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A portable laser-heating system for XES and NIS spectroscopy at extreme conditions

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The experimental investigation of structural properties, phase relations, chemical equilibria and transport properties of material of the Earth's core and lower mantle requires pressures and temperatures which are statically achievable only by the combination of diamond-anvil cells (DACs) and laser-heating.
While X-ray diffraction (XRD), nuclear forward scattering (NFS) and X-ray absorption techniques require measurement in forward scattering geometry, X-ray emission spectroscopy (XES) and nuclear inelastic scattering (NIS) strongly benefit from measurement at or near 90° with respect to the incident beam. XES is a powerful tool for determining local structure and electronic state. NIS yields the phonon density of states and and sound velocity of materials.
We present a portable and versatile IR laser heating system, which is optimized for X-ray spectroscopy applications like XES and NIS at 90° scattering angle. In several aspects, the setup resembles common stationary laser heating systems installed at extreme conditions beamlines: a) incidence of the primary beam through one of the diamonds, b) double-sided on-axis heating with geoheat-objectives and a single laser source, and c) simultaneous double-sided spectrometric temperature measurement.
Besides its portability, advantages of the described laser heating system for spectroscopic applications at X-ray energies between 6 and 15 keV are the attenuation-free incidence of the primary beam at the DAC through a small hole in the upstream mirror, and the versatility for future combined measurements of XES/XRD and NIS/NFS.
We demonstrate the construction of the laser heating system and show XES and NIS measurements of iron compounds, carried out at beamline P01 at PetraIII, DESY.