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Effect of observed micropolar motions on wave propagation in deep Earth minerals

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We provide a method to compute the Cosserat couple modulus for a bridgmanite ($MgSiO_3$ silicate perovskite) solid from frequency gaps observed in Raman experiments. To this aim, we apply micropolar theory which is a generalization of the classical linear elastic theory, where each particle has an intrinsic rotational degree of freedom, called micro-rotation and/or spin, and which depends on the so-called Cosserat couple modulus μ_c that characterizes the micropolar medium. We investigate both wave propagation and dispersion. The wave propagation simulations in both potassium nitrate (KNO_3) and bridgmanite crystal leads to a faster elastic wave propagation as well as to an independent rotational field of motion, called optic mode, which is smaller in amplitude compared to the conventional rotational field. The dispersion analysis predicts that the optic mode only appears above a cutoff frequency, ω_r, which has been observed in Raman experiments done at high pressures and temperatures on bridgmanite crystal. The comparison of the cutoff frequency observed in experiments and the micropolar theory enables us to compute for the first time the temperature and pressure dependency of the Cosserat couple modulus μ_c of bridgmanite. This study thus shows that the micropolar theory can explain particle motions observed in laboratory experiments that were before neglected and that can now be used to constrain the micropolar elastic constants of Earth's mantle like material. This pioneer work aims at encouraging the use of micropolar theory in future works on deep Earth's mantle material by providing Cosserat couple modulus that were not available before.