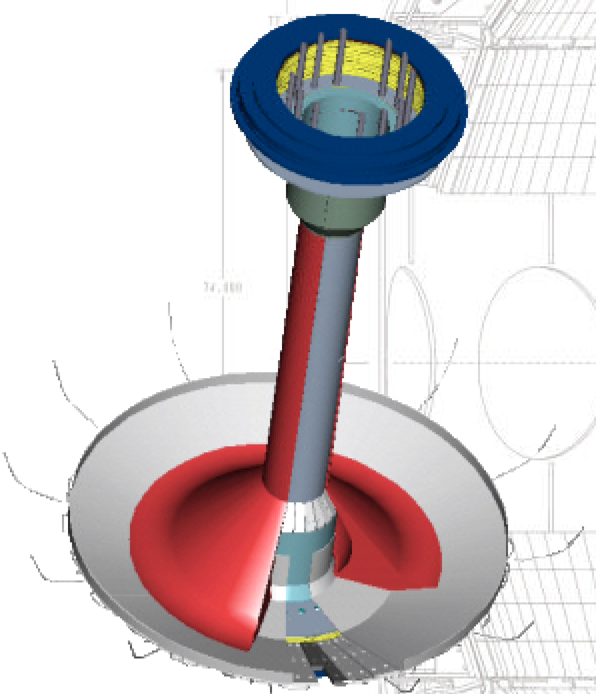
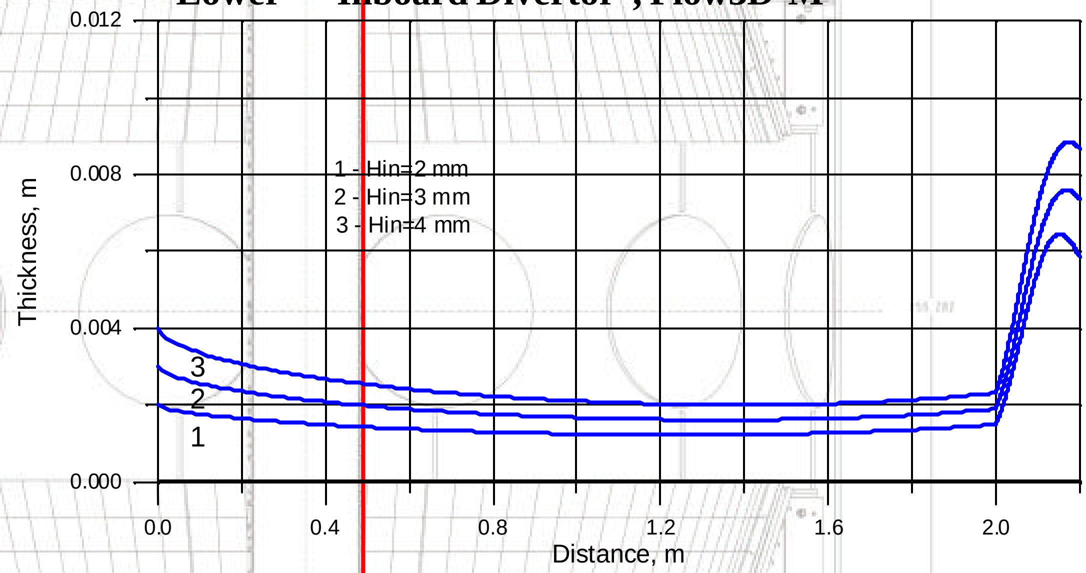
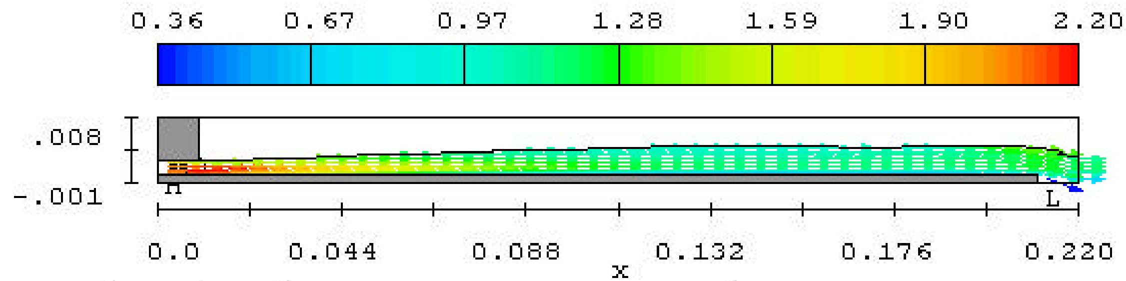
Simulations of Flowing Lithium in NSTX



Upper - “Center Stack +Inboard Divertor”, 2.5-D model; Lower – “Inboard Divertor”, Flow3D-M

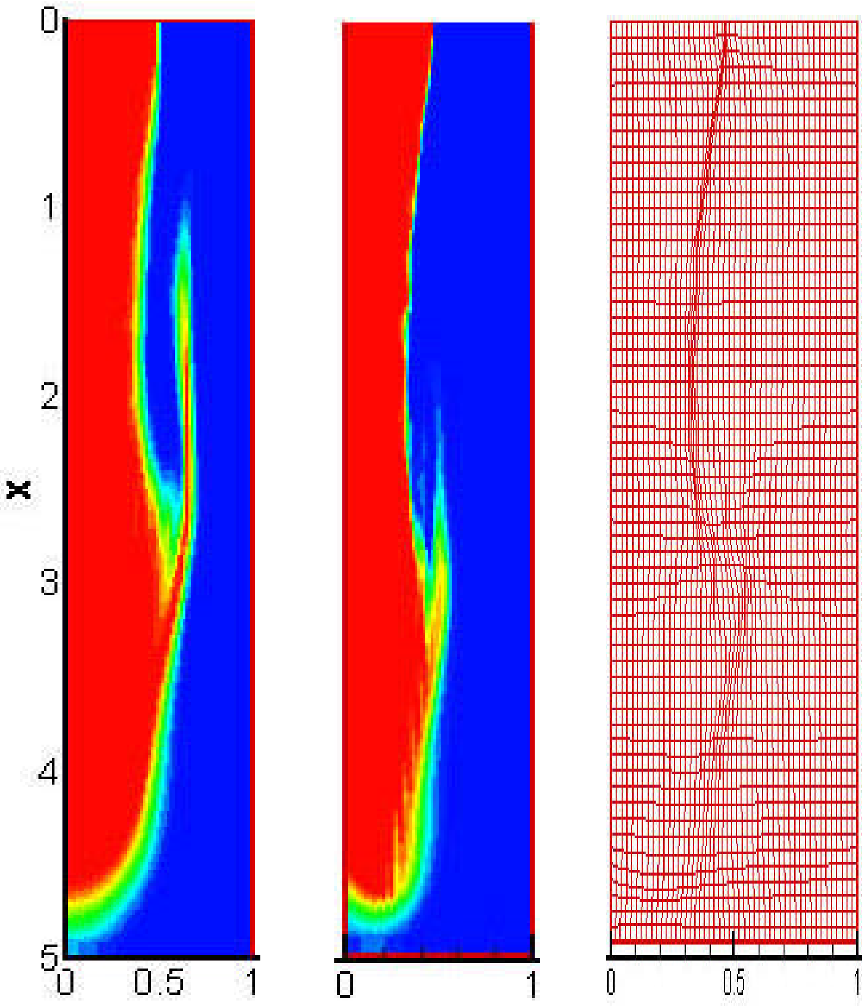




MHD and Heat Transfer Conclusions:

- **Stable Li film flow can be established over the Center Stack;**
- **The Center Stack projected heat load can be removed by a 4 mm film ejected at 2 m/s.**

State-of-the-Art Computational Techniques are Required for Intensive LW Simulation



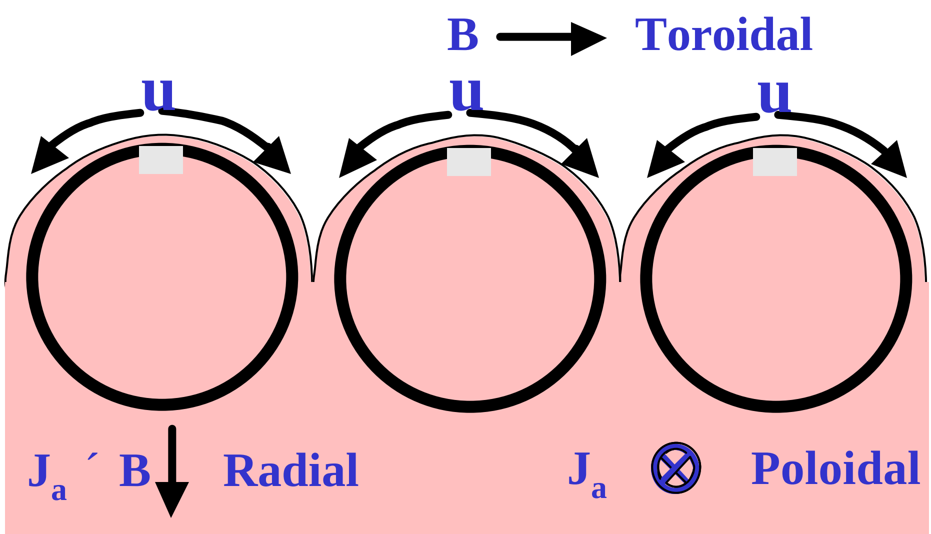
- **Grid adaption or multi-resolution**
- **Parallel Algorithm Implementation**
- **Unstructured Meshes**
- **High-order advection and free surface tracking algorithms**

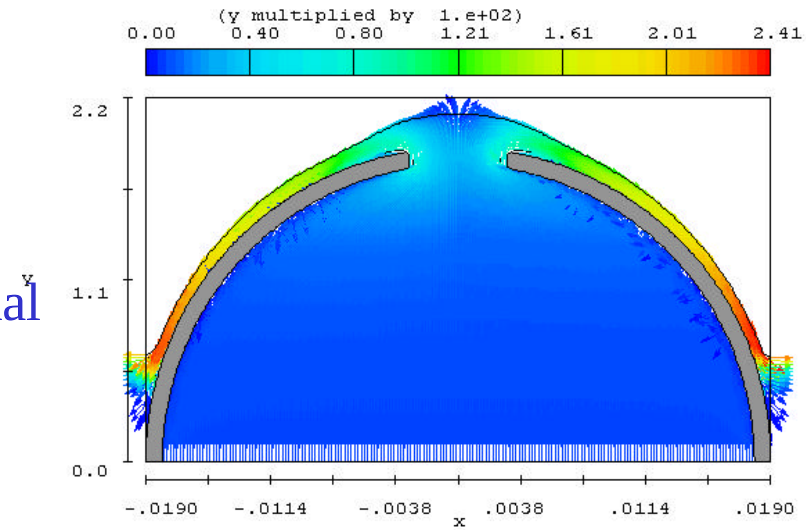
Lithium Jet start-up without and with grid adaption -
HyperComp Simulation

USING MHD FORCES TO CONTROL FLOW

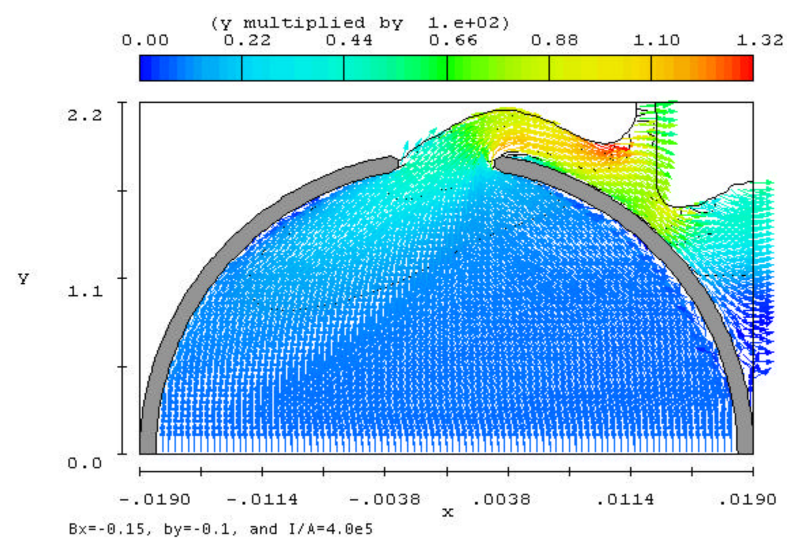
Soaker Hose Concept

- Leak liquid radially inward from supply tubes
- Stagnate inward flow and drive liquid radially over short path with applied poloidal current
- **Complex interaction with other field components seen in simulations**



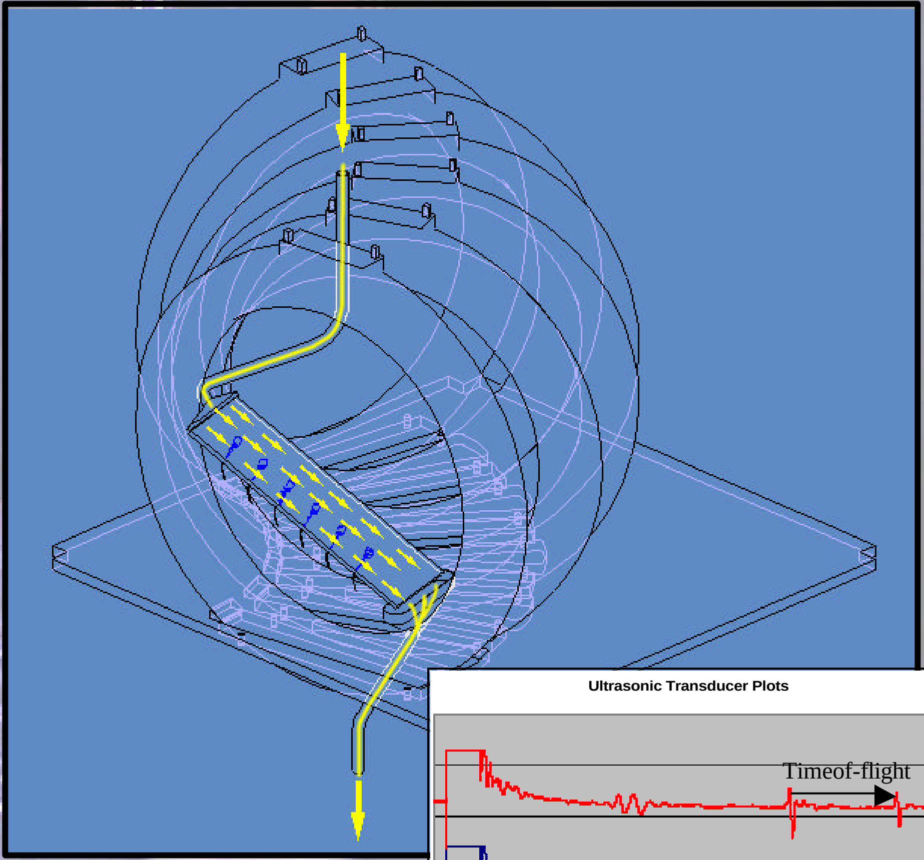


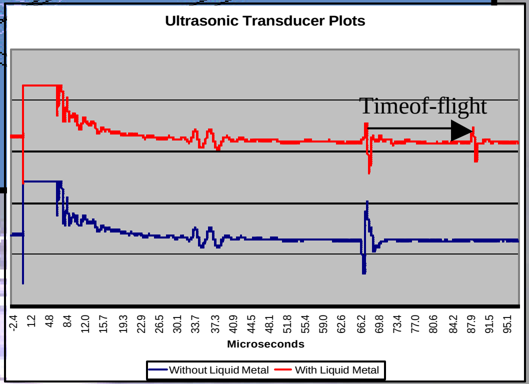
UCLA Simulation



Exploring Free Surface LM-MHD in MTOR Experiment

- **Study toroidal field and gradient effects:** Free surface flows are very sensitive to drag from toroidal field 1/R gradient, and surface-normal fields
- **3-component field effects on drag and stability**: Complex stability issues arise with field gradients, 3-component magnetic fields, and applied electric currents
- **Effect of applied electric currents**: Magnetic Propulsion and other active electromagnetic restraint and pumping ideas
- **Geometric Effects**: axisymmetry, expanding / contacting flow areas, inverted flows, penetrations
- **NSTX Environment simulation:** module testing and design



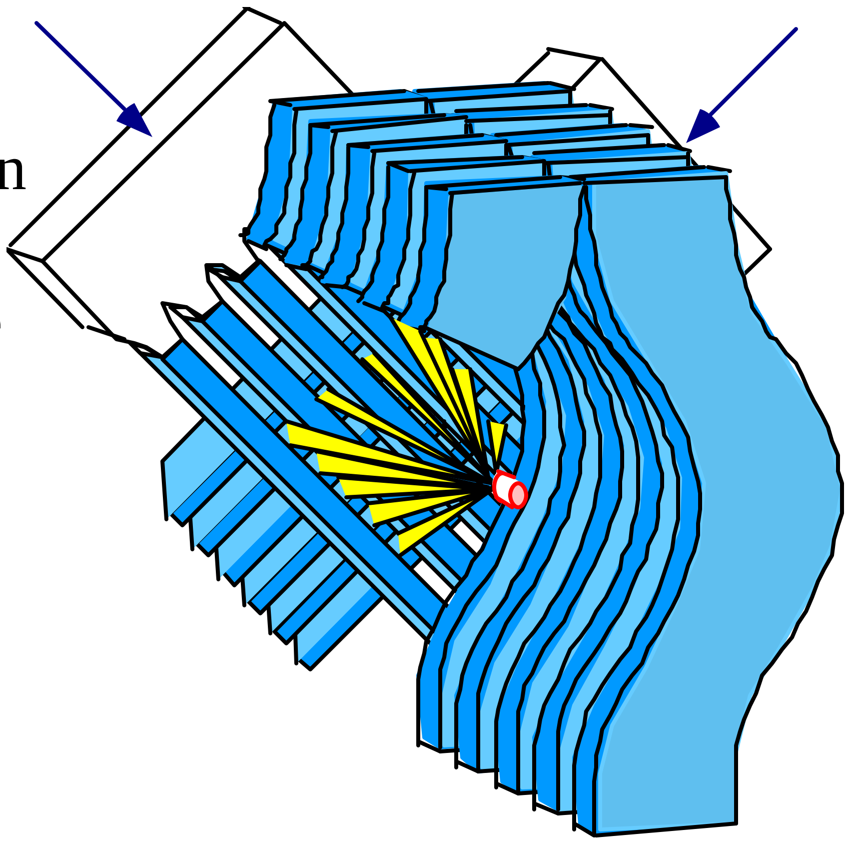


MTOR Magnetic Torus and LM Flowloop: Designed in collaboration between UCLA, PPPL and ORNL

Liquid Jet Research for IFE Chambers

High-velocity, oscillating <u>jets for liquid "pocket"</u>

•flow trajectory and jet deformation
•primary breakup / droplet formation
•dissembly processes
•liquid debris interaction / clearance
•partial head recovery



High-velocity, low surface-ripple <u>jets for liquid "grid"</u>

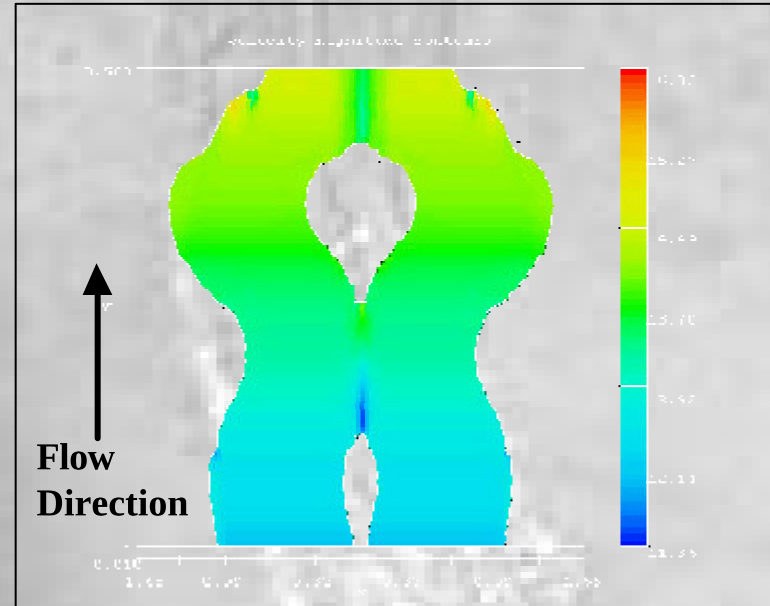
•surface smoothness control
•pointing accuracy / vibration
•primary breakup / droplet ejection

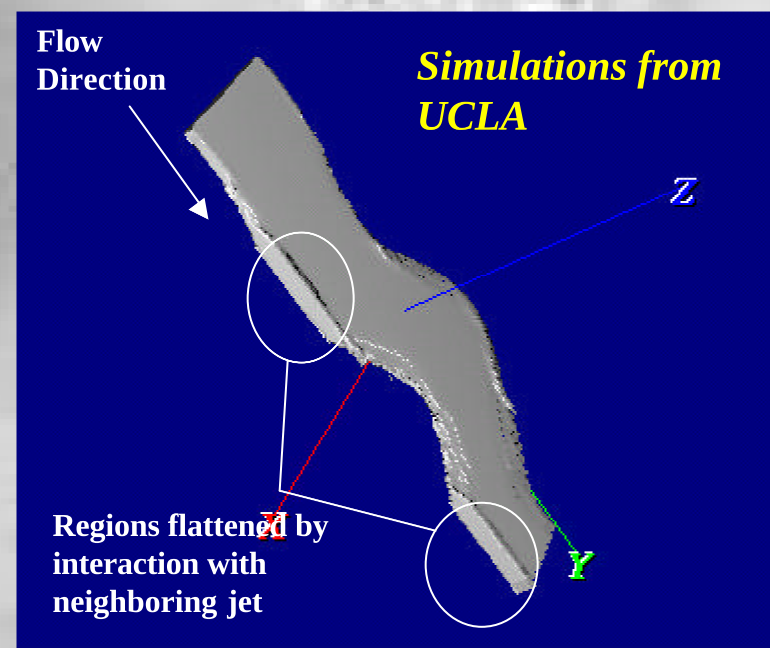
Graphics from UCB

Oscillating IFE jet experiments and simulations

•**Single jet water experiments and numerical simulations demonstrate control of jet trajectory and liquid pocket formation at near prototypic Re**

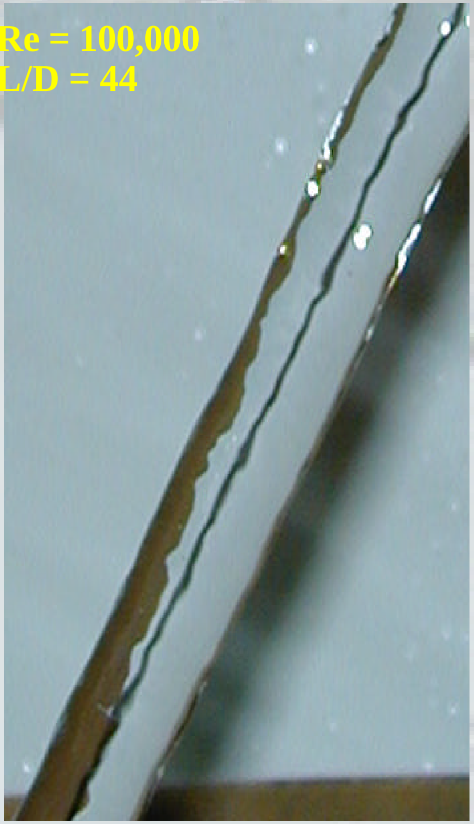
Experimental Data from UCB





Understanding mechanisms of flow instability leads to improved control of jet surface smoothness for IFE

- Upstream turbulence and nozzle boundary layer thickness heavily influence downstream jet stability
- Turbulence conditioning and boundary layer trimming in nozzle dramatically improves jet quality



w/ conditioning

w/o conditioning

UC Berkeley data

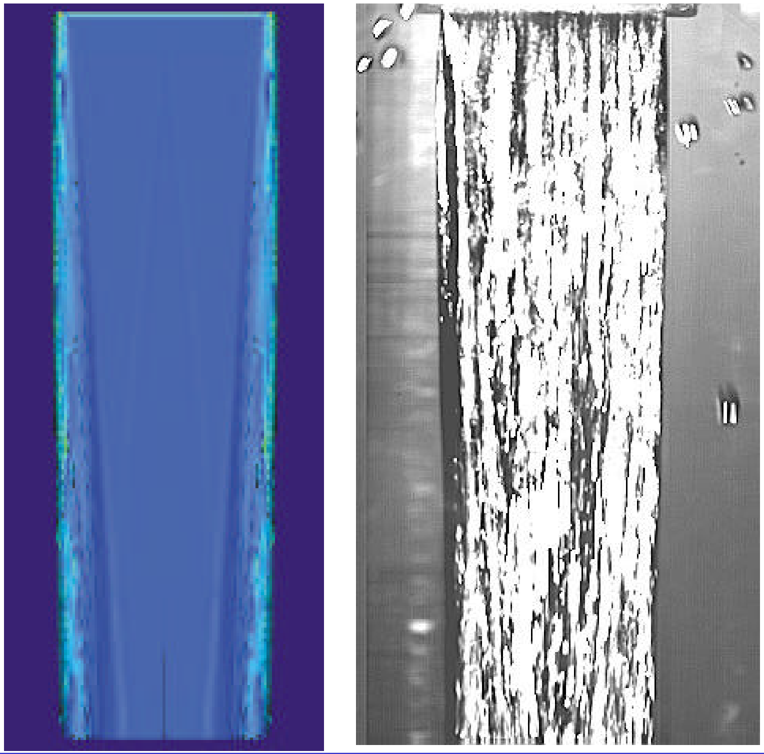
Modeling of Stationary Jet Deformation

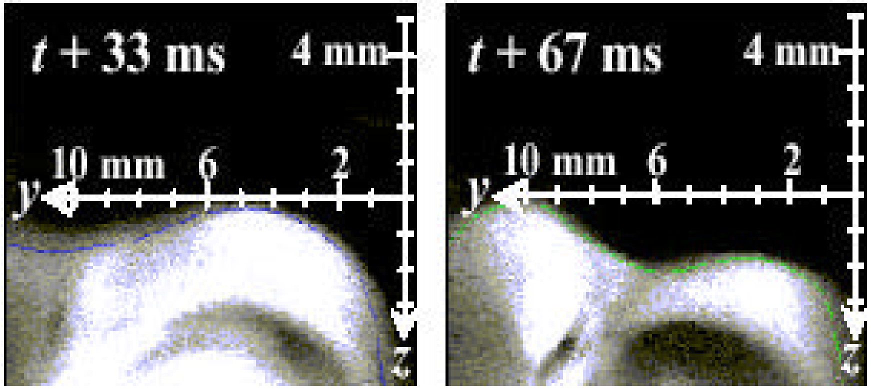
•Initially rectangular jets deform due to **surface tension** and **corner pressurization** in nozzle

•Capillary waves from corner regions fan across jet face - **largest source of surface roughness!**

•Numerical simulations and quantitative surface topology measurements are critical tools for **understanding jet deformation,** and **controlling jet behavior** with nozzle shaping

Modeling **UCLA** **Experiment**



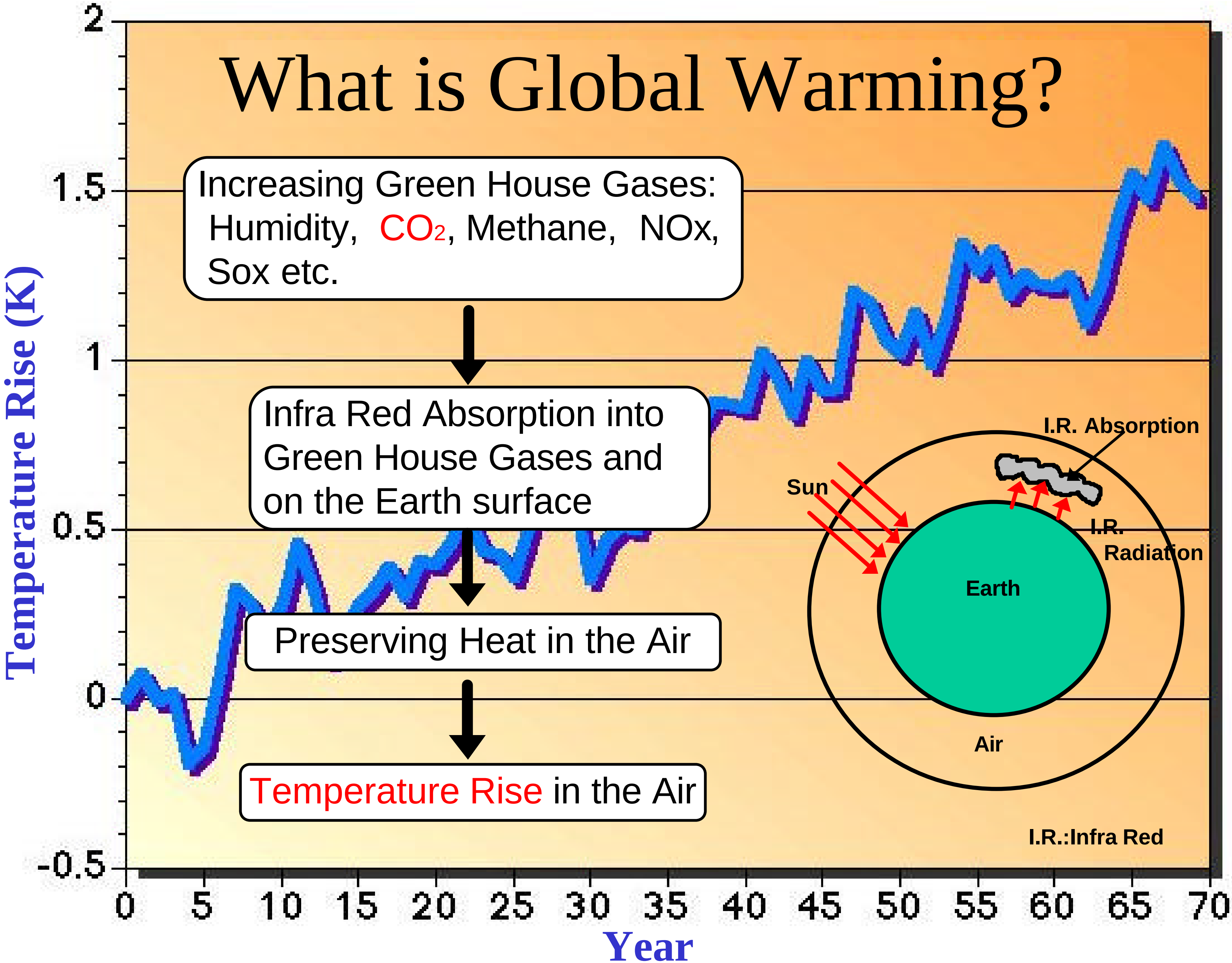


LIF measurement of surface topology at Georgia Tech

Liquid Wall Science is important in many scientific pursuits and applications

- **Liquid Jet and Film Stability and Dynamics:** fuel injection, combustion processes, water jet cutting, ink jet printers, continuous rod/sheet/ribbon/sphere casting, flood/jet soldering, ocean waves, hull design, ocean/river hydraulic engineering, surfing, liquid walls for fusion reactors
- **Liquid MHD / free surface interactions:** melt/mold stirring and heating, liquid jet/flow control and shaping, crystal growth, astrophysical phenomena, liquid metal walls for particle accelerators and fusion reactors
- **Liquid MHD / turbulence interactions:** microstructure control in casting, boundary layer control, astrophysical dynamos and plasmas, liquid walls for particle accelerators and fusion reactors
- **Free surface heat and mass transfer:** oceanography, meteorology, global climate change, wetted-wall absorbers/chemical reactor, condensers, vertical tube evaporator, film cooling of turbine blades, impurity control in casting, liquid walls for particle accelerators and fusion reactors

Watermark: Turbulent flow effect on dendrite formation in casting - Juric simulation


What is Global Warming?
Increasing Green House Gases:
Humidity, CO2, Methane, NOx,
Sox etc.
Infra Red Absorption into
Green House Gases and
on the Earth surface
Preserving Heat in the Air
Temperature Rise in the Air
I.R. Absorption
Sun
I.R.
Radiation
Earth
Air
I.R.:Infra Red
Temperature Rise (K)
2
1.5
1
0.5
0
-0.5
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Year