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First DC electrical conductivity measurements of warm dense matter using ultrafast THz radiation[1]

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The DC electrical conductivity is an important parameter for characterizing warm dense matter and dense plasmas as it is connected with carrier density and electron-electron and electron-ion collisional processes. Accurate knowledge is vital, for instance, for modeling the magnetic field produced by planetary dynamos, or for understanding instability growth in inertial confinement fusion implosions. However, investigations of the DC conductivity have remained a significant challenge due to the highly transient nature of laboratory generated warm dense matter. Probing transient states on ultrashort time scales is possible using ultrafast laser pulses, but these approaches measure the high frequency AC response which must then be extrapolated to the low-frequency near-DC regime. Additionally, theoretical models predict different results based on how the strong coupling of dense plasmas is handled. Taken together, these highlight the need for accurate measurements of the response close to DC. This talk presents recent measurements of the DC electrical conductivity of warm dense matter using terahertz (THz) pulses. THz fields are sufficiently slowly varying that they behave like DC fields on the timescale of electron-electron and electron-ion interactions, and hence probe DC-like responses. The THz pulses are produced using laser- or accelerator-based techniques and measured with high-fidelity single-shot electro-optic sampling. Using a pump-probe measurement, the electrical conductivity of laser generated warm dense matter is determined with < 1 ps temporal resolution. The measurements demonstrate the influence of material density and changes in the collision frequency, and agree with density functional theory results in a controversial regime of warm dense aluminum.Finally, an outlook on using THz pulses for studies of dynamically compressed matter will be presented.

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