Simulations of a stable helical shear-flow stabilized plasma jet

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Helicity Drive magneto-inertial fusion concept

Plectonemic plasma jets

= non-axisymmetric double helical Taylor states [SSX, MOCHI]

Magnetic reconnection-heating

Arbitrary number \( (N \gg 2) \) of plasma jets

Peristaltic magnetic compression

⇒ \( P_{fus} \propto N^{3/2} \)

Exhaust

Experimental foundation for (I)

Dense plasma jets formed in MOCHI experiment.

Plasma gun design of MOCHI experiment


Jet is stable beyond classical Kruskal-Shafranov threshold

\[ V_{\text{core}} = -6.1 \text{ kV}; \quad V_{\text{skin}} = -5.7 \text{ kV}; \quad \psi_{\text{gun}} = 4 \text{ mWb} \]

I. \( t = 9.5 \mu s \)
II. \( t = 30.5 \mu s \)
III. \( t = 55.5 \mu s \)

Jet is stable beyond classical Kruskal-Shafranov threshold with helical shear flows

Lamb-Oseen vortex
LA-COMPASS 3D MHD Simulations of MOCHI

Engine region

Ideal MHD region (open boundaries)

Imposed Core and Skin profiles in Engine Region:
1) Mass injection ($\dot{m}$) imposed
2) Kinetic energy ($v_z$) imposed
3) Current profile ($B_{\text{tor}}$) imposed

Core Skin “Outside”

Figure 1. (a) Log(n) contours. (b) n^2 plot which simulates light emission ($\propto n^2$).
Simulation confirms long(er!) stable jet
Simulations confirm helical flow shear

\[ T = 35.9 \mu s, \text{ number density } n^2_{\text{p}} \left[ m^{-3} \right] \]

MOCHI wall

72 cm

Lamb-Oseen vortex

Core Skin

“Outside”

Axial flow shear

density/pressure, \( T = 36.3 \mu s, z = 72 \text{cm} \)

velocity, \( T = 36.3 \mu s, z = 72 \text{cm} \)
Without the 3 key ingredients, unstable jets.

- No current profile
- With mass injection
- With $v_z$ flow injection

- With current profile
- With mass injection
- No $v_z$ flow injection

- With current profile
- No mass injection
- No $v_z$ flow injection
Thank you