Magnetothermodynamics: Measuring the equations of state in a relaxed MHD plasma

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We have explored the thermodynamics of compressed magnetized plasmas in laboratory experiments and we call these studies magnetothermodynamics. The experiments are carried out in the linear Swarthmore Spheromak eXperiment (SSX) device. In this device, a magnetized plasma source is located at one end of the device and at the other end, a closed conducting can is installed. We generate parcels of magnetized, relaxed plasma and observe their compression against the end wall of the conducting can. The plasma parameters such as plasma density, temperature, and magnetic field are measured during compression, using HeNe laser interferometry, ion Doppler spectroscopy and a linear B-dot probe array, respectively. To identify the instances of ion heating during compression, a PV diagram is constructed using measured density, temperature, and volume of the magnetized plasma. Various equations of state of the magnetized plasma are analyzed to estimate the adiabatic nature of the compressed plasma. Although our magnetized plasmas relax to an equilibrium described by magnetohydrodynamic*, one might expect their thermodynamics to be described by the corresponding equation of state. But we find that the magnetohydrodynamic equation of state is not supported by our data.

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