Equation-of-state and transport properties of liquid and solid CO$_2$ shock-compressed to 1 TPa and 93,000 K

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Equation-of-state and transport measurements of shock-compressed CO$_2$ at and above the insulating-to-conducting transition reveal new insight into the chemistry of simple molecular systems in the warm-dense-matter regime. In this work, we extend the measured CO$_2$ liquid and solid Hugoniot to 1 TPa, and present the first temperature measurements of shocked CO$_2$ to 93,000 K. CO$_2$ was precompressed in diamond-anvil cells before being dynamically compressed with laser-driven shock waves. Uniquely, the different initial densities in these experiments allow us to extract thermodynamic derivatives, including specific heat and Gruneisen coefficient. At the most extreme conditions we reach, the data is inconsistent with a simple atomic fluid. A constant reflectivity implies a constant carrier density, but a rising specific heat implies increasing degrees of freedom. We conclude that at these conditions, CO$_2$ is more likely an electrically conducting bonded fluid of increasing chemical complexity. This material is based upon work supported by the Department of Energy National Nuclear Security Administration under Award Number DE-NA0003856, the University of Rochester, and the New York State Energy Research and Development Authority. A portion of this work was conducted at Lawrence Livermore National Laboratory under Contract Number DE-AC52-07NA27344.

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