Laboratory astrophysics: acceleration of electrons in magnetized plasma shock waves.

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In this project we will use a combination of the Imperial College MAGPIE Z-pinch and Cerberus laser systems to create scaled laboratory models of some of the astrophysical processes. The overall objective is to investigate the acceleration of particles by shock waves in magnetised plasma in conditions relevant to the acceleration of cosmic rays. The shocks will be formed by supersonic plasma flows created by Mega-Ampere-level pulsed currents. The first set of experiments will investigate the initial acceleration of electrons, which should allow the formation of electron population with energies significantly exceeding their initial thermal energy. This is expected to occur due to plasma wave turbulence which is excited in the pre-shock plasma by the ions reflected from the shock front. We will characterise the development of the turbulence and measure the parameters of the accelerated electrons using state-of-the-art diagnostic techniques such as Thomson scattering, Faraday rotation, laser interferometry and others. In the second set of experiments, we will investigate the so-called diffusive shock acceleration mechanism, which is considered as the most plausible mechanism of cosmic ray acceleration. This will be achieved by injecting sufficiently energetic electrons into the shock, in such a way that these electrons will then sample both the pre- and post-shock regions, performing multiple passages through the shock front as required for this mechanism to operate efficiently. Finally, we will investigate conditions for acceleration of electrons in magnetic reconnection regions, formed by colliding magnetized plasmas.

Work on the project will involve close collaboration with experimental and theoretical groups at the Universities of Oxford and Strathclyde.

