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Power Flow Studies with the Hairpin Experiment

In order to develop a better understanding of current losses in the magnetically insulated region of high-power pulsed power machines, it is crucial to be able to conduct experiments at scale in smaller facilities. However, on university-scale pulsed power drivers (of typically ~1 MA peak current), it is difficult to produce stripline experiments with current densities and magnetic fields that match expected peak fields in next generation pulsed power machines. In this poster, we present a novel experiment that has been tested on the MAGPIE driver at Imperial College. Called the "hairpin", this geometry uses small wires of circular cross-section bent into slightly inductive loops. Since it is far easier to work with small-diameter wires than very thin planar foils, manufacturing costs are dramatically reduced compared to similar stripline experiments. In addition, the curvature of the wire cross-section provides field enhancement at the apex of the curve, making even higher magnetic and electric field strength attainable. Lastly, the inductance of the loop can easily be varied, providing precise tuning of the electric and magnetic field strengths in the experiment. Simulation results indicate that magnetic fields ranging from 70 T to 300 T and electric fields ranging from 30 MV/m to 650 MV/m can be produced with this geometry on MAGPIE. Several simulations of different hairpin designs are presented using COMSOL and GORGON; these simulations are then compared to the experimental results, and possible explanations for current losses in the inner MITL are then discussed in light of the experimental results.