August 14, 2000
Opening Plenary Speaker

# Physical Sciences Research Priorities and Plans in OBPR

Dr. Eugene Trinh
NASA Headquarters
Director for Microgravity Research Division

# Sixth Microgravity Fluid Physics and Transport Phenomena Conference

## Microgravity Fluid Physics and Engineering: Fundamental and Applied Research

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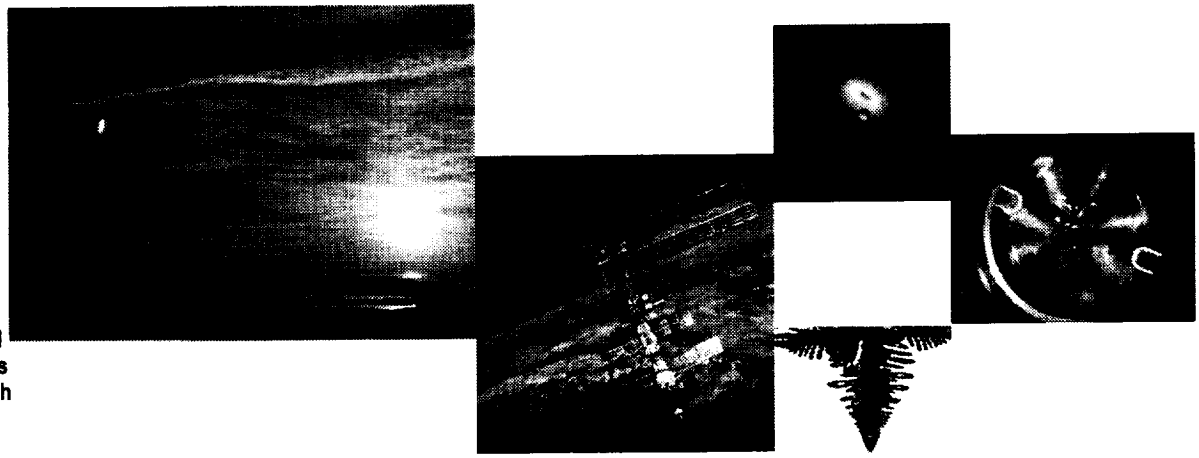

E. Trinh
Physical Sciences Research Division
OBPR / NASA

# Beneficial Characteristics of the Space Environment

- Long-term and significantly reduced gravitational acceleration (i.e. Extended Microgravity)
- Clear window to outer space
- Ultra-high vacuum
- Quiescent noise-free environment
- Human presence and creative interaction on some platforms
- Next frontier and NASA's domain to explore

**OBPR**

**Physical Sciences Research Division**

*Opportunity for unique and exciting research:*

- *Directly participate in developing the enabling technologies for space exploration*
- *Exploit the unique experimental environment of space to unravel outstanding fundamental scientific mysteries*

# Windows of Opportunity for Research Derived from Microgravity

$10^{-2}$ to $10^{-6}$ g

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**Convection-free Hydrostatic Pressure-free**

- Quantum fluid properties
- ***Classical fluids & transport processes***
- ***Fluid-phase thermophysical properties***
- Diffusion-controlled processes
- ***Surface/Interfacial phenomena***
- Thermally-driven chemical reactions
- Materials synthesis & processing
- ***Morphological stability/pattern formation***
- ***Bio-fluids statics and dynamics***
- ***Multi-phase systems engineering***
- Physiological systems analysis
- Large scale systems modeling
- Gas-grain systems dynamics

**Sedimentation-free**

- Bose-Einstein condensates
- Critical phenomena/Phase transitions
- Supercritical fluids properties
- ***Multi-phase fluids physics***
- ***Colloid dynamics***
- ***Self-assembly/Meso-scale structures***
- Multi-component materials processing
- Cellular assembling mechanisms
- Bio-organisms interaction
- 3-D Tissue engineering
- ***Container-free experimentation***
- ***Spray and dust clouds dynamics***

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# Physical Sciences Research Program

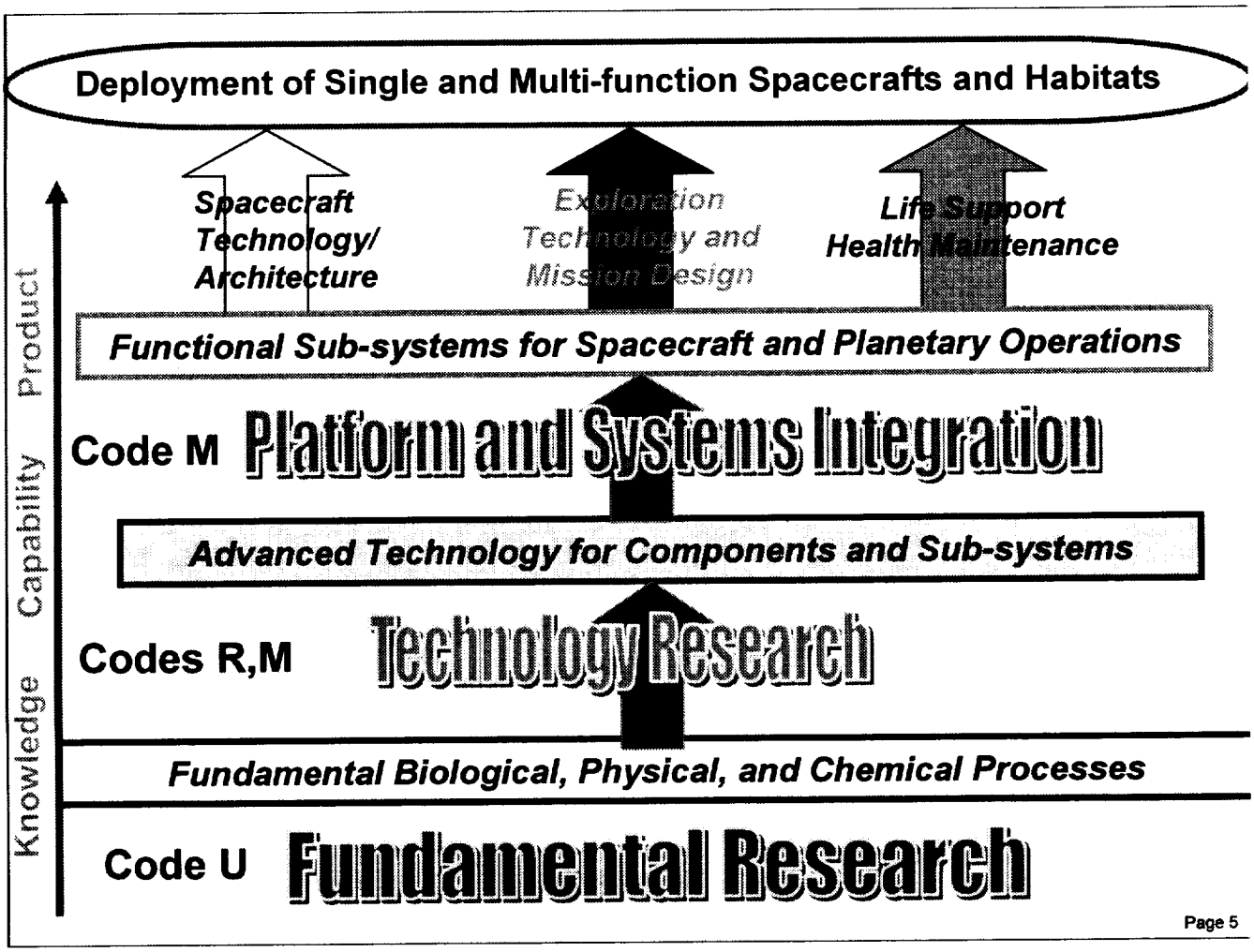
*Slide presented at the:*
*Fifth Microgravity Fluid Physics and Transport Phenomena Conference*
*Cleveland, Ohio, August 9-11, 2000*

Fluid Physics Program Dual Thrust:

- Peer-reviewed research based on scientific value and exploiting the advantages of the microgravity environment
- Peer-reviewed research based on engineering applications and relevant to human and robotic space exploration endeavor

*The second component will be strengthened with a rigorous research program coordinated with other NASA enterprises*

***We really mean it now!***


Deployment of Single and Multi-function Spacecrafts and Habitats
Spacecraft Technology/ Architecture
Exploration Technology and Mission Design
Life Support Health Maintenance
Functional Sub-systems for Spacecraft and Planetary Operations
Code M
Platform and Systems Integration
Advanced Technology for Components and Sub-systems
Codes R,M
Technology Research
Fundamental Biological, Physical, and Chemical Processes
Code U
Fundamental Research
Knowledge
Capability
Product
Page 5

# Fundamental Research: Space-based Results and Ground-based Applications

- Surface-tension controlled drop equilibrium shapes and dynamics: Use of the unique microgravity environment to obtain benchmark data.
- The development and implementation of microgravity investigations has allowed ground-based applications to gather complementary information on the effects of external forces and initial shape deformation on gyrostatic equilibrium shape and nonlinear oscillation characteristics.

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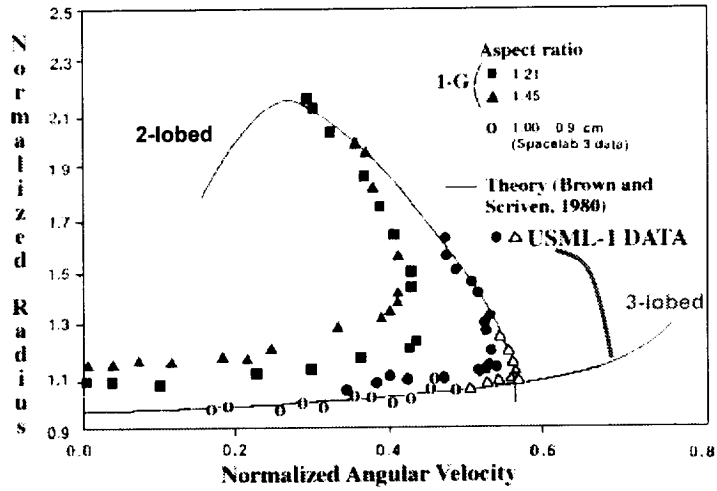
- Theory validated for first stability limit
- No higher order bifurcation detected
- Effects of initial drop distortion measured
- Exact bifurcation velocity measured




[Wang et al., J. Fluid Mech. 308,1 (1996)]

# Fundamental Research: Space-based Results and Ground-based Applications

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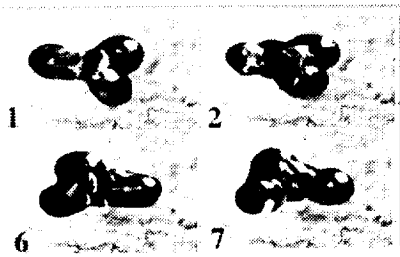
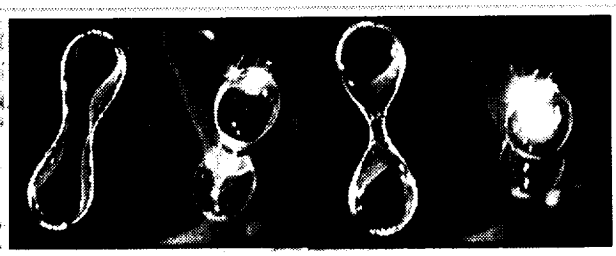
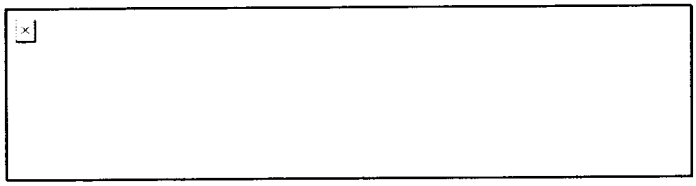



**Ground-based 3-lobed Bifurcation**



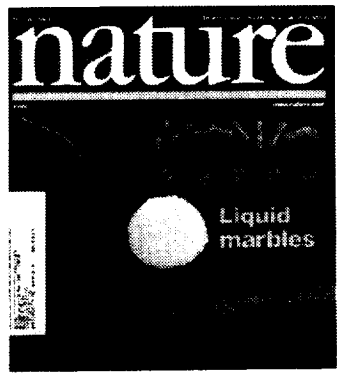
***Space-based 2-lobed Bifurcation***

"Three-lobed shape bifurcation of rotating liquid drops",
K. Ohsaka and E.H. Trinh. Phys. Rev. Lett. 84, 1700 (2000)



**Ground-based 2-lobed and toroidal shapes obtained with coated rolling drops**

("Liquid Marbles", P. Aussillous and D. Quere, Nature 411,924 (2001))



# Nonlinear Oscillations

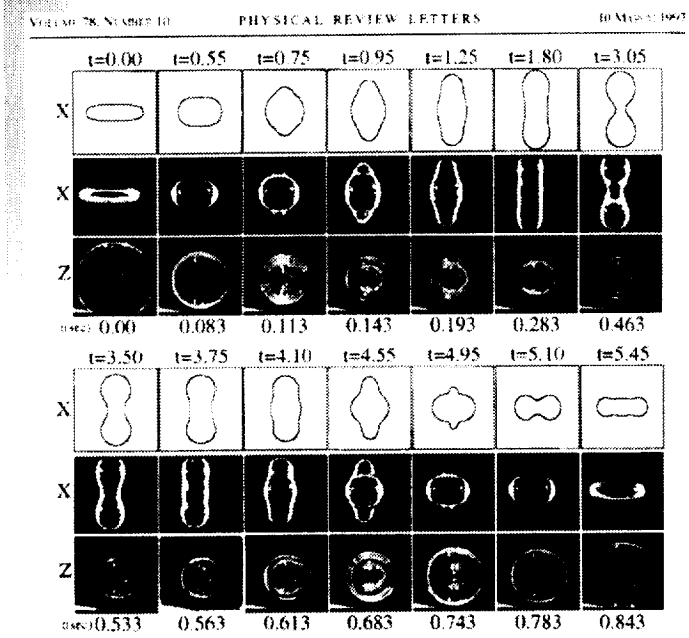
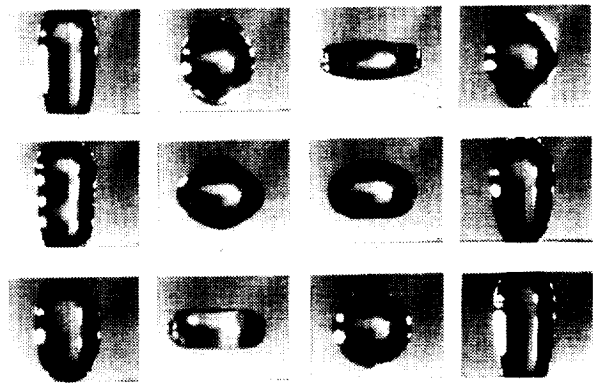



FIG. 1. Sequence of 14 frames showing single complete oscillation of a 6.6 cm³ drop that begins as a highly deformed oblate shape owing to a high intensity acoustic field, and which then oscillates after the acoustic field intensity is suddenly reduced. The top images in each row are the X (side) view, and the bottom images are the Z (top) view demonstrating the axisymmetric nature of the oscillation. The time of each frame is marked. Shown above the X view observations is a sequence of frames computed using the boundary integral method, assuming a Reynolds number of 600. The nondimensional time T shown with each frame is defined in the text. Note that the last two frames of the predictions differ from the observations, because the predictions are showing the center plane of the drop (which is dimpled in), whereas the observations are showing the front view image which cannot show the inward dimpling effect.

**Microgravity Data**



**Ground-based Data.**
**Large amplitude oscillations obtained**
**By varying excitation mechanism**

# Fundamental Research: Space-based Results and Ground-based Applications

- Application to ground-based high-temperature thermophysical properties measurement by electrostatic levitation.

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- **An advanced sample levitation device developed by NASA**
- **Process refractory materials in high vacuum (metals, alloys and semiconductors)**
- **Studies of overheated as well as deeply undercooled liquids**
- **Non-contact diagnostic techniques for various thermo-physical properties**
- **Studies of phase transformation and development of new microstructures**

QuickTime™ and a Video decompressor are needed to see this picture.

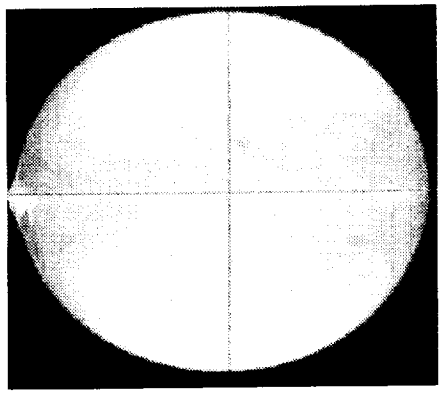
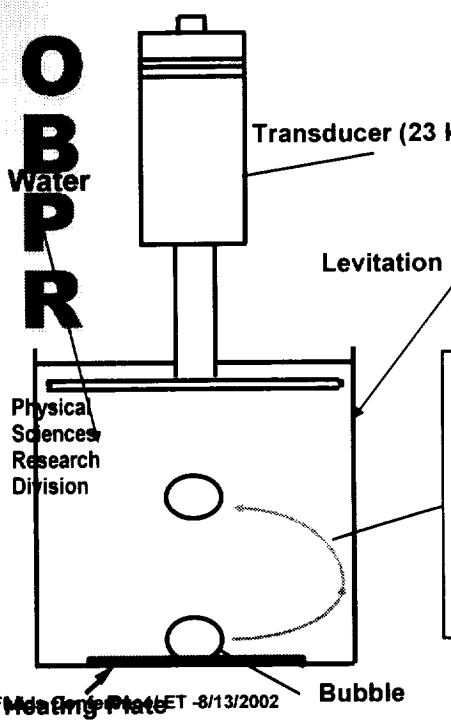


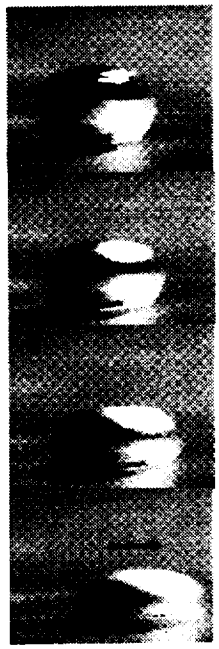
**Figure: Molten Zirconium sphere at 2300 K**

# Fundamental Research: Applications to Mission-oriented Research

## Vapor Bubble Removal from a Heated Surface




Motion of the vapor bubble as the acoustic pressure increases. The sound field detaches the bubble from the heated plate to trap it at the pressure node.



Increasing Acoustic Pressure