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Elasticity of (Mg,Fe)O through the spin transition of iron in the lower mantle[1]

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Recently, the important question of spin-pairing transitions of iron from high-spin (HS) to low-spin (LS) states in ferropericlase (Ref. 1 and references therein) affecting the lower mantle's density and seismic-wave velocities has been recognized (2,3). Since knowledge of this deep and inaccessible region is derived largely from seismic data, it is essential to determine the influence of the spin transition on elastic wave velocities at lower-mantle pressures. Here we discuss the results of measurements of the elastic tensor of (Mg0.94Fe0.06)O up to 60 GPa using impulsive stimulated light scattering. We find that all tensor elements soften substantially through the HS to LS transition, and that the softening occurs over an extended pressure range from 40 GPa to at least 60 GPa at room temperature. By invoking a simple thermodynamic description (4) of the transition we can compare our results to literature compression data (2,5) obtained from material with the higher iron concentrations likely to be found in ferropericlase in the lower mantle. The agreement is good and thus suggests that the thermodynamic description is reasonable. This in turn allows us to predict the effect of high temperature on the transition; we find that as temperature is increased the transition region is extended (see also Ref. 6) and the magnitude of the softening decreases. We conclude that although the spin transition in (Mg,Fe)O is too broad to produce an abrupt seismic discontinuity in the lower mantle, the transition will produce a correlated negative anomaly for both compressional and shear velocities that extends throughout most if not all of the lower mantle. 1. J. Badro, et al., Science, 300, 789 (2003). 2. J. F. Lin, et al., Nature, 436, 377 (2005). 3. J. F. Lin, et al., Geophys. Res. Lett., 33, L22304 (2006). 4. T. Tsuchiya, R. M. Wentzcovitch, C. R. S. da Silva, S. de Gironcoli, Phys. Rev. Lett., 96, 198501 (2006). 5. Y. Fei, et al, Geophys. Res. Lett. 34, L17307 (2007). 6. J.F. Lin, et al., Science, 317, 1740 (2007).

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