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Ab initio calculation of transport properties of hydrogen-helium mixtures along the isentrope of Jupiter

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The planet Jupiter contains matter under extreme pressures in the megabar regime and temperatures of several thousand Kelvin. Accurate knowledge about the behavior of the major constituents, hydrogen and helium, is required to model and understand the interior of Jupiter and other gas giant planets. In particular, transport properties like the thermal and electrical conductivity as well as the viscosity need to be known. For instance, these quantities are a fundamental input in magneto-hydrodynamic simulations used to model magnetic fields.
The investigation of matter under extreme conditions is a challenge for both experiment and theory. We use ab initio molecular dynamics simulations to obtain the transport coefficients. The method is based on a combination of finite-temperature density functional theory for the electrons with classical molecular dynamics for the ions. This approach allows us to obtain equation of state data, phase diagrams, as well as transport and optical properties of warm dense matter with high accuracy.
Here we present new results for the viscosity and the electrical and thermal conductivity in hydrogen-helium mixtures along the isentrope of Jupiter, for which only relatively simple estimations are available so far. Our results cover the range from the outer molecular regions (2000 K, 5 kbar) to the core-mantle boundary (19000 K, 40 Mbar). These new data will lead to significant improvements in understanding the dynamo of Jupiter.