Implementation of the peak scaling method for temperature measurement in the laser heated diamond anvil cell at ALS beamline 12.2.2

Martin Kunz, Alastair MacDowell, Jinyuan Yan, Christine Beavers, Andrew Doran, Quentin Williams

The laser-heated diamond anvil cell (LHDAC) is an important tool in the quest to correlate seismologically derived density and velocity profiles of the Earth with mineralogical models. Precise and accurate measurement of pressure and temperature is crucial for the LHDAC to be useful. Measuring accurate temperatures of laser-heated samples is an ongoing challenge. One of the more promising approaches is the 'peak-scaling method' as proposed by Kavner and Panero [2004]. This method relies on imaging the entire hot spot, rather than only the peak region onto the grating of a spectrometer. The temperature derived from the entire hotspot is an 'average' temperature of the full hot spot. Combined with a monochromatic intensity map of the hot spot and a single temperature spot on this map (normally the peak temperature), a complete temperature map of the LHDAC can be derived. The crux of the method is to determine an accurate peak temperature.

To avoid biases introduced into the temperature map by erroneous assumptions on the peak temperature, we implemented on ALS beamline 12.2.2 an iterative way to fit a correct peak temperature based on the measured average temperature and measured monochromatic (700 nm) intensity map of the hot spot. The method calculates an average temperature by inverting the Planck equation on the intensities extracted from the monochromatic hotspot image and compares this value to the value obtained by fitting the Wien approximation to the averaged measured spectrum of the entire hotspot. The peak temperature is adjusted until the difference between calculated and observed averaged temperature is minimal. This is done in real time and provides the user with continuously updated information on peak temperature and average temperature, as well as a high-resolution temperature map of the sample chamber during the data collection.

When combined with X-ray diffraction at defined positions, accurate temperature maps may allow the measurement of the temperature-induced pressure increase in the sample chamber, as well as the temperature dependence of the bulk modulus. Example measurements on AgI will be presented.

Kavner A., & Panero W.R. (2004): Physics of the Earth and Planetary Interior, 143 – 144, 527 – 539