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Kinetic simulations of power flow in the Z accelerator[1]

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The challenge for the Terawatt-class accelerators driving Z-pinch experiments, such as Sandia National Laboratories' Z machine, is to efficiently couple power from multiple storage banks into a single multi-mega amp (MA) transmission line. The physical processes that degrade efficiency are identified in the first-ever, multi-dimensional simulations of the Z machine. Kinetic models follow the range of physics occurring during a pulse, from vacuum pulse propagation to charged-particle emission and insulated flow to electrode plasma expansion. Simulations demonstrate that current is diverted from the load through a combination of standard and anomalous transport. Standard transport occurs in the adder region where the electrode current density is a few $10^4 - 10^5$ A/cm^2 and current is diverted from the load via uninsulated charged-particle flows. In regions with $> 10^6$ A/cm^2, electrode surface plasmas develop velocity-shear instabilities and a Hall-field-related transport which scales with electron density. These results provide the physics basis for designing future pulsed-power systems.

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