ESRF	**Experiment title:** Nuclear resonance experiments at Earth's core conditions using pulsed-laser heating in a diamond anvil cell	**Experiment number**: HC-1427
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Report:

Although the Earth's core is the most remote region on our planet, many phenomena – strength and dynamics of the geomagnetic field, heat transfer from the Earth's inertia, functioning of hot spot volcanoes, etc. – directly link to core properties and processes and thus affect life and human society. Many fundamental issues concerning the Earth's core remain controversial and poorly understood. In our previous LTP (HE-3618) we successfully set up a double-sided continuous laser heating facility for DACs at ID18 to reach 100 GPa and > 2200 K, which yielded many important scientific results related to the Earth's lower mantle. The higher pressures and temperatures of the Earth's core (> 140 GPa and 3000 K) pose challenges that require a different strategy, which we addressed in a new LTP to set up pulsed-laser heating in DACs for nuclear resonance studies of iron and iron-based alloys at core pressures and temperatures. In the single beamtime slot that we were allocated for the new LTP we focused on technical development of the system.

We used the existing portable double-sided heating system with one laser in pulsed mode. For pulsed operation we used a trigger signal that was supplied to the trigger input of a delay generator. The generator was configured to supply two negative fast NIM veto signals to two constant fraction discriminators (complementary to the normal gating of synchrotron prompt radiation) in order to acquire data during and in between laser pulses. The start and duration of the veto signals were adjusted according to a laser pulse profile.

We conducted tests using iron metal and iron oxides loaded into DACs. Synchrotron Mössbauer Source (SMS) spectra were collected for ~ 30 min each during operation in multibunch mode (7/8+1 filling) with the X-ray beam focused to 8 µm x 13 µm using Kirkpatrick-Baez mirrors. Initial heating tests were carried out using one-sided pulsed laser heating. The centre shift (through the second order Doppler shift) varies approximately linearly with temperature and thereby provides a measure of the temperature of exactly those atoms which are responsible for the spectral signal.

Time-discriminated data were collected that allowed extraction of time series in order to investigate reliability of the alignment, stability of heating, and whether chemical reactions were taking place during the heating. One example is shown below where data were binned according to two large regions of interest (ROIs) (Fig. 1a). The spectra for different ranges of integral counts (Fig. 1b) show varying centre shifts (Fig. 1c) that reveal the sensitivity of time-resolved SMS to allow such variations to be quantified and the data to be binned accordingly. Subdivision of the same dataset between 1 and 4 x 10^6 counts into 20 ROIs show centre shifts that are nearly constant over the laser heating pulse (Fig. 1d), implying nearly constant temperature, demonstrating the possibility to extract meaningful and important data. Further analysis of all time-discriminated data is ongoing and a paper is in preparation.

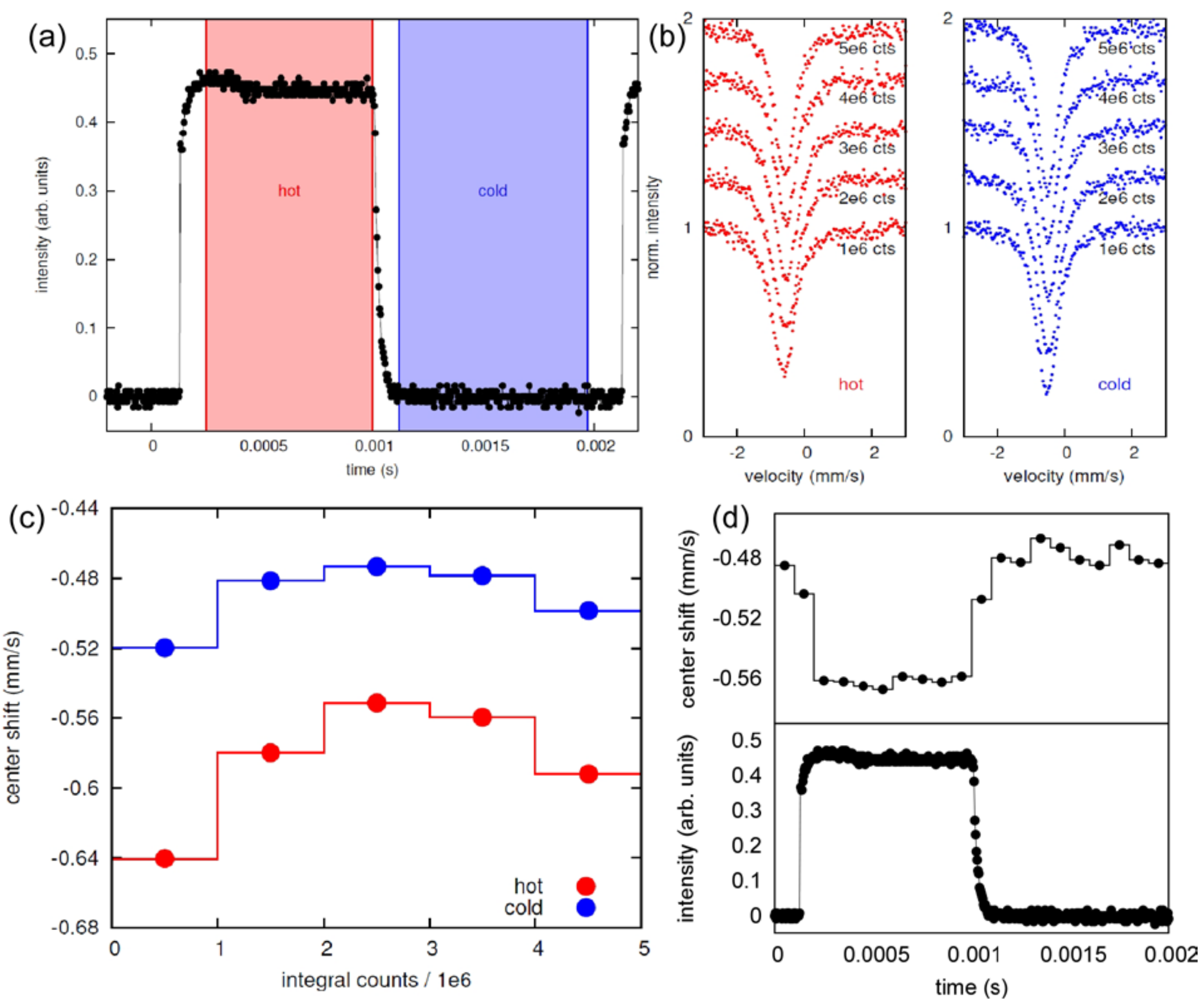

Fig. 1: (a) Laser profile for pulsed heating showing initially selected ROIs; (b) SMS spectra of hcp-Fe at 32 GPa for different ranges of integral counts; (c) centre shift variation of SMS spectra for these ranges; (d) centre shift variation (upper) for laser pulse (lower) divided into 20 smaller ROI for data with integral counts between 1 and 4 x 10^6.