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# Transition from Rutherford to Sweet-Parker Reconnection

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Magnetic reconnection is explored in a 2-D MHD model to understand the transition between the Rutherford and Sweet-Parker description. The calculations are carried out in a double current layer with a large guide field where the value of the tearing mode stability parameter $\Delta'$ can be calculated and systematically varied. Current sheets form in the vicinity of the x-line for all but the smallest values of $\Delta'$ and increase in length with this parameter. It is suggested that the formation of these sheets is a consequence of magnetic flux conservation as discussed by Waelbroeck for the case of the $m = 1$ mode and, consistent with this idea, self-similarity of the structure of the current layer is obtained for strongly unstable cases. Above modest values of $\Delta'$ the plasma outflow from the x-line is limited by the upstream Alfvén speed as in the Sweet-Parker theory and the reconnection rate exhibits the Sweet-Parker scaling with resistivity. For modest island widths a modified Sweet-Parker theory is developed in which island growth remains exponential and the length of the current layer scales linearly with $\Delta'$. The results suggest that since the values of $\Delta'$ in cylindrical and toroidal plasmas can be large, care should be exercised in applying Rutherford theory to fusion plasma systems. The impact of these results on the growth of neoclassical tearing modes should be explored.