Spin Crossover in Iron and Thermal Conductivity in the Earth's Lower Mantle

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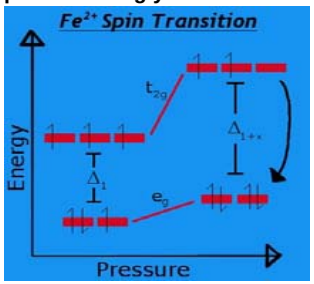
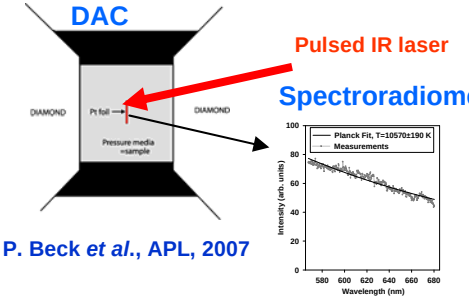
$$\kappa = \kappa_{Latt} + \kappa_{rad}$$

Motivation

- Heat conducts through: Conduction, Radiation or Convection
- Convection only occurs if the former two methods fail to transfer heat
- Changes in mineral conduction and radiation properties strongly affect mantle dynamics

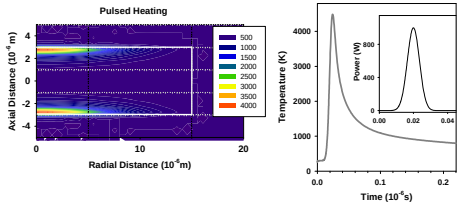


Time-resolved spectroradiometry



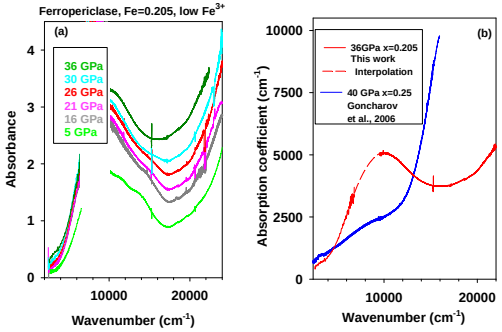
P. Beck *et al.*, APL, 2007

Finite element calculations



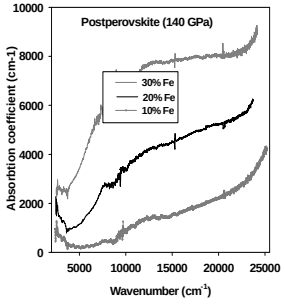
Radiative conductivity

Absorption spectra: ferropericlase with very small content of Fe^{3+}

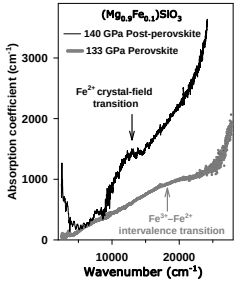


Optical absorption spectra of ferropericlase. (a) Pressure dependence of absorbance of sample with a low ferric iron concentration from this work. (b) Comparison of the 36 GPa absorption coefficient spectrum from this work with that determined by Goncharov et al., 2006 for another sample batch. The absorption coefficient has been calculated using k = A*ln10/d, where A = log10(I0/I) is the absorbance, d is the sample thickness (see text).

Absorption spectra: Perovskite vs post-perovskite



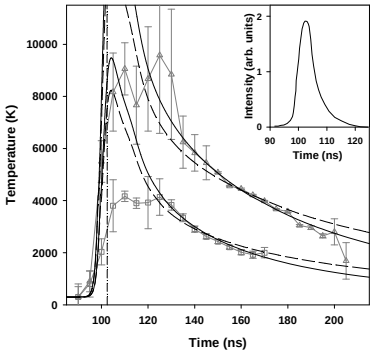
Optical absorption spectra of post-perosvskite with different iron compositions. The sample thickness was estimated to be 5.75 micrometers (see text).



Comparison of the optical absorption spectra of post-perosvskite (this work) and perosvskite from work of Goncharov et al., 2008.

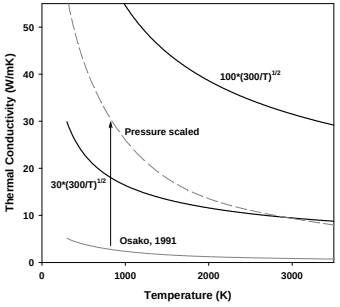
Phonon (lattice) conductivity

Pulsed laser heating: time dependent spectroradiometry



Time dependence of surface temperature of the iridium foil imbedded into perovskite sample at 125 GPa. The two datasets are for different pulse energies. Symbols with error bars- spectroradiomeric measurements, solid lines - FE calculations with k_{320K}=100 W/mK, dashed lines – same with k_{300K}=30 W/mK. Vertical dot-dashed line corresponds to the maximum of the laser pulse. Inset – the laser pulse profile.

Thermal condictivity: P & T dependence



Thermal conductivity of perovskite as a function of temperature. Solid gray line- ambient pressure data from the Ref. (Osako, 1991). Dashed gray line – extrapolation to 125 GPa data of (Osako, 1991) using an empirical relation k=k0*(V0/V)7, where zero subscript refers to P=0 GPa (Manga & Jeanloz, 1997). Thick bold lines represent the temperature dependences of the thermal conductivity used in the FE calculation in this work.

Conclusions:

- Spin-state change of Fe^{2+} does no affect critically on the radiative thermal conductivity
- The presence of ferric iron in ferropericlase strongly affects the optical properties, and, hence, the radiative part of thermal conductivity
- Perovskite and postperovskite exhibit substantially different optical absorption in near infrared and visible spectral ranges (cf., the results of Lin et al., 2008); this difference may have a profound effect on the dynamics the lowermost mantle.
- We present preliminary results of measurements of the thermal conductivity of perovskite at 125 GPa. The available data suggest a larger value than what previously estimated, although the uncertainty is very large.

Acknowledgement

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