**Sheared-Flow Stabilized Z pinch: Stability via Sheared Flow**

- **Z pinch**
- Axial current in “Z” direction (green arrows)
- Azimuthal magnetic field (blue loops)
- Field compresses plasma
- Radial shear in axial flow stabilizes the Z pinch

**FuZE Demonstrates Sustained Neutron Production**

- ARPA-E ALPHA supported project UW & LLNL
- Neutron production for ~10 us, thousands of MHD growth times (Zhang et al., PRL 2019)
- Neutron spectra consistent with thermonuclear production
  - Any D beam < 7.5 keV (Mitrani in preparation)
- Over 400 kA pinch current averaged over a flow time
- Results are guiding next steps and reactor development

**Zap Energy’s Next SFS Z Pinch: FuZE-Q**

- Increasing current to over 600 kA
- Further improvement of fusion triple product and neutron yield
  \[ n kT \propto D^{1.3} \text{ and } Y_e \propto D^{1.1} \]
- \( Y_e \propto D^{1.3} \) observed in D-D scaling, experimental and computational results
- Improved diagnostics for higher performance SFS Z pinches
  - Increased resolution for smaller pinches at high current
  - Working with ARPA-E Diagnostic Teams
- High-fidelity modeling and validation with experimental results
  - PMI, electrode durability, improved operational domains, etc.

**Detailed Numerical Simulations have been Critical to Improved Understanding**

Nonlinear fluid and kinetic simulations using Mach2 (MHD), WARPXM (multi-fluid), and LSP (PIC) to:
1. Study sheared flow stabilization, (b) design experimental details, (c) model whole device, (d) predict neutron yield

**Zap Energy Reactor: Liquid LiPb Outer Wall**

- No magnetic field coils nor auxiliary heating
- Liquid LiPb outer wall
  - Return electrode
  - Heat transfer fluid
  - Tritium breeding
  - Biological shield
- Pulses several times per second
  - ~200 MWh per core
- Multiple fusion cores in plant
  - Aids maintenance
  - Common tritium handling facility
  - Can vary generating capacity to match demand

**3-m LiPb Blanket Yields TBR~1.1**

- Limited number of components in direct line of D-T neutrons
  - TBR ~ 1.1 eutectic LiPb & natural 6Li enrichment
  - Bootstrap from D-D to 50-50 D-T in about 1 month
  - Refining pilot plant development and reactor design (Series B)

**Summary:**

- A radial shear in the axial flow stabilizes the Z-pinch
- FuZE has demonstrated sheared-flow stabilized (SFS) Z-pinches:
  - SFS Z-pinch lifetimes 10,000x the static-pinch MHD growth time
  - D-D neutron production \( Y_e \propto D^{1.1} \) & consistent with thermonuclear production
  - Over 400 kA pinch current, averaged over the flow-through time
  - \( n kT \approx 10^{17} \text{ keV s m}^{-3} \)

- FuZE-Q underway to push to over 600 kA pinch current (~breakeven)
- SFS Z-pinch reactor concept is compact: ~3-m cylinder, no coils
  - LiPb walls
  - TBR ~ 1.1; D-D to 50-50 D-T bootstrap in ~ 1 month
  - Modular 200-MWth cores
- Pilot plant and reactor design under development

**www.zap.energy**