The DiMES Electromagnetic Force in Liquids Evaluation Experiment (DEFLEX)

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Overview

- Motivating factors
- A new approach
- Experimental Setup
- Expected Results
- Work Plan and Schedule
- Budget

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The Perceived Trouble with Liquid Metals in Fusion Reactors

- Using molten lithium or other liquid metals in fusion devices could cause large scale excursions of the molten material due to J x B forces from induced currents. Basically, people are afraid the stuff will splash all over the place.
- DiMES is one of our premier experiments devoted to studying interactions of molten materials in direct contact with a major fusion plasma
- Current monitoring diagnostics planned for next DiMES experiment will capture much information and make an explanation of possible lithium excursions easier
  - A laboratory-scale experiment will allow DiMES to carry out more important measurements
  - Controlling induced currents and field-surface orientation would provide measurements that complement DiMES measurements

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A Reduced Risk Approach

- We propose to create a laboratory experiment to optimize use of available time in D-IIID
  - Mimics the DiMES environment in D-IIID in the essentials
  - can allow user-controlled pulsed currents to be added in any direction with respect to the magnetic field,
  - can be run on a daily basis in many different configurations – including those that would cause liquid ejection,
  - allows for direct validation of modeling codes
  - may be able to bolster the case for more DiMES run time.

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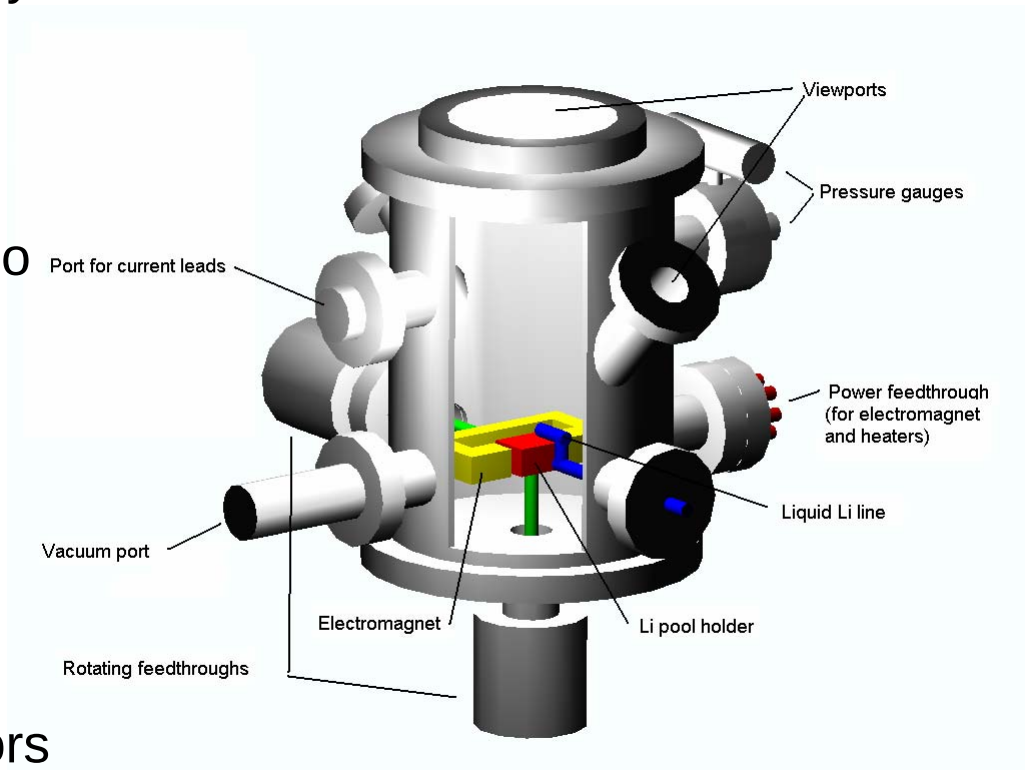
Experimental Setup

- Use FLIRE's liquid metal delivery system
  - Share vacuum systems, safety systems, heaters and diagnostics
  - Can be run independently, so as not to impact the deliverables and tasks of FLIRE
- Sample holder rotates on the plane of the chamber floor, and the electromagnet rotates in a perpendicular plane
- Arbitrary relative angle between Magnetic field and current vectors



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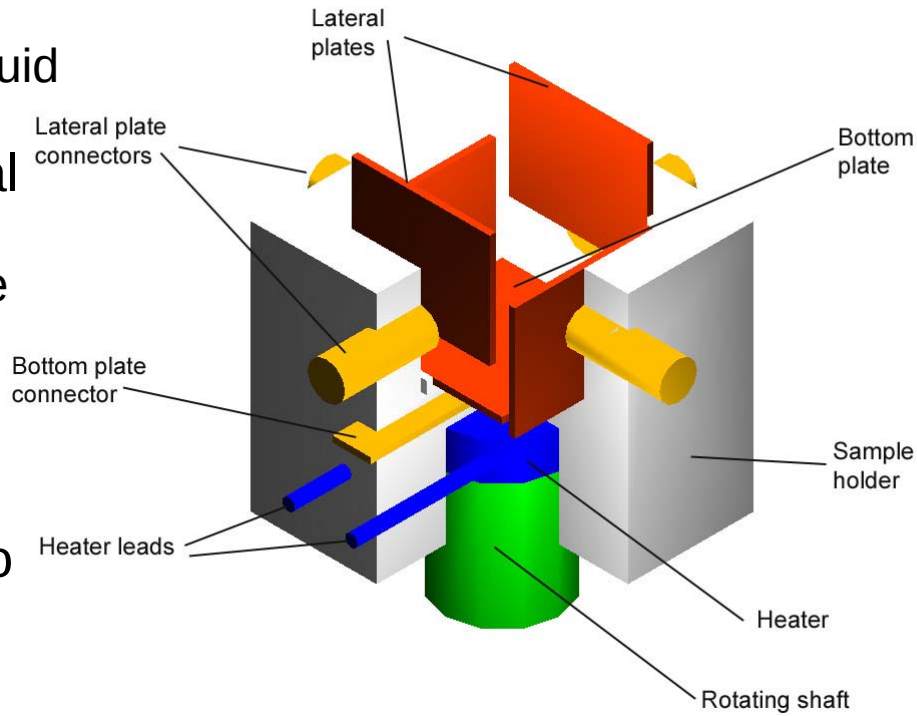
Sample Holder

- Heated by button-type UHV heater
- Made of non-conductive material
  - Boron Nitride to ensure compatibility with most relevant materials (including lithium)
  - current only passes through the liquid metal.
- And/or made of conducting material (graphite)
  - Mimic cases where all surfaces are conducting and connected.
- Single-slot holder will have contact plates on all five faces for uniform current to sample
- Insertable current lead extending to open face



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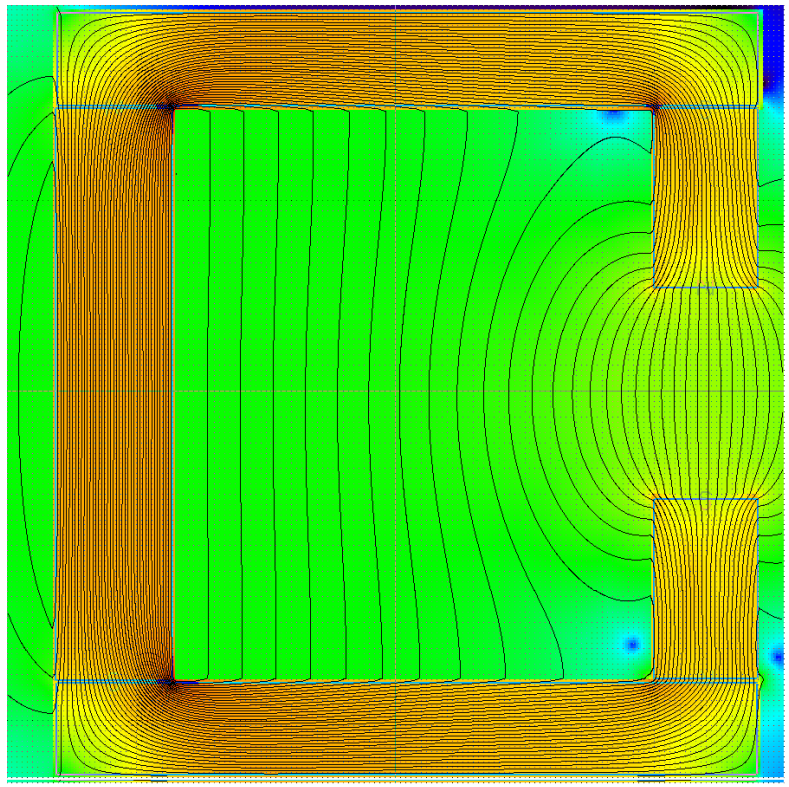
Field Generator

- Produced by an electromagnet with soft iron core
- Sample holder in gap of the iron core
- Windings on three legs (not on gap leg)
- Existing equipment allows measurements with pulsed, DC and AC fields
- Uniform field in sample gap



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Expected Results

- DEFLEX will provide useful information about the behavior of static liquid pools under the influence of an electromagnetic force. Some of the issues that could be addressed on the DEFLEX facility include:
- Motion of free surface liquids when exposed to EM forces, with current and magnetic field in multiple orientations.
- Threshold values for loss of material containment from the pool
- Effect of alternating currents and time-varying magnetic fields
- Effects of suddenly induced currents from any orientation

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Expected Results (cont)

- Validation of 3-D free-surface MHD modeling efforts
- Effect of conducting and non-conducting sample holder
- Eventual addition of an intense plasma source to simulate plasma-pool interactions.
- The DEFLEX experiments will complement some of the MHD studies to be carried out in the FLIRE facility under flowing film conditions. It could also aid in the study of retention and bubble formation under various J x B conditions

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Work Plan and Timeline

Task	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9	M 10	M 11	M 12
Detailed System Design												
Component Acquisition												
Construction and Testing												
Integration with FLIRE												
Constant EM field measurements												
Material containment threshold measurement												
AC EM field Measurements												
Pulsed EM field measurements												
Collaboration with MHD modeling efforts												
Plasma gun tests (budget permitting)												

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Budget

Vacuum Chamber and Flanges	$ 10,000
Electromagnet	3,000
Holder and Leads	2,000
Graduate Student (1 year)	19,000
Tuition and Fees	5,000
Materials and Supplies	3,000
Travel	2,000
Indirect Costs	15,000
Total Costs	**$ 59,000**

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