Laser-driven High-Energy-Density Physics

Research fields for the HED Instrument at the European XFEL with instrumentation from the HIBEF User-Consortium

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HZDR
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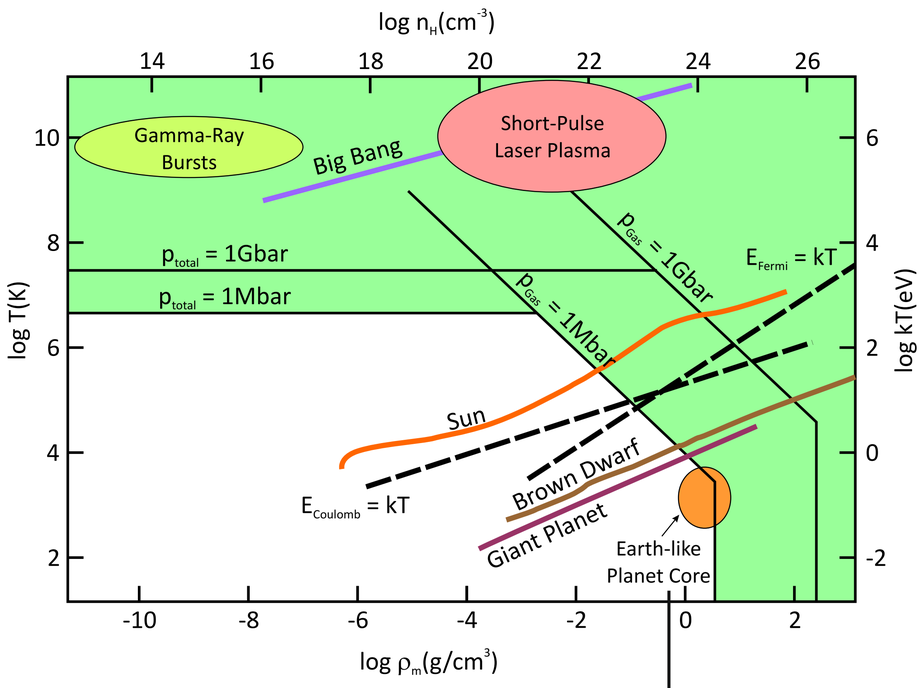
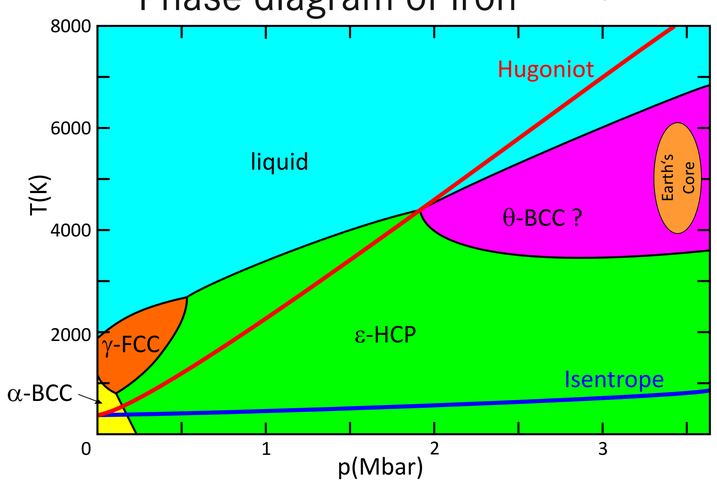
Laser-driven shocks and high-density states

High-Energy Density (shaded green)
- more than 100 kJ / cm^3 or more than 1 Mbar

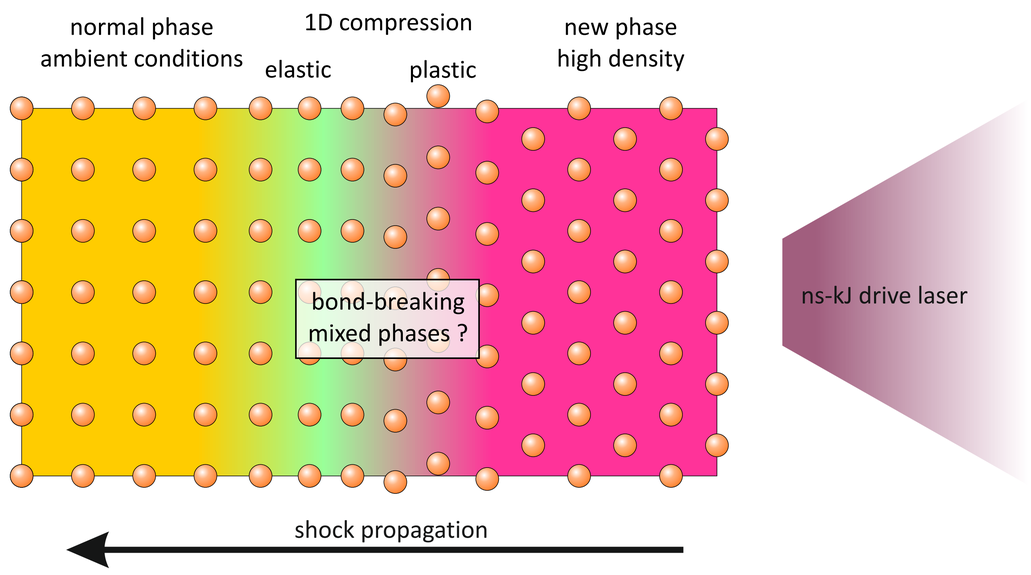


Examples
- earth's interior and magnetism
- structure of giant planets

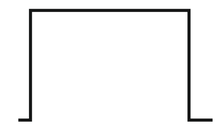
Phase diagram of iron



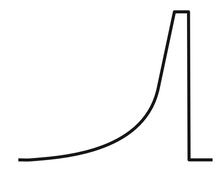
Laser-based approach
- adiabatic compression via laser ablation
- reaches beyond diamond anvil cells etc.
- highly dynamic, i.e. intrinsic heating and involvement of strain rate



Shock-compression along Hugoniot
- with flat-top laser pulse
- strong shock wave in material
- can be scaled down to tabletop lasers (ps, J)
- can be used to vary strain rate
- but reaches high temperatures and low compression



Quasi-isentropic compression
- with ramp-shaped pulses
- reaches higher compression with less heating
- but typical large laser installation



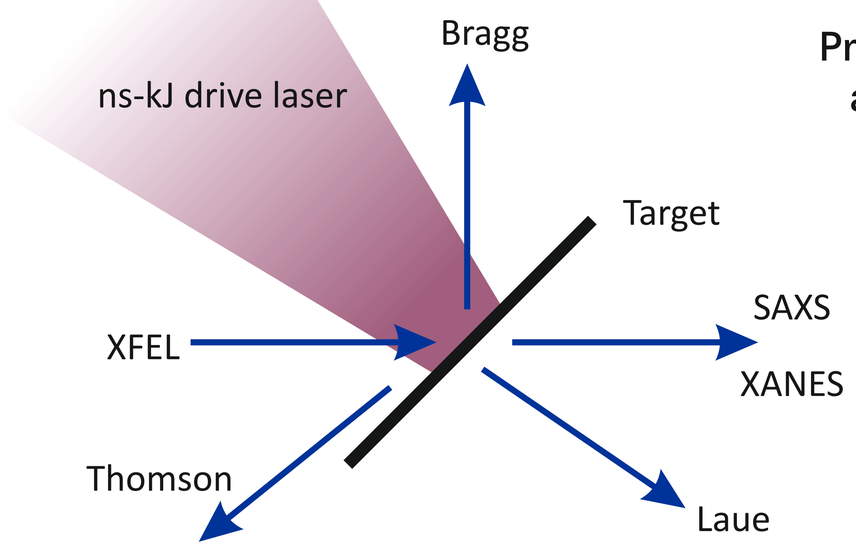
Experimental capabilities

HEDP or WDM studies with ns laser
- direct drive: compression and heating

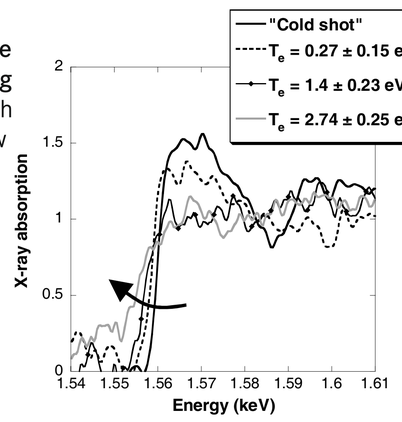
XFEL beam as probe for
- structural properties via Bragg/Laue scattering
- electron density and temperature via Thomson scattering
- electron density modulations via SAXS/CXDI
- short-range order via XANES

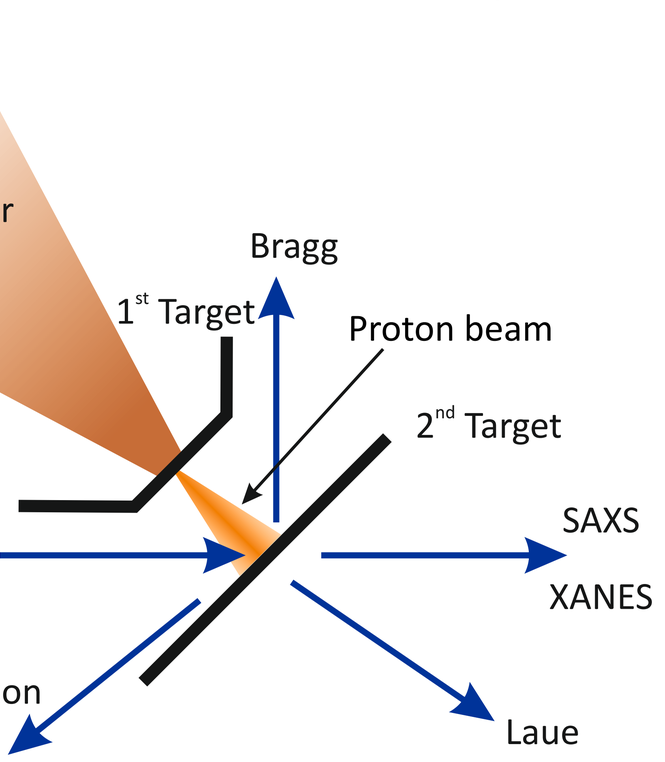
WDM studies with fs laser
- indirect drive with secondary beam

Probing methods can be employed in parallel and will provide high temporal resolution.



Example: Fast loss of short-range order by isochoric proton heating
- isochoric heating of 1 µm Al with laser-accelerated protons to few eV temperatures within 10 ps
- probing with XANES from ps-laser-driven Kα source
- Lévy et al. PPCF **51**, 124021 (2009)





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