock waves to probe equation-of-state of gold

Interest in investigation of equations-of-state (EOSs) of materials arises from both fundamental and applied points of view. Properties of materials for pressures between 1 and 100 TPa (between 10 and 1000 Mbar) and temperatures up to a few hundred electron volts are relevant to areas such as hydrodynamics, planetary physics, astrophysics and inertial-confinement-fusion programs. In the higher pressure regime, many new phenomena become apparent.

Static high pressures and shock waves using gas guns have provided precise data up to about 1 TPa (10 Mbar). Static or cold compression experiments are performed using diamond-anvil high-pressure cells, exerting progressively high pressures slowly over many hours or days. The experiments are limited by the insulator–metal transition of diamond which occurs at about 1 TPa. This is in contrast to the gas gun, whose shock experiments get completed in a millionth of a second or less. Such pressure shocks can also occur in detonation of nuclear weapons, in inertial fusion experiments, or when a large meteorite hits Earth. The shock wave travels in the target material with a supersonic velocity, taking the material to a new state with higher density, temperature, and pressure. The relationship amongst the target's pressure, density, and temperature, together constitute the material's EOS.

Direct illumination of metals by a terawatt laser can produce pressures of 10 TPa or greater, albeit a transient one. To perform this type of experiment in the pressure range of 1–5 TPa requires laser intensities of nearly 10^{13} to 10^{14} W/cm^2.

In shock physics experiments, the set of new compression states that can be reached are not along thermodynamic or equilibrium paths. The resulting curve of loci of the new states is the material's characteristic Hugoniot. The straight lines joining the initial condition to each of the points in the pressure–volume plane are the Rayleigh lines. The slope of a Rayleigh line is proportional to the shock velocity – higher strength compressions are associated with faster shock velocities. The final shock state can be determined from a knowledge of the initial state and two dynamic variables. The two dynamic variables are (a) the velocity at which the shock propagates through the undisturbed medium u_s, (b) the velocity of the material behind the shock front, known as the mass or particle velocity u_p. The Rankine–Hugoniot relations, which express conservation of mass, momentum, and energy across the shock front relate the pressure P to these variables by the relation $P = \rho_o u_s u_p$, where ρ_o is the density of the solid.

H. C. Pant *et al.* describe (**page 149**) experiments (carried out at the Centre for Advanced Technology, Indore) to determine EOS of gold based on laser-driven shock waves. They have used a Nd : YAG laser-based system (2 J/200 ps at 1.06 μm wavelength, peak intensity 10^{14} W/cm^2). By using 'impedance matching technique', they have measured the Hugoniot EOS data points of gold to good accuracy. They have compared their data with experimental and theoretical results available in the literature. Thereby they have 'shown the feasibility of using a simple laser-driven system for conducting shock wave experiments for EOS measurements in gold at moderate pressures of nearly 10 Mbar'.

Over the past three decades, shock physics experiments have provided data about materials at high pressures. Originating in the background of cold war, they were used to improve output from weapon design codes and simulation models. Researchers have been able to predict in detail the behaviour of nuclear weapons. Apart from results related to weapons research, there have been other important fall-outs. The shock physics data obtained at various experimental conditions have provided insight into the material properties in the planetary interiors. Shocks can induce transformations in materials' new properties – for example, it is theorized that hydrogen would become a metal at room temperature in a shocked state. The emphasis in the paper of Pant *et al.* has been on basic high-pressure properties of a 'standard' metal, namely gold. Many properties like electrical conductivity and thermal conductivity of materials and non-equilibrium properties, all at extreme pressures and temperatures, could also be studied with availability of higher power laser systems.

K. R. Rao

Towards mitigating earthquake damages

Many processes related to earthquakes continue to be evasive. Gaps in our knowledge are perhaps the greatest stumbling blocks in our ability to predict what could lie ahead, for example, the location and size of a future earthquake. As efforts in this direction continue, there is an increasing emphasis on the ability to predict seismic hazard; more importantly, how the man-made structures will respond to the expected level of ground shaking at a specific location. Recent experiences have demonstrated that even regions in the outskirts of an active zone are not free from damage. Many of our own cities face threats, the capital city of New Delhi being one of the most vulnerable to earthquakes from the Himalaya. The 1999 Chamoli earthquake caused damages to buildings in some parts of Delhi and most notably, those affected were built on the sediment fill of the Yamuna valley. Damage to multistoried buildings in Ahmedabad, located more than 300 km from the epicentre of Bhuj earthquake, is another grim reminder of such eventualities. Such selective destruction is the result of the increase or decrease of ground motion, determined by the properties of the surface material through which the seismic waves propagate. The modern-day seismic hazard maps are amalgamation of both geologic and seismologic data, giving due importance to the character and distribution of strong ground motion.

Ability to predict site-specific effects of earthquake shaking elevates seismic hazard analysis to a new platform, one that enables the engineers to design structures with an *a priori* knowledge of what may lie in store. This is what is expected from microzonation, which is a block-by-block scale mapping of seismic hazard, based on local conditions. Requiring a variety of data from ground motion to soil properties, microzonation is now being done in many regions of the world facing threat from near or far earthquakes. The paper by Parvez *et al.* (**page 158**) provides an example of first order microzonation in a part of Delhi city. Using the strong motion data from the 1999 Chamoli earthquake, the authors demonstrate that the level of strong motion – both acceleration and velocity – are different for eastern and western Himalaya. For many who live in the alluvial plains of the Himalayan hinterland, possibility of a distant earthquake is a reality that must be reckoned with. That cannot be averted. What can be and should be done is to equip the society to cope up with such disasters. Perhaps, the ability to design structures based on modern-day seismic hazard maps is the starting point. That is the context from which the paper by Imtiaz Parvez and his co-authors must be looked at. There is a long way to go, but this paper marks an excellent beginning.

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