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Generation of cylindrically convergent shockwaves in water on the MACH facility

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We report on initial shock physics experiments performed on the MACH –Mega Ampere Compression and Hydrodynamics –facility at Imperial College London.

The MACH generator is a 2MA, 400ns, 100kV 'dry air'Linear Transformer Driver cavity, which can be readily expanded to higher currents and drive voltages. The generator was designed for ease of use, and rapid turnaround with a load region that can be readily reconfigured to drive a variety of HEDP experiments from the ramp and shock loading of condensed matter to the generation of dense streams of plasma for astrophysics research.

Here we report on the first experiments utilizing MACH to explode copper wire arrays in water, generating highly symmetric, cylindrical convergent shockwaves. The experiments were carried out with 10mm diameter arrays consisting of 60 x 130μm wires, and currents >500kA were achieved despite the high inductance load. Laser backlit framing images and streak photography of the implosion showed a highly uniform, stable shockwave that travelled towards the axis at velocities up to ~7.5kms-1. For the first time, imaging of the shock front has been carried at radii < 0.5mm, and there is strong evidence that even at radii <0.1mm the shock front remains stable, resulting in a convergence ratio of 50:1. 2D hydrodynamic simulations that match the experimentally obtained implosion trajectory suggest pressures of >1Mbar are produced within 10μm of the axis, with water densities 3gcm-3 and temperatures of many 1000s of Kelvin. The results represent a significant step in the application of the technique to drive different material samples, and calculations of scaling the technique to larger pulsed power facilities are presented.

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