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Experiments and simulations studying electrothermal instabilities in magnetically accelerated implosion systems[1]

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Electrothermal instabilities in electrical conductors can occur whenever the electrical conductivity depends on temperature. Of particular interest are electrothermal instabilities that occur when the electrical conductivity decreases with temperature, which is the case in most metals until they are heated into a Spitzer-like conductivity regime. These instabilities form stratified structures perpendicular to the current flow that are similar in appearance to m=0 sausage type instabilities and can geometrically couple to magneto-Rayleigh-Taylor (MRT) instabilities as the system is accelerated. Several experiments were performed using the 100-ns Z accelerator that drove up to 20 MA through well-characterized, initially solid and smooth (<50 nm RMS) Al and Cu rods. The experiments used 2-frame (6151 eV) or 2-color (1865/6151 eV) monochromatic x-ray backlighting to image instability growth on the surface of the rods. Excellent agreement is obtained between measurements and simulations that show the majority of the instability growth occurs immediately after the surface of the rod melts and is in regions that are stable to MRT instabilities and unstable to electrothermal instabilities. We will also show how MRT instability theory alone cannot explain the levels of instability growth observed in experiments.

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