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# ICC/P8-01: Dynamics of Open-field-line MHD Experimental Configurations and Theoretical Investigation of Action Integrals as Effective Hamiltonians

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The Taylor relaxation theory prediction that there exists a unique minimum-energy state towards which a magnetized plasma invariably relaxes has applicability to magnetic fusion confinement (spheromaks and RFP' s), the solar corona, and certain astrophysical plasmas. While Taylor theory predicts the minimum-energy end state reasonably well, it does not even attempt to describe what actually happens, i.e., does not predict the dynamics underlying relaxation. Furthermore, Taylor theory assumes zero beta whereas actual plasmas have finite beta. The actual dynamics underlying self-organization of a magnetized plasma has been investigated using two related devices, a coaxial magnetized plasma gun and a bipolar magnetized plasma gun. Experimental observations using high speed imaging that resolves sub-Alfven time scales have given insights into what happens during Taylor relaxation and also have revealed unexpected and altogether new phenomena. Measurements revealed that a highly collimated MHD-driven plasma flow, i.e., a magnetized plasma jet, is a critical feature of the dynamics. The jet velocity is found to be in good agreement with an MHD acceleration model. These MHD jets are self-collimating as a result of interaction between the magnetic pinch force and jet stagnation. Depending on the flaring of the flux tube radius, open flux tubes can have jets flowing into the flux tube from both ends or from just one end. Jets kink when the Kruskal-Shafranov stability limit is breached; the effective gravity resulting from the acceleration of a sufficiently strong kink can cause a fine-scale, extremely fast Rayleigh-Taylor instability that erodes the current channel to be smaller than the ion skin depth. This cascade from the ideal MHD scale of the kink to the non-MHD ion skin depth scale results in a fast magnetic reconnection whereby the jet breaks off from its source electrode. A multi-channel time- and space-resolved polarimeter has measured the internal magnetic fields of the jet spectroscopically. Theoretical consideration of particle orbits motivated a model showing that adiabatic invariants (action integrals) act as effective Hamiltonians for orbit-averaged motion. This has the consequence that particle drifts can be obtained by taking partial derivatives of adiabatic invariants with respect to their arguments.
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## Country or International Organization of Primary Author

United States of America

**Primary author:** Mr BELLAN, Paul (USA)

**Co-authors:** Ms MOSER, Auna (Caltech); Dr KUMAR, Deepak (Caltech (current address is Johns Hopkins University)); Ms STENSON, Eve (Caltech); Dr PERKINS, Rory (Caltech (current address is Princeton Plasma Physics Lab)); Prof. SHIKAMA, Taiichi (Caltech (permanent address is Kyoto University))

**Presenter:** Mr BELLAN, Paul (USA)

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