Multi frame synchrotron radiography of pulsed power driven high energy density physics experiments

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Pulsed power driven underwater wire explosions are accompanied by the efficient generation of strong shockwaves. In the case of cylindrical or quasi-spherical wire arrays, convergence of these shockwaves results in high energy density conditions with multi Mbar pressures being obtained on axis, even in compact 'table-top' experiments. However much of the physics underlying wire explosion and shockwave interactions remains undiagnosed.

On ID19 at ESRF we have performed the world's first high current pulsed power experiments coupled to a synchrotron. The resultant multi-frame, phase contrast radiography images provide absolute density measurements for critical comparison to theory and simulation. Wires in various configurations were exploded in water baths using a simple ~30kA, 500ns rise time current source. In experiments examining single wires, as the wires expanded and ionised, unexpected striation instability growth was observed inside the dense wire material. This could significantly alter our previous understandings of the conductivity of warm dense matter. In two wire experiments, interacting the shockwaves launched into the water with the expanding wire material produced a new test bed for analysing Richtmyer-Meshkov instability growth. With a cylindrical array of wires an increase in density of the water at convergence of the shockwaves agreed well with previous theories demonstrating the techniques use as a driver for extreme pressure research. Finally in arrangements with 2 crossed wires ('X-pinches') mass clear out was observed at the cross over point due to the high magnetic fields produced.

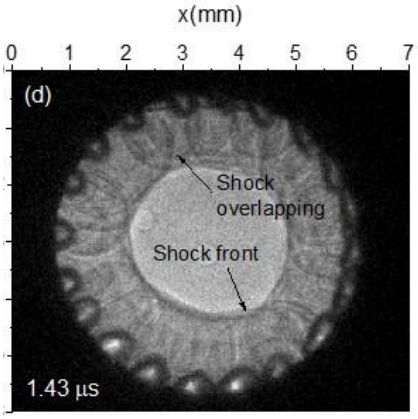

Figure 1: Radiograph through axis of cylindrical wire array showing merger of shockwaves from exploding wires and shock front travelling at high speed towards the axis

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