Thermal conductivity anomaly in spin-crossover ferropericlase under lower mantle conditions

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Thermal conductivity of the mantle minerals is one of the key parameters that control mantle convection. The heat flux from the core, which is determined by the heat conductivity of the thin layer overlying the core-mantle boundary (CMB), is critical to the understanding of many processes such as the Earth’s evolution, mantle convection, and geodynamo. Iron in ferropericlase experiences a spin crossover from a high spin to a low spin under lower mantle conditions, which generates anomalies in many properties such as the heat capacity and sound velocity (Wu et al., 2009, 2013). Since the thermal conductivity is proportional to the heat capacity and the square of the sound velocity, the spin-state crossover of iron in the lower mantle minerals may profoundly affect the lattice thermal conductivity of the lower mantle. However, knowledge of the spin-crossover effect on the lattice thermal conductivity is very limited.

Here, I found that the spin crossover completely changes the conventional pressure and temperature dependences of the thermal conductivity. The pressure dependence of the thermal conductivity of ferropericlase will show a double-valley feature across the spin-crossover region. Thermal conductivity of ferropericalse may increase with the temperature in some temperature region. The spin crossover can explain the anomalous reduction in thermal conductivity of ferropericlase observed recently by Ohta et al (2017) in the spin crossover region. The unusual effect of spin crossover on the thermal conductivity can be expected in other minerals with spin crossover. Since the spin-crossover region of ferropericlase covers the CMB conditions, the spin crossover effect needs serious consideration when estimating the thermal conductivity at the core-mantle boundary

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