Magnetohydrodynamic Instabilities in Jets and Bubbles Using a Compact Coaxial Plasma Gun in a Background Magnetized Plasma

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Magnetohydrodynamic (MHD) instabilities are ubiquitous in space and astrophysical plasmas, including in the ionosphere, magnetosphere, and within the solar corona. A number of such cases are the result of a dense magnetized plasma interacting with less dense background plasma. For many decades, laboratory experiments have investigated MHD relaxation and instability dynamics through the study of plasma jets and bubbles (spheromaks) injected into vacuum. However, there appears to be very little previous work on injection of jets or bubbles into background plasma. Here we describe the use of a compact coaxial plasma gun to launch dense magnetized plasma into a lower density background magnetized plasma, generated by a helicon source. Four distinct operational regimes of the gun with qualitatively different dynamics are identified. In the first regime, a supersonic plasma jet is formed with a global helical magnetic structure. When the jet is injected into background vacuum, an $m = 1$ kink instability is observed. In contrast, when the jet is injected into a background magnetized plasma, it shows a longer stable length and lifetime (> 3 Alfven times). It is found that a sheared axial flow, caused by the background magnetic tension, contributes to the increased stability of the jet body. In the second gun regime of interest, a plasma bubble is formed which evolves in time consistent with Taylor relaxation and spheromak formation, when the gun plasma is injected into vacuum. Conversely, when the bubble propagates into a background magnetized plasma, the spheromak closed magnetic field configuration does not maintain, and a lateral side, Magneto-Rayleigh-Taylor (MRT) instability is observed. Detailed experimental results and analysis will be presented for these cases.