Picosecond X-ray Diffraction from Laser-Shocked Crystals

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In situ X-ray diffraction allows the determination of the structure of transient states of matter. We have used laser-plasma generated X-rays to study how single crystals of metals (copper and iron) react to uniaxial shock compression. We find that copper, as a face-centred-cubic material, allows rapid generation and motion of dislocations, allowing close to hydrostatic conditions to be achieved on sub-nanosecond timescales. Detailed molecular dynamics calculations, involving tens of millions of atoms for simulation times of more than 100 picoseconds, provide novel information about the process. The diffraction images from shock compressed iron are also of great interest, in that they show clear evidence that is consistent with the well-known bcc-hcp transition, and via a mechanism that is also consistent with molecular dynamics simulations.[1]

[1] Kai Kadau, Timothy C. Germann, Peter S. Lomdahl, Brad Lee Holian, Science 296, 1681 (2002).