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Creating Planetary Interior Conditions via Laser Ablation - A Perspective.

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The use of laser-ablation to create solid-state matter at planetary-core like conditions is a burgeoning field which has advanced considerably with the development of exquisite laser pulse shaping which allows for ramp, as well as shock, compression of targets. The state of the compressed crystalline matter can be diagnosed via x-ray diffraction, using either laser-plasma or Free-Electron-Laser sources. However, owing to the uniaxial strain conditions under which such experiments are generally performed, significant plastic work heats the sample, even under ramp loading. The amount of heating - largely unknown owing to a dearth of accurate temperature measurements - will be determined by the strain, strain-rate, and material-dependent strength, which is currently poorly understood for many materials. There is also considerable evidence that in many cases the phase boundaries, and indeed nature of the phases themselves, that are formed on these nanosecond timescales do not necessarily correspond to their static counterparts - perhaps due to strength effects, perhaps due to kinetic effects, or both. We thus posit that a degree of circumspection is warranted in assuming that such experiments are immediately relevant to planetary core conditions. We present here some of our attempts to address one small aspect of the above issues - an understanding of the details of plasticity mechanisms at the lattice level as evinced by diffraction measurements. [1-3]

References

[1] Patrick G. Heighway and Justin S. Wark, J. Appl. Phys. **129**, 085109 (2021)
[2] Patrick G. Heighway and Justin S. Wark, arXiv:2202.08813 [cond-mat.mtrl-sci]
[3] Justin S. Wark, Malcolm I. McMahon, Jon H. Eggert, arXiv:2203.02545 [cond-mat.other]