Airborne measurements of atmospheric trace gases via infra-red laser absorption spectroscopy

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Recent laboratory and field studies demonstrated that replacing lead-chalcogenide tuneable diode lasers by cw operated quantum cascade lasers (QCL) results in sensitivity improvements of mid-IR TDLAS systems by a factor 2 to 3. Therefore, the MPI-C three laser TRacer In-situ Tdlas for Atmospheric Research (TRISTAR) was equipped with 3 QCL emitting at 1268.98, 2158.30, and 1759.72 cm-1 to measure CH4, CO and HCHO, respectively. In October 2005 the modified TRISTAR instrument was installed on a Lear Jet 35A as part of a scientific payload to study the photochemistry over the tropical rainforest in South America during the GABRIEL campaign. A second deployment was during fall 2006 and summer 2007 as part of the HOOVER campaign to study HOx and its precursors in the upper troposphere over Europe. Since 2012 the instrument has been successfully flown on the new HALO aircraft during the TACTS/ESMVAL and OMO-Europe missions. These missions investigated the influence of convection and stratosphere-troposphere-transport on the photochemistry of the tropopause region. The performance of the instrument during these airborne campaigns was examined for the three species and precisions for CO and CH4 were measured in the field to be 0.5% and 0.8% respectively (2σ). The 1σ detection limit for HCHO was ~500 pptv for a 2 second average, while post-flight signal averaging over a 2 minute time interval resulted in a 150 pptv detection limit.

Phase diagrams of FeO and Fe-Si alloys

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Earth's core is less dense than pure iron, implying the presence of one or more lighter element(s) [1] such as Si, O, or S [2]. The phase diagrams of iron alloyed with these elements at high pressures and temperatures (*P*-*T*) are critical input for understanding the thermodynamics of these systems. Here we present results on FeO and a suite of Fe-Si alloys.

High *P*-*T* conditions (up to 200 GPa) were generated using a laser-heated diamond anvil cell. In situ X-ray diffraction to determine crystal structures was performed at beamline 13-ID-D of the Advanced Photon Source, Argonne National Laboratory. Melting was determined from diffuse X-ray scattering, by laser power-temperature relationships, and by temperature-emissivity relationships.

We have determined the melting curve of FeO [3] and clarified the location and slope of the B1/B8 phase transition [4]. We also identified an insulator-metal transition [5]. The B1 metallic phase of FeO is the stable phase at conditions of Earth's lower mantle and outer core, with possible implications for the high *P*-*T* character of Fe-O bonds, magnetic field propagation, and lower mantle conductivity.

FeSi has the B20 structure at 1 bar, the B2 structure at high pressures, and a wide two-phase field in between [6]. Fe-9Si has the hcp structure at high *P* and low *T*, and converts to an hcp+B2 mixture and then fcc+B2 with increasing temperature [6]. Fe-16Si has the $D0_3$ structure at low pressures and is an hcp+B2 mixture at higher pressures [7]. We have also measured melting temperatures for each alloy. Phase diagrams in *P*-*X* and *T*-*X* space imply that the stable phase of Fe-Si alloy at inner core conditions for compositions that match the observed density deficit is an hcp+B2 mixture [6].

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