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Compression of single-crystal magnesium oxide to 118 GPa and a ruby pressure gauge for helium pressure media

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Abstract

The pressure-volume equation of state (EoS) of single-crystal MgO has been studied in diamond-anvil cells loaded with helium to 118 GPa and in a non-hydrostatic KCl pressure medium to 87 GPa using monochromatic synchrotron X-ray diffraction. A third-order Birch-Murnaghan fit to the non-hydrostatic *P*-*V* data (KCl medium) yields typical results for the initial volume, V_0 = 74.698(7) Å^3, bulk modulus, K_{T0} = 164(1) GPa, and pressure derivative, K' = 4.05(4), using the non-hydrostatic ruby pressure gauge of Mao et al. (1978). However, compression of MgO in helium yields V_0 = 74.697(6) Å^3, K_{T0} = 159.6(6) GPa, and K' = 3.74(3) using the quasi-hydrostatic ruby gauge of Mao et al. (1986). In helium, the fitted equation of state of MgO underdetermines the pressure by 8% at 100 GPa when compared with the primary MgO pressure scale of Zha et al. (2000), with K_{T0} = 160.2 GPa and K' = 4.03. The results suggest that either the compression mechanism of MgO changes above 40 GPa (in helium), or the ruby pressure gauge requires adjustment for the softer helium pressure medium. We propose a ruby pressure gauge for helium based on shift of the ruby-R_1 fluorescence line ($\Delta\lambda/\lambda_0$) and the primary MgO pressure scale, with P (GPa) = $A/B\{[1 + (\Delta\lambda/\lambda_0)]^B - 1\}$, where A is fixed to 1904 GPa and B = 10.32(7).

Keywords: MgO, helium pressure medium, static compression, equation of state, ruby fluorescence