Three-dimensional magnetic field line reconnection involving flux ropes and Alfvén waves.

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We report on two very different experiments in which three dimensional magnetic field line reconnection plays a role. In the first experiment two magnetic flux ropes are generated from initially adjacent pulsed current channels in a background magnetoplasma in the LAPD device at UCLA $(L = 17m, dia = 60cm, 0.3 \le B_{0z} \le 2.5kG, n \cong 2\times10^{12}\, cm^{-3})$. The currents exert mutual $\vec{J}\times\vec{B}$ forces causing them to twist about each other and merge. The currents are not static but move towards or away from each other in time. In addition the currents are observed to filament after merging. Volumetric space-time data show multiple reconnection sites with time-dependent locations. The quasi-separatrix layer (QSL) is a narrow region between the flux ropes. Two field lines on either side of the QSL will have closely spaced foot-points at on end of the flux ropes, but a very different separation at the other end. Outside the QSL, neighboring field lines do not diverge. The QSL has been measured, for the first time in this experiment [1] and its three dimensional development will be shown in movies made from the data. We will also discuss instabilities of the magnetic flux ropes and how they play a role in the reconnection process. In the second experiment three-dimensional currents associated with colliding laser produced plasmas, in the background magnetoplasma are observed. The currents in this situation are those of shear Alfvén waves. The wave fields are a small fraction of the background field; nevertheless, reconnection regions, multiple magnetic "X" points (which are three dimensional) and a quasi seperatrix layer are all observed. These measurements lead one to suspect that magnetic field line reconnection is not an independent topic, which can be studied in isolation, but part of the phenomena associated with broader subject of 3D waves and current systems in plasmas. Furthermore reconnection is one process among many of which the phenomenon is comprised.

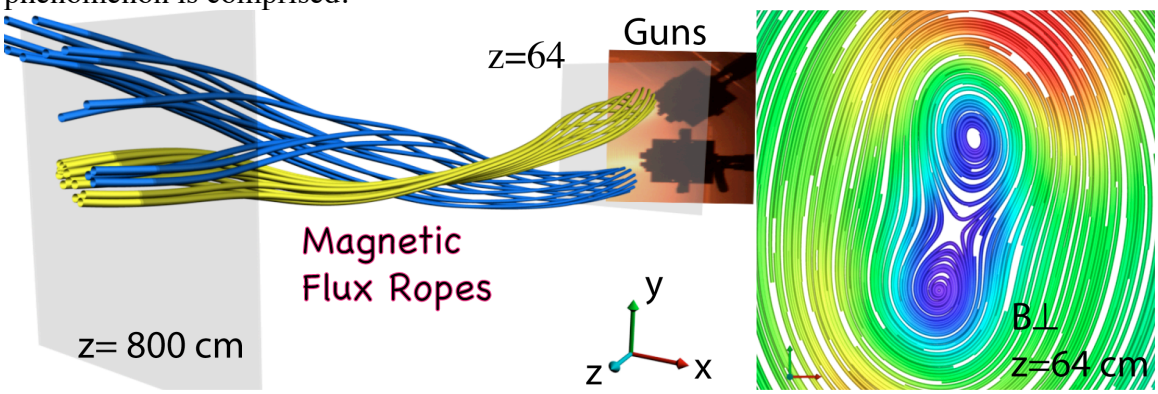

Figure: Experimental data showing selected field lines associated with the flux ropes. The insert at the right shows measured magnetic field lines in a plane 64 cm from the origin of the flux ropes.

[1] E. Lawrence, W. Gekelman, "Identification of a quasi-seperatrix layer in a reconnecting laboratory magnetoplasma", accepted Phys. Rev. Letts. (July 2009)