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Experimentally Validated Equations of State for Planetary Fluids to GPa Pressures

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Sound speeds provide a precise measure of thermodynamic potentials in the pressure domain. Prior equations of state for pure ammonia (Harr and Gallagher 1978, Tillner-Roth et al. 1993) are based on density measurements primarily, with no accounting for sound speed. We couple previously unconsidered sound speed data with careful analysis of prior density and heat capacity data.

Our analysis results in an improved and expanded equation of state, with corrections in density as large as 2%, and in heat capacity up to 10%. We extend knowledge of density and heat capacity to 4 GPa pressure, beyond those of prior measurements to 100 MPa and 1 GPa, respectively.

We discuss application of this framework for aqueous equations of state validated by experimental measurements. Preliminary equations of state have been prepared applying the new methodology to aqueous ammonia and magnesium sulfate. We will describe the use of this new methodology for developing new equations of state, and provide some applications of the new thermodynamic data to the interior structures of gas giant planets and ocean worlds.

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