

Immersive Visualization in CAVE

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Collaborators

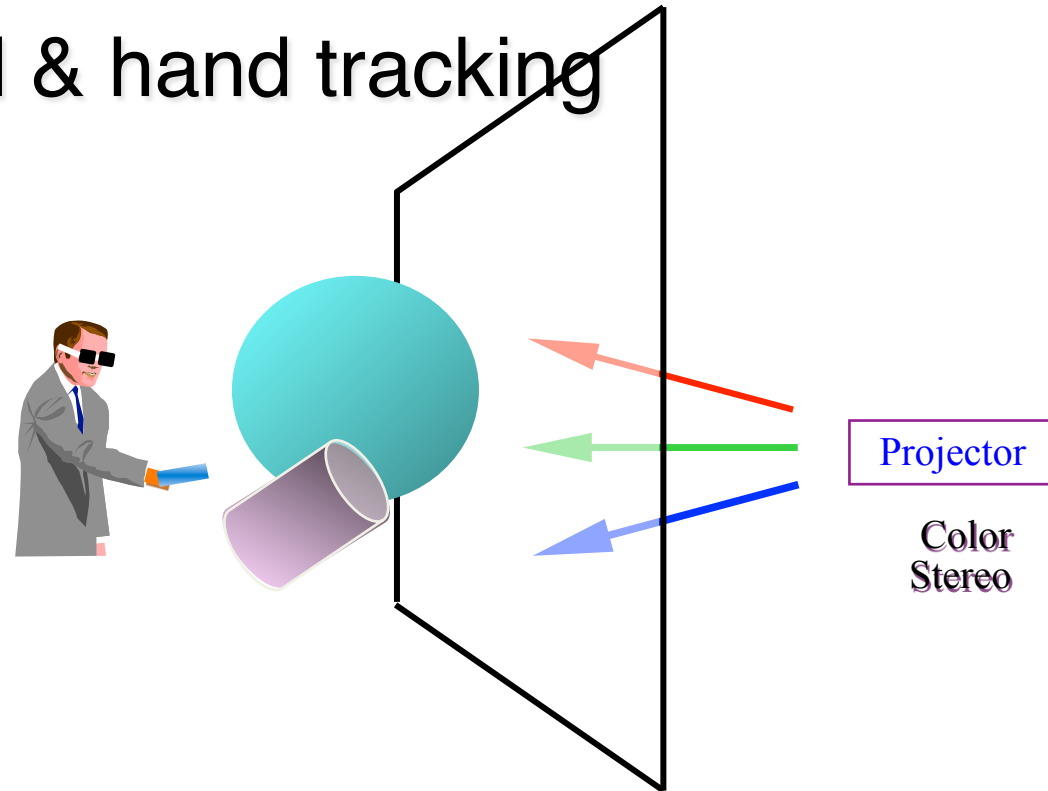
Geodymo MHD simulation	J. Li, M. M., Ochi, T. Miyagoshi, T. Sato
VR visualization of vector fields	K. Murata, K. Yoshizaki
Multiverse VR framework	Y. Yamaura, D. Meno, Y. Masada

Visualization

- Huge numerical data in N-dimension ($N > 2$)
- Needs new technology for visualization
- Ideal visualization system would enable...
 - Stereoscopic (3D) visualization,
 - Immersive visualization,
 - Interactive visualization

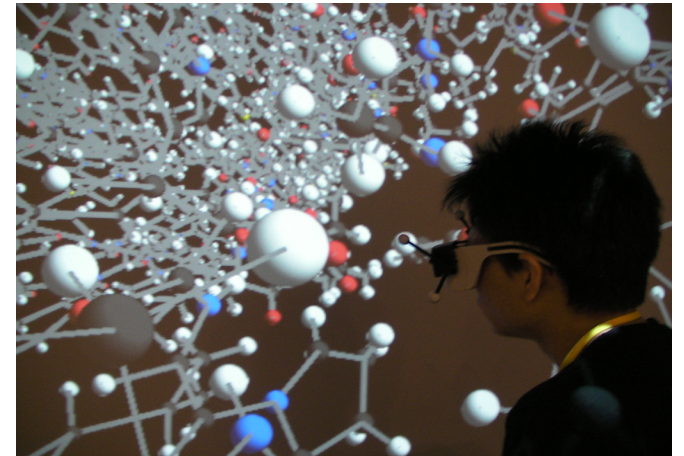
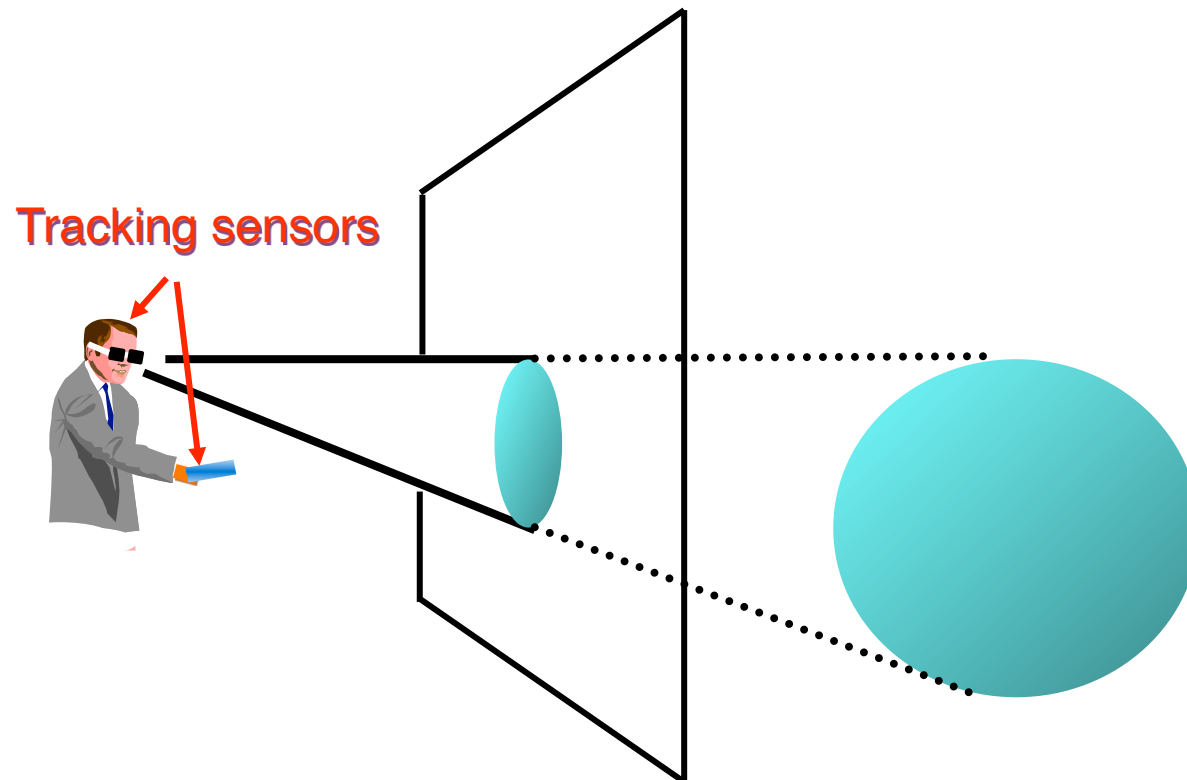
Virtual Reality (VR)

- Stereo: 3D projector
- Immersive: Large screen
- Interactive: Head & hand tracking



VR

- Position / direction sensor on 3D glasses
- Real time rendering from the view point.



Outline

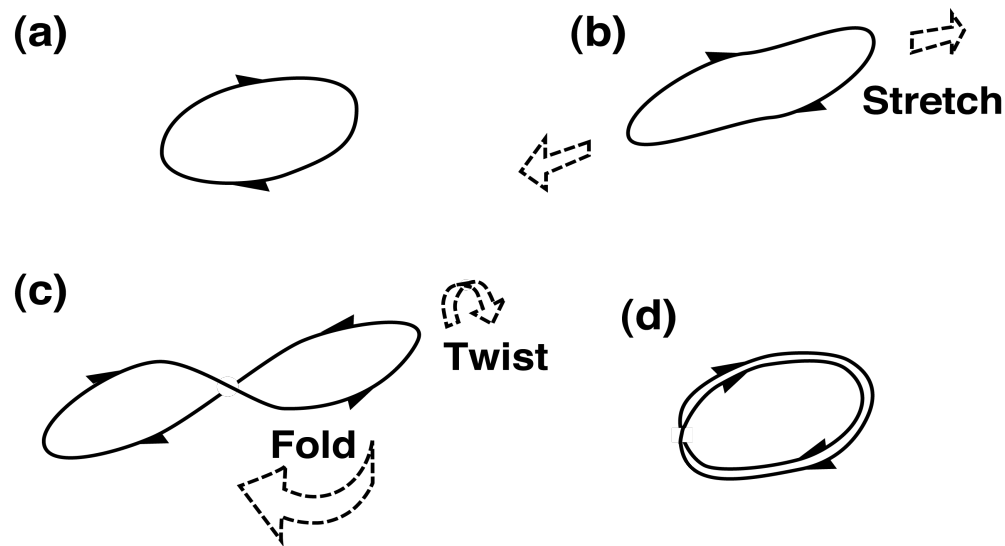
1. Visualization of frozen-in field (software)
2. New VR system at Kobe Univ. (hardware)
3. VR application framework (middleware)

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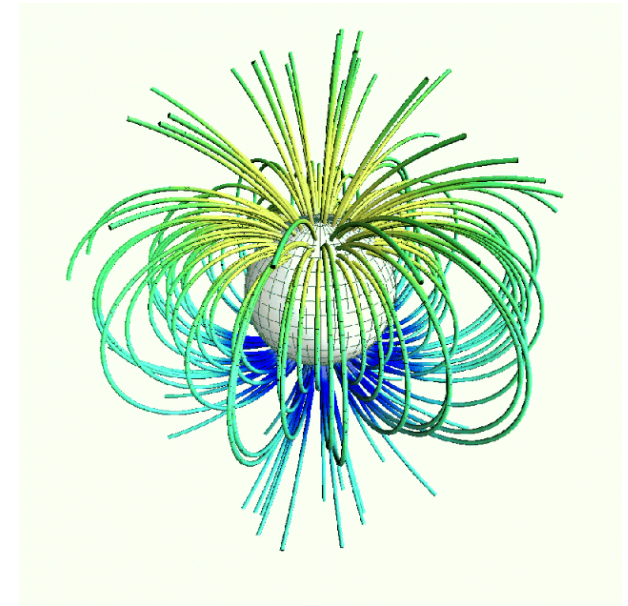
VR visualization of vector field

- Vis. of frozen-in vector fields
 - Magnetic field lines in ideal MHD
 - Vortex filament in Euler fluid

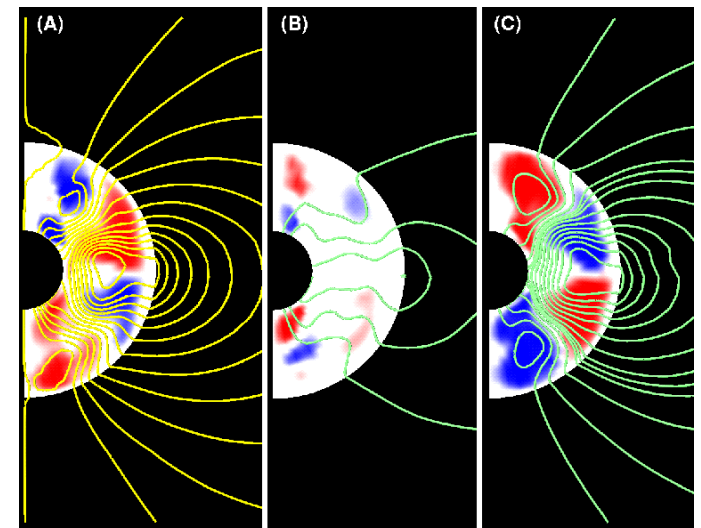


Motivation

- Geodynamo MHD simulation
- Geomagnetic field
 - Dipole
 - Reversals

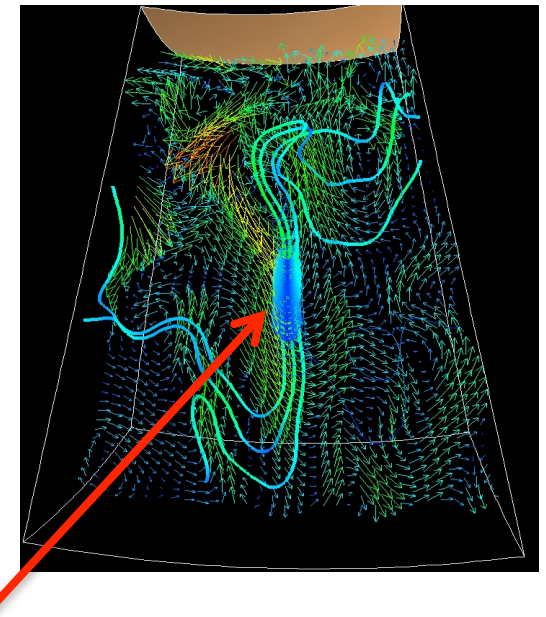
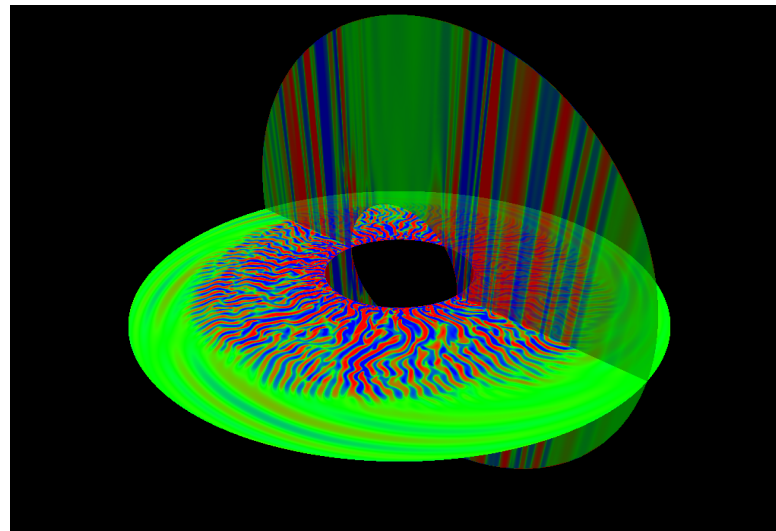
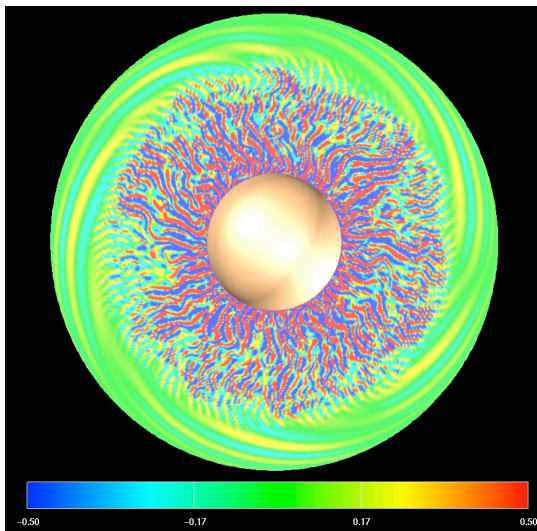


Phys. Rev. E, 1997, Kageyama & Sato
Phys. Rev. Lett., 1999, Kageyama et al.
Science, 2002, Li et al.



Motivation

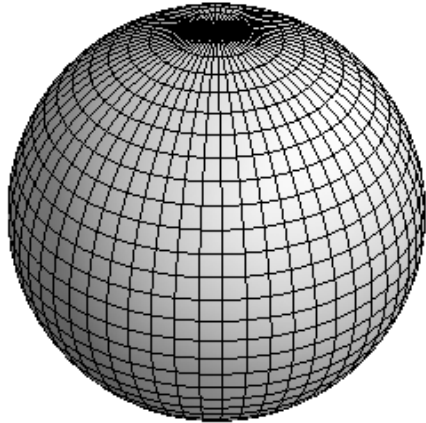
- High resolution geodynamo MHD simulation
 - 4096 cores on Earth Simulator, 8192 cores on T2K
- $Rm = O(10^3)$: Field lines are “almost” frozen-in.



Nature, 2008, Kageyama et al.
Nature, 2010, Miyagoshi, et al.
Phys. Plasmas, 2011, Miyagoshi et al.

Stretching in sheet-like plumes.

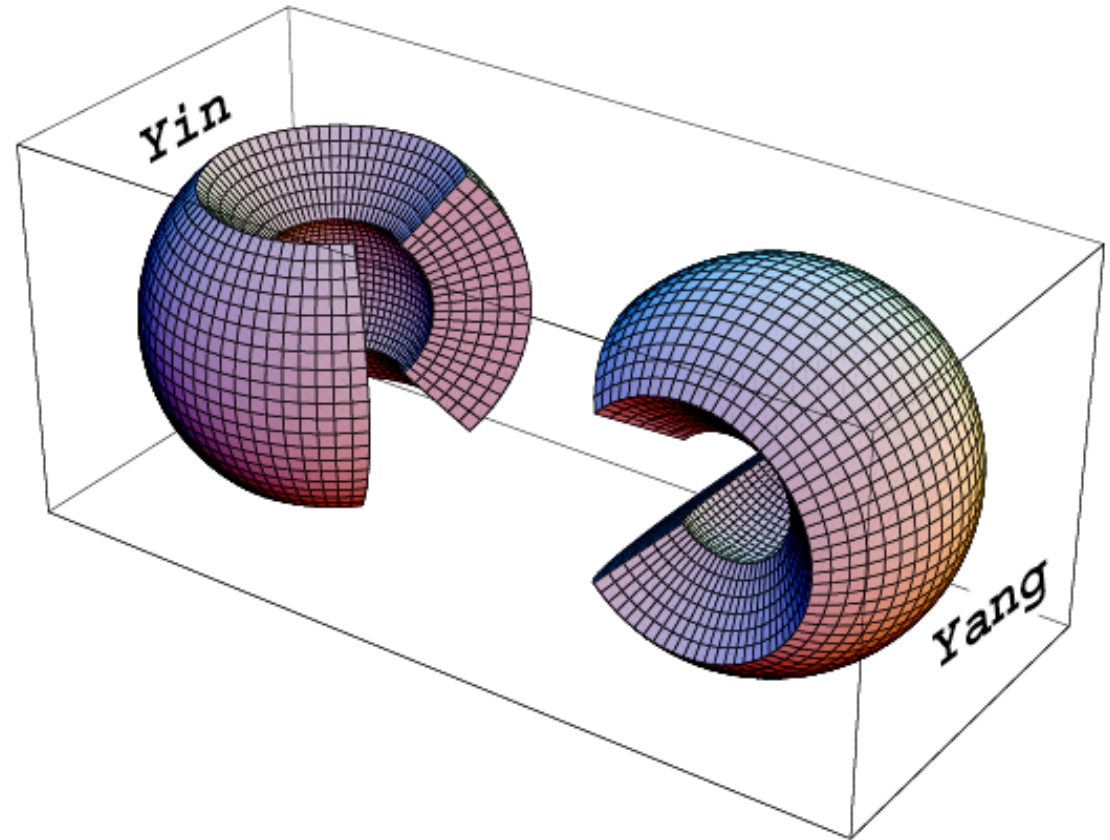
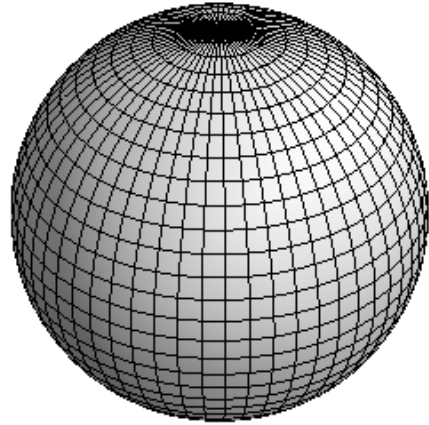
Yin-Yang grid



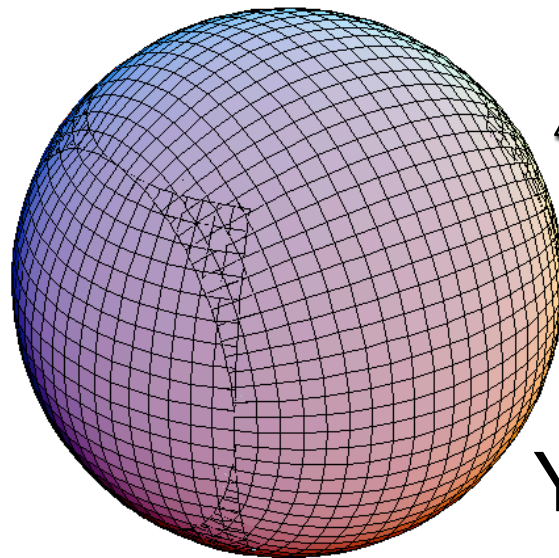
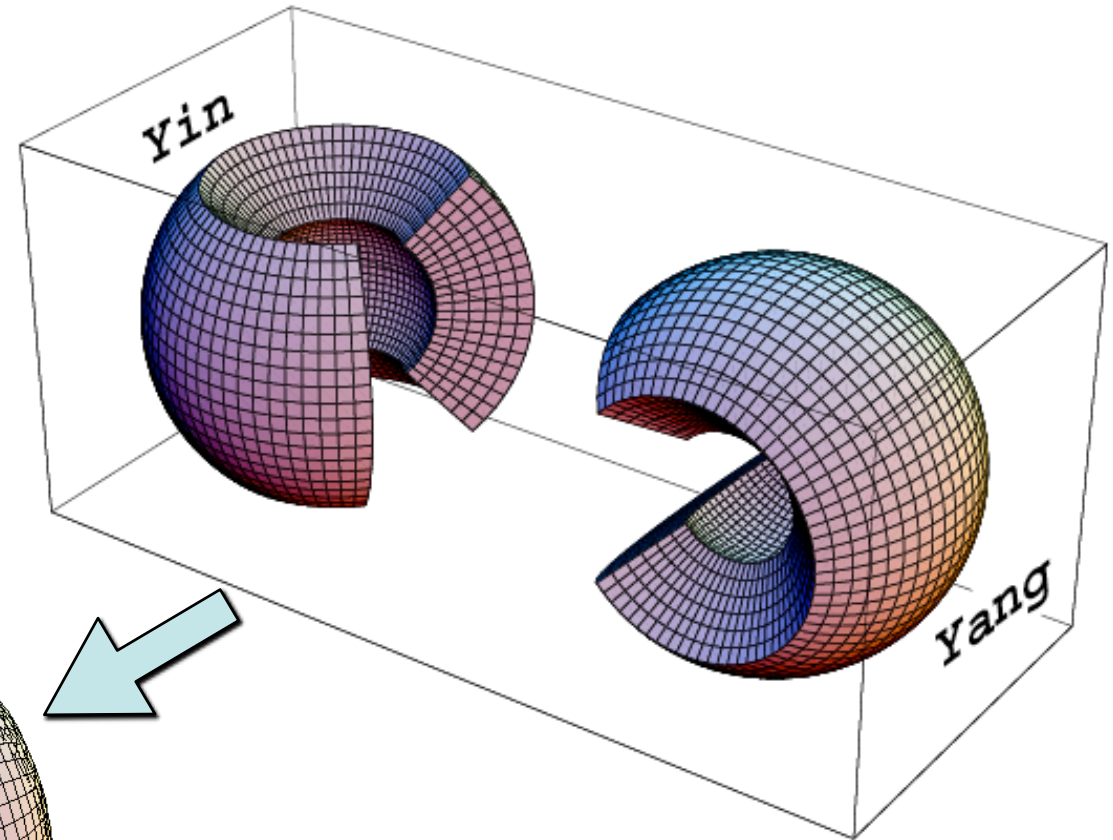
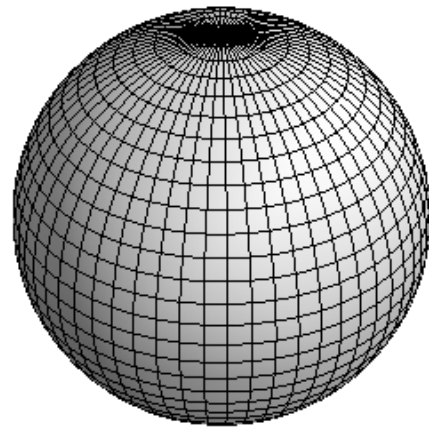
Spherical (latitude-longitude) grid

1. Coordinate singularity \rightarrow l'Hopital's theorem
2. Grid convergence \rightarrow

Yin-Yang grid

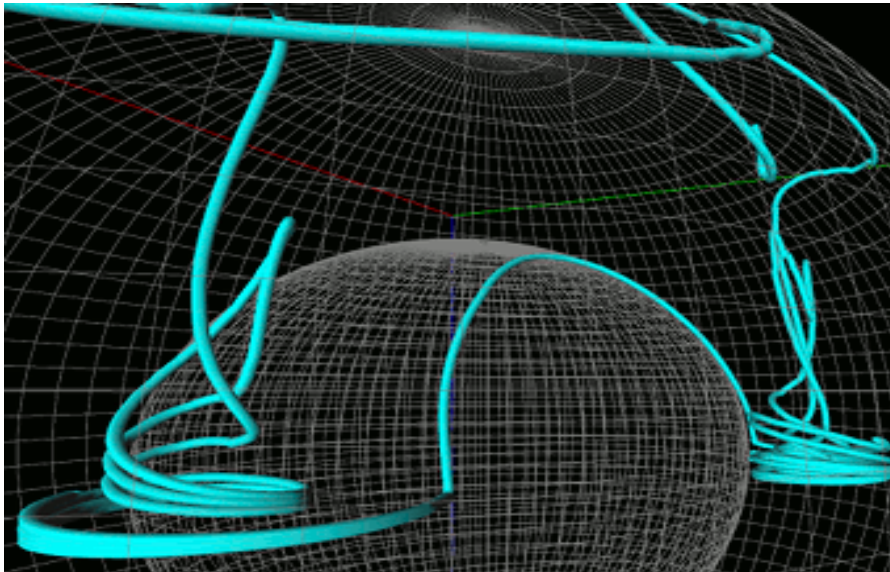
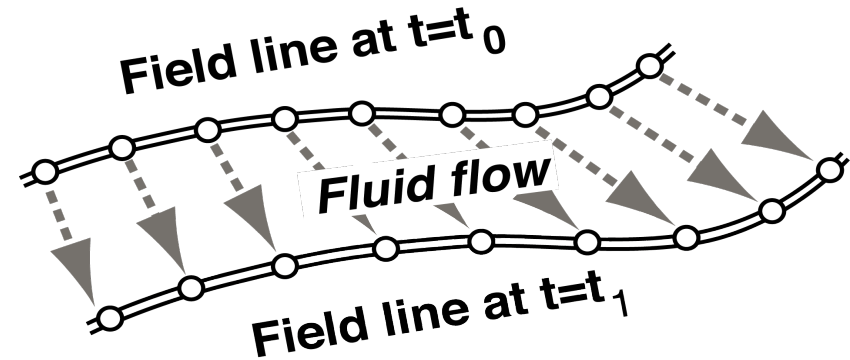
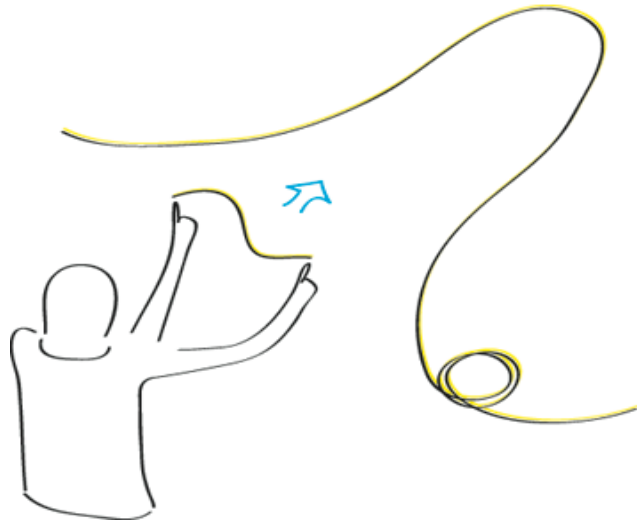


Yin-Yang grid



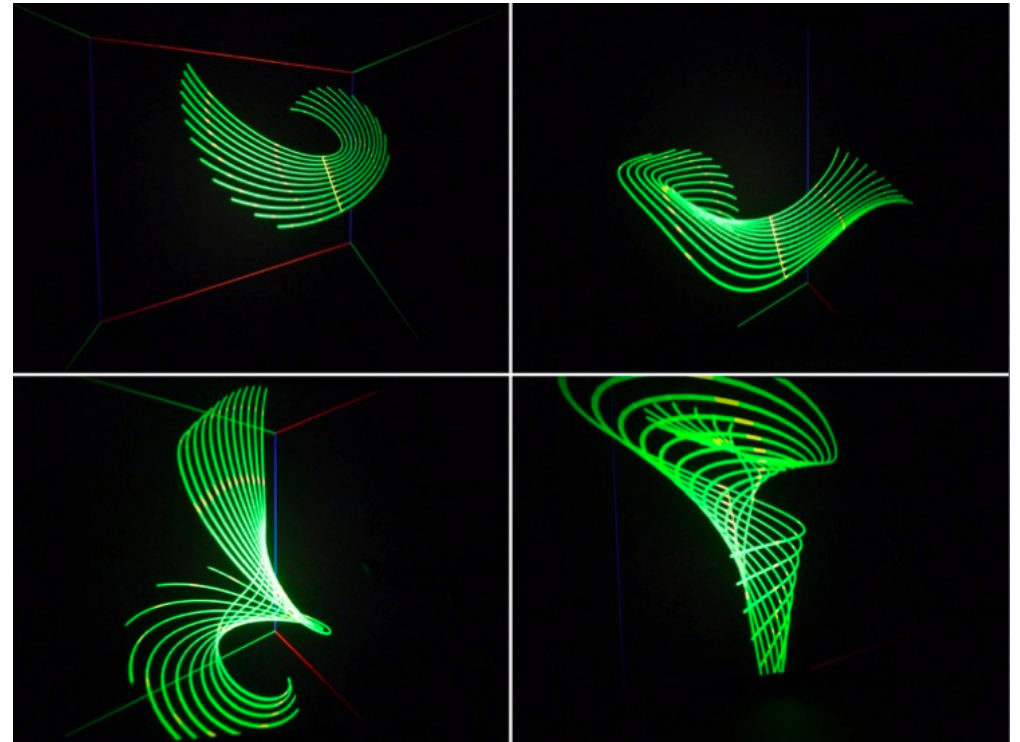
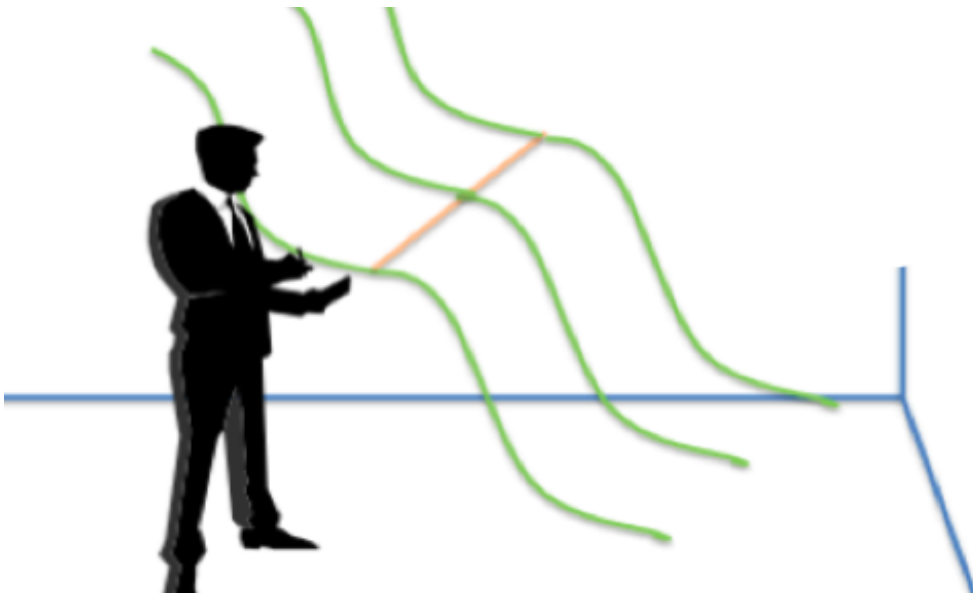
Yin-Yang grid

VR viz of frozen-in field



Another VR application to vector field visualization

Real time tracing of lines of force
Seeding points from “beam” from the hand.

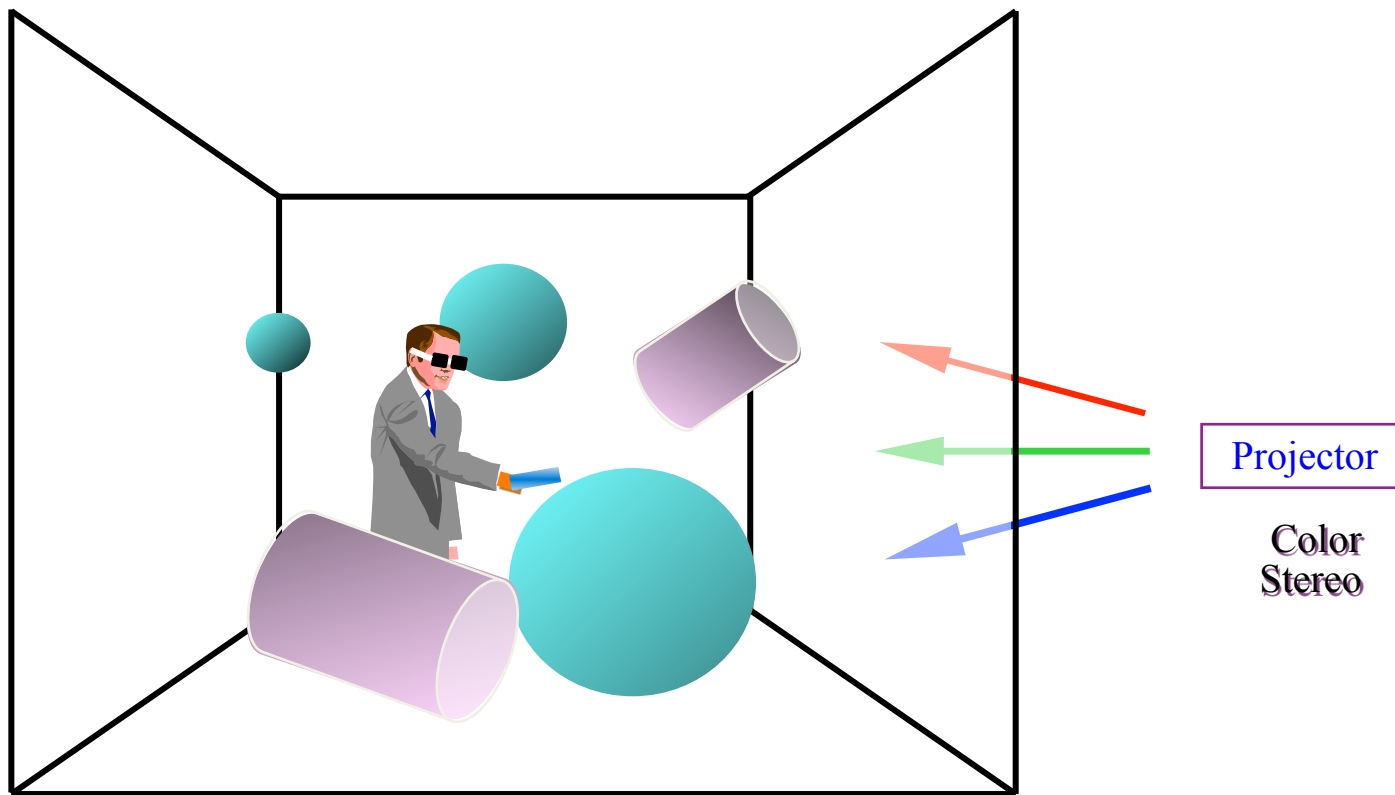


Outline

1. Visualization of frozen-in field (software)
- 2. New VR system at Kobe Univ. (hardware)**
3. VR application framework (middleware)

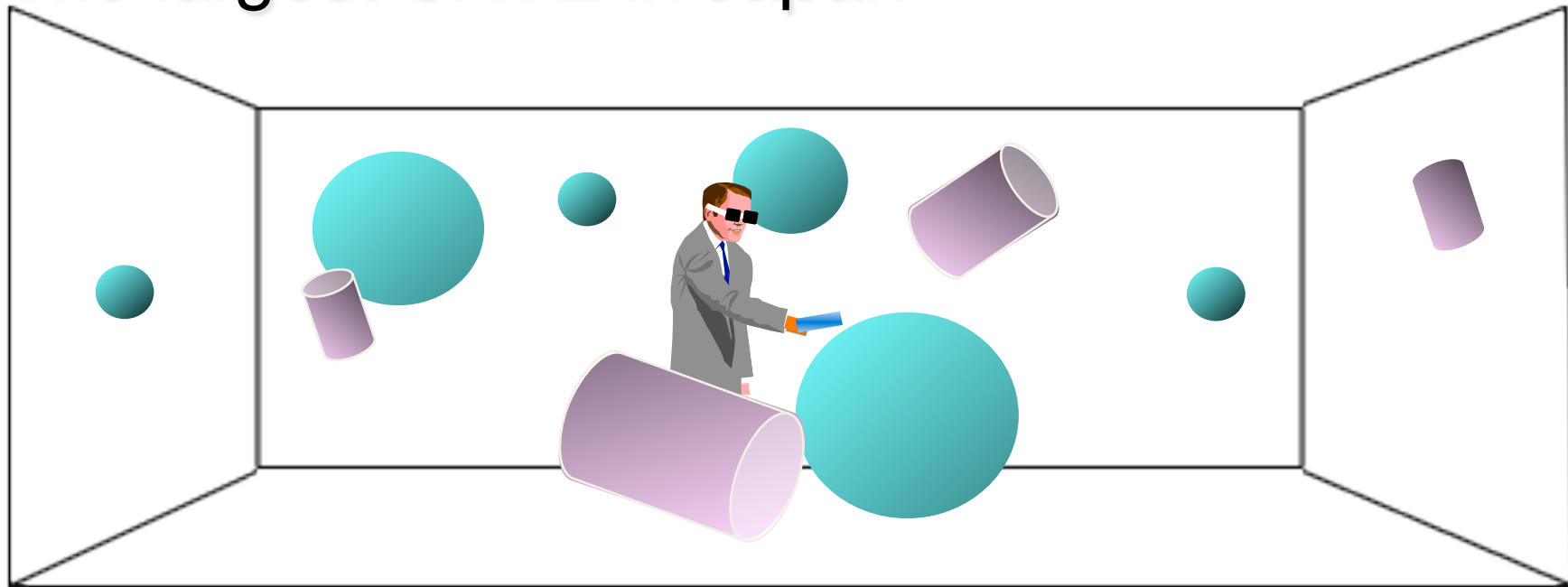
CAVE-type VR System

- Classical CAVE configuration (cube)

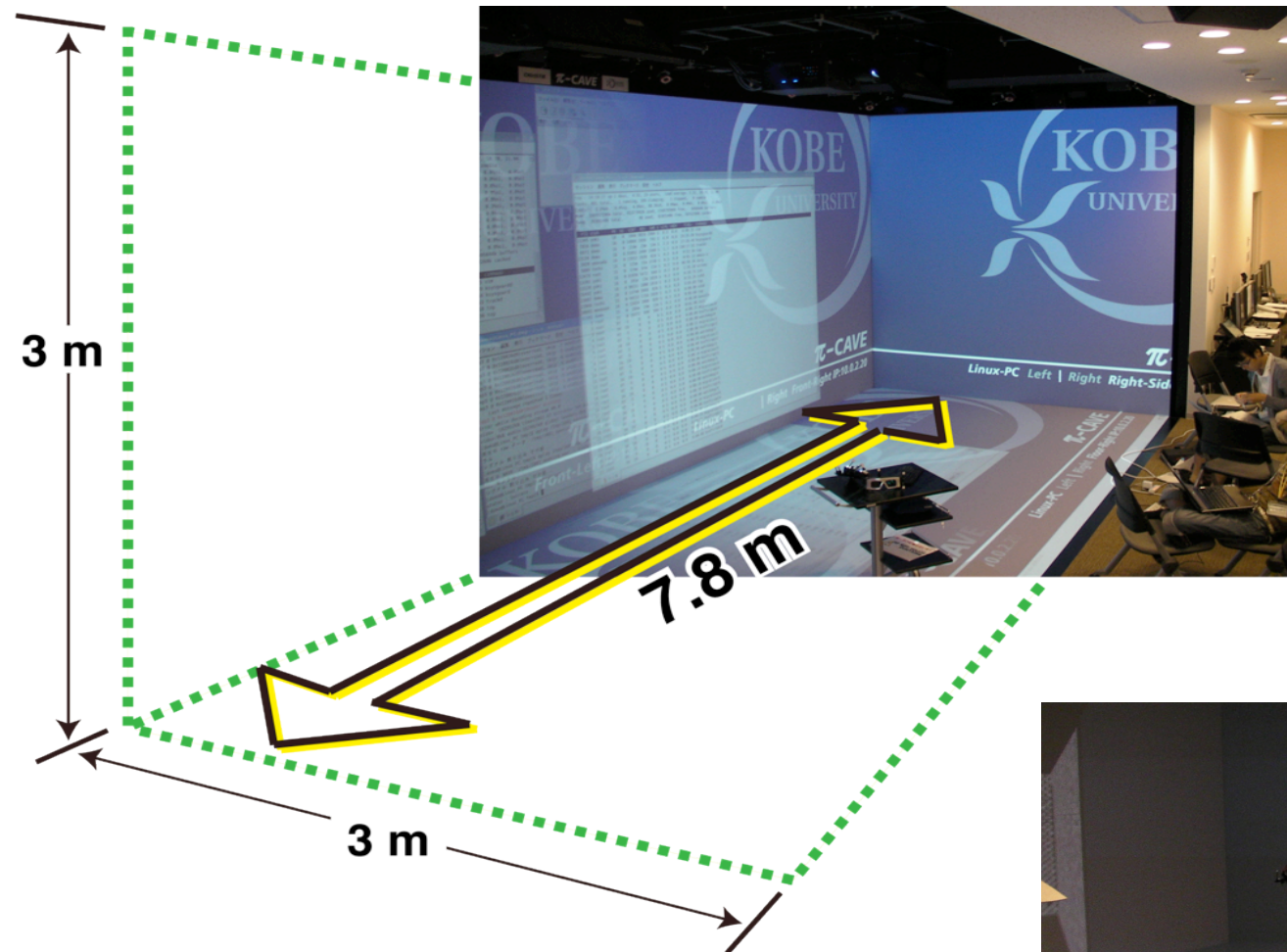


Our New CAVE System

- 4 screen system
- π -CAVE: Port Island (P. I.) CAVE
- The largest CAVE in Japan

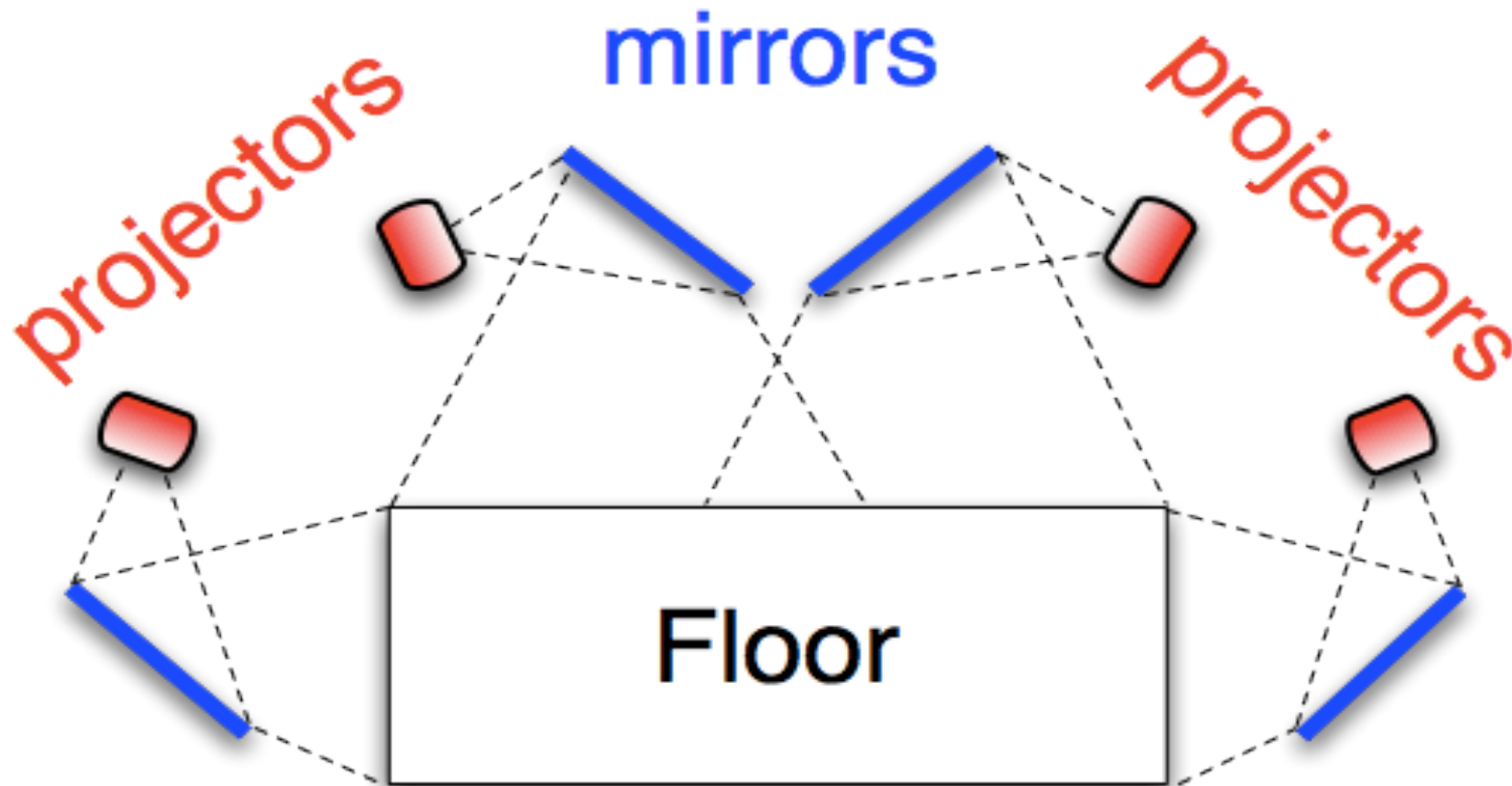


π -CAVE: Configuration



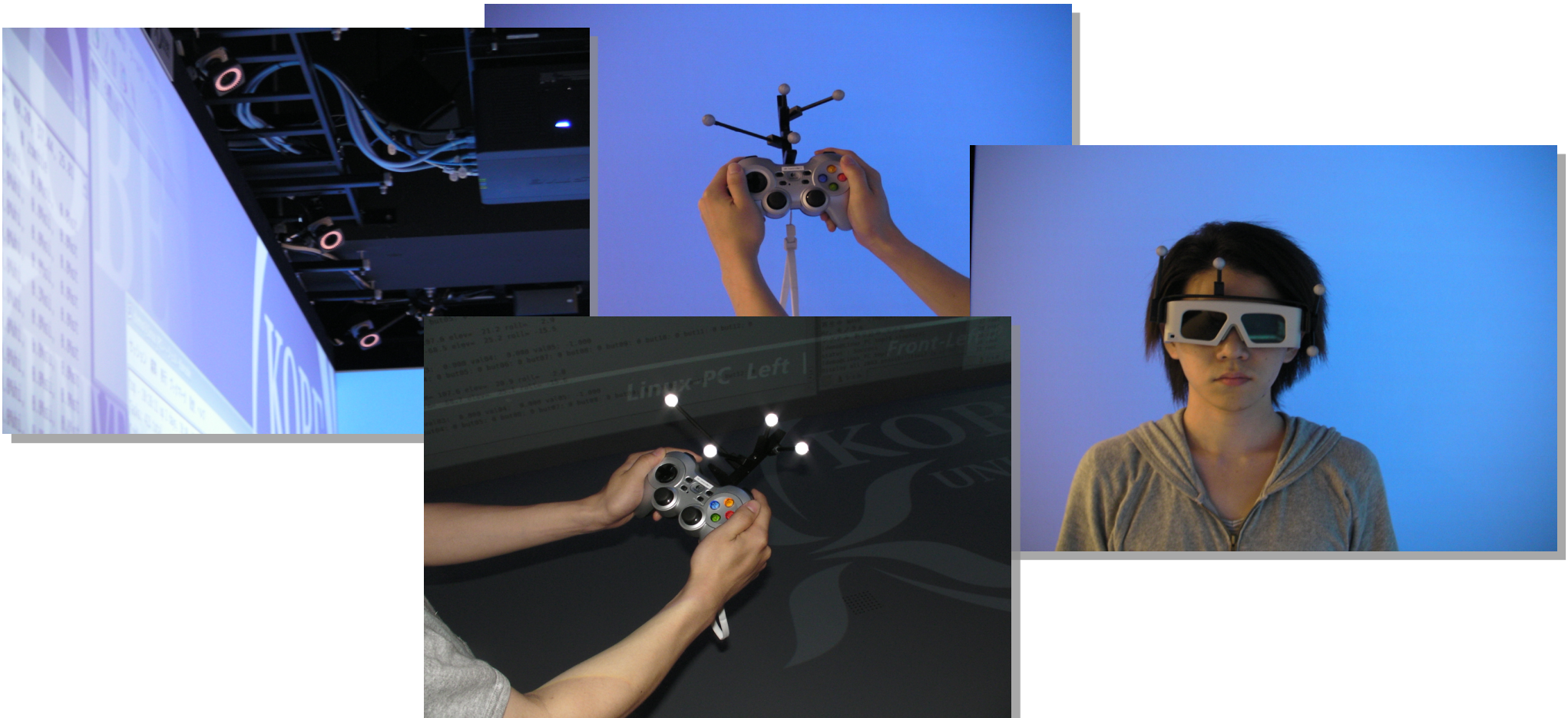
π -CAVE: Hardware

- Stereo projectors: Christie WU12K-M x 6
 - 1920 x 1200 pixels, 10500 lumens



π -CAVE: Hardware

- Tracker: Optical method (ViconTracker)
 - 10 cameras of 640x480 resolution



π -CAVE: Hardware

- Computers
 - (1) Linux-based PC (HP Z800)
 - ▶ 192 GB memory
 - ▶ NVIDIA QuadroPLEX x 3
 - (2) PC-Cluster System
 - ▶ HP Z400 x 6

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π -CAVE: Basic Software

- VR API: CAVElib
- Tracker device interface: trackd
- Graphics API: OpenGL 3.3

Visualization in CAVE

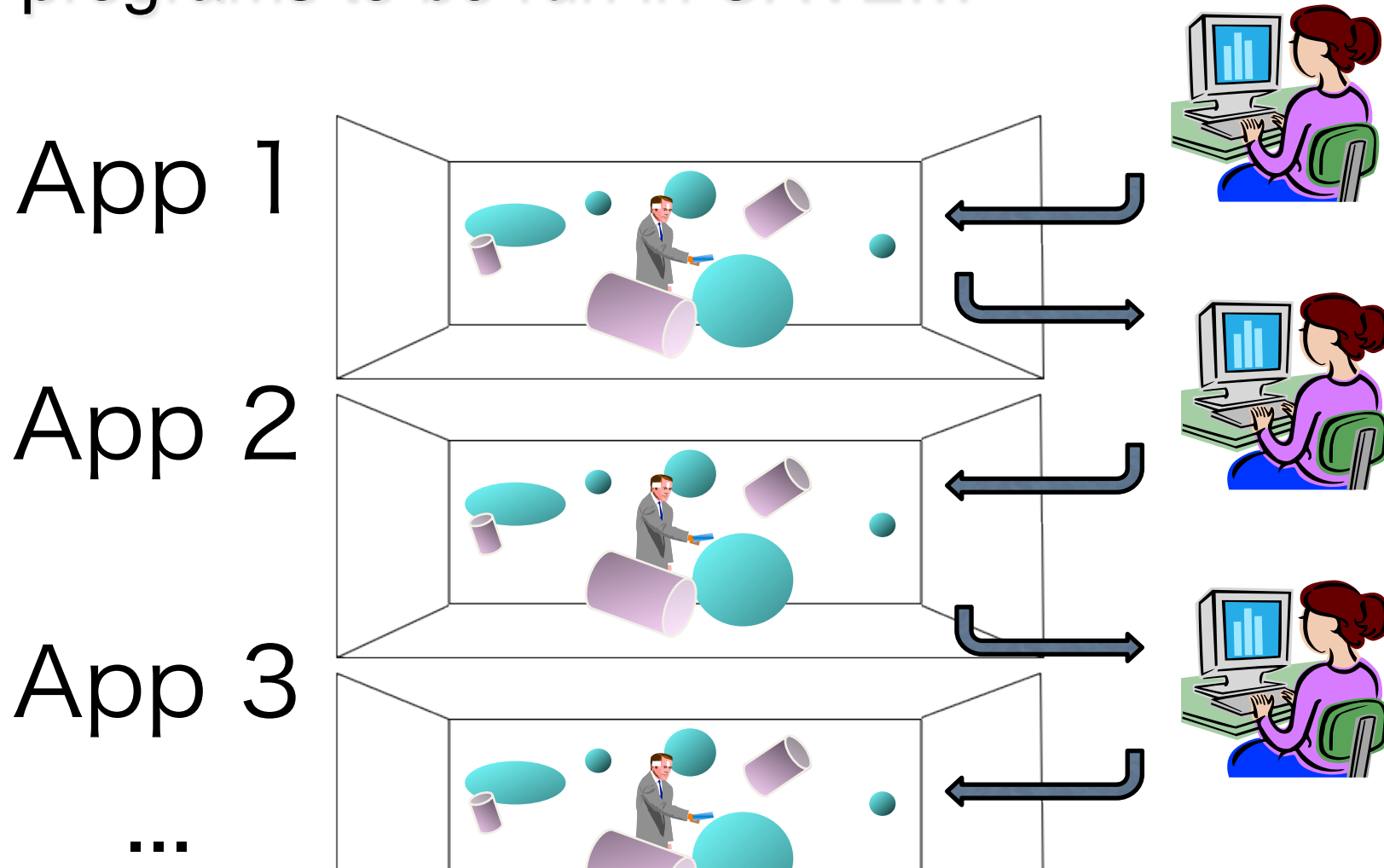
- (1) To discover
 - Viewer = Data generator
- (2) To present
 - Viewer \neq Data generator
 - VR to convey scientific image
(idea/understanding) to non-specialists

Visualization in CAVE

- To convey scientific image (idea & understanding)
 - Needs “decorations”
 - Needs switcher (or launcher) for multiple visualization applications

Necessity of middleware

- When we have multiple VR visualization programs to be run in CAVE...



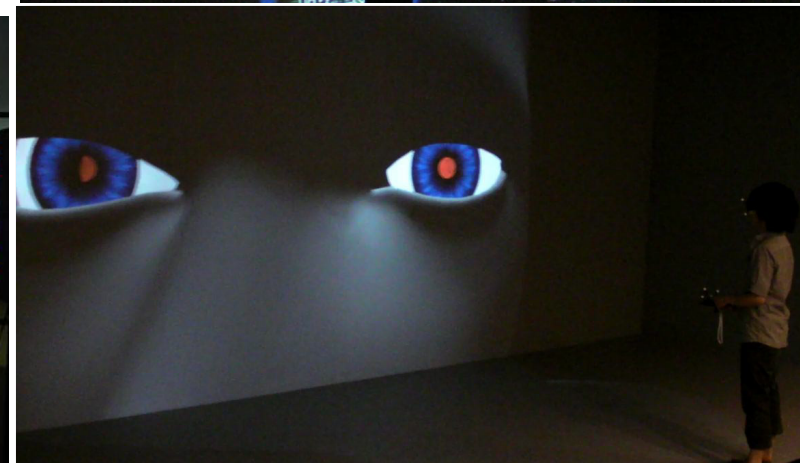
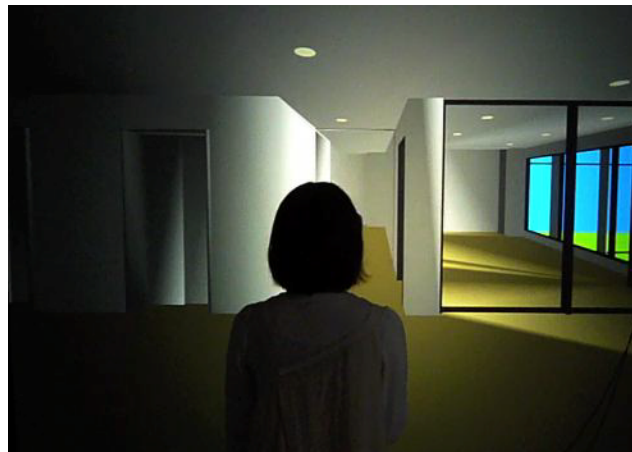
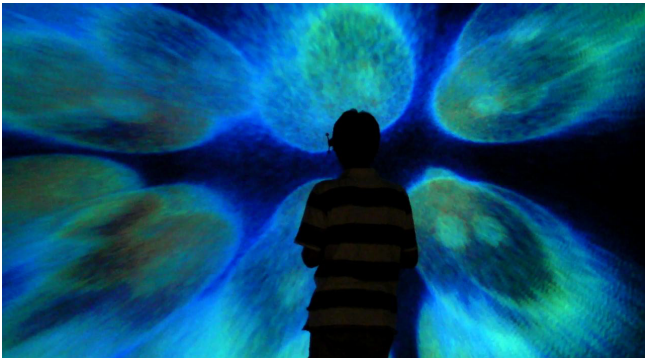
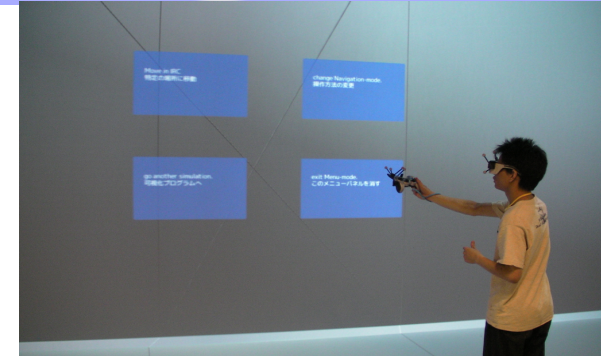
Application framework



- Multiverse = Application launcher
- Multiverse = “Desktop” for VR

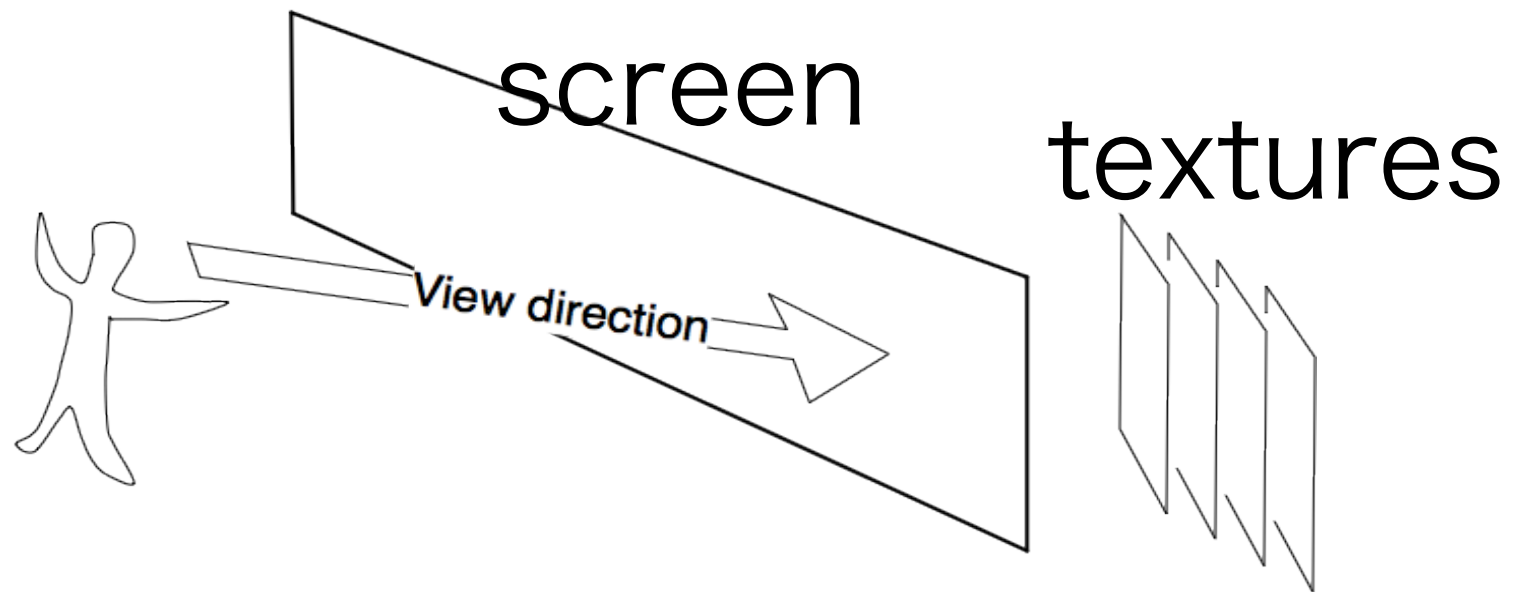
Component technologies

- Virtual touch-screen interface
- VR Helper
- Movie player (MPEG)
- 3D model (object) data loader
- 3D stereo volume rendering



Component technologies

- Fast speed 3D volume rendering using texture mapping
- Textures are always perpendicular to view angle.



New VR viz programs

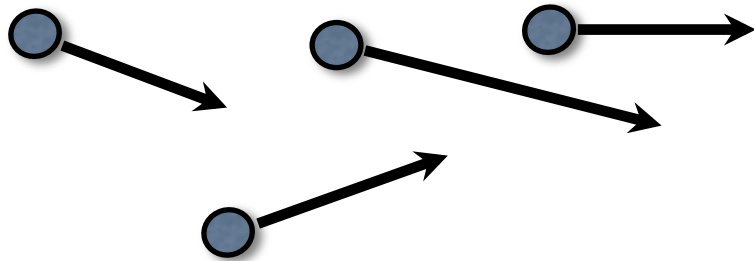
- IonJetEngine (plasma particle simulation)
- RetinaProtein (MD simulation of a protein)
- GeomagField (MHD geodynamo simulation)
- SeismicWave (Wave propagation simulation)
- CellDivision (Live cell microscope 4D image)

IonJetEngine

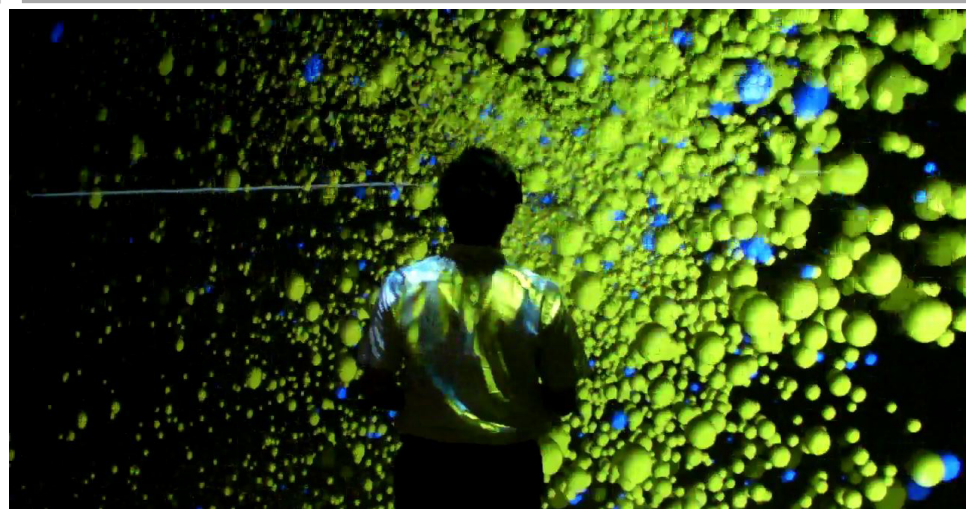
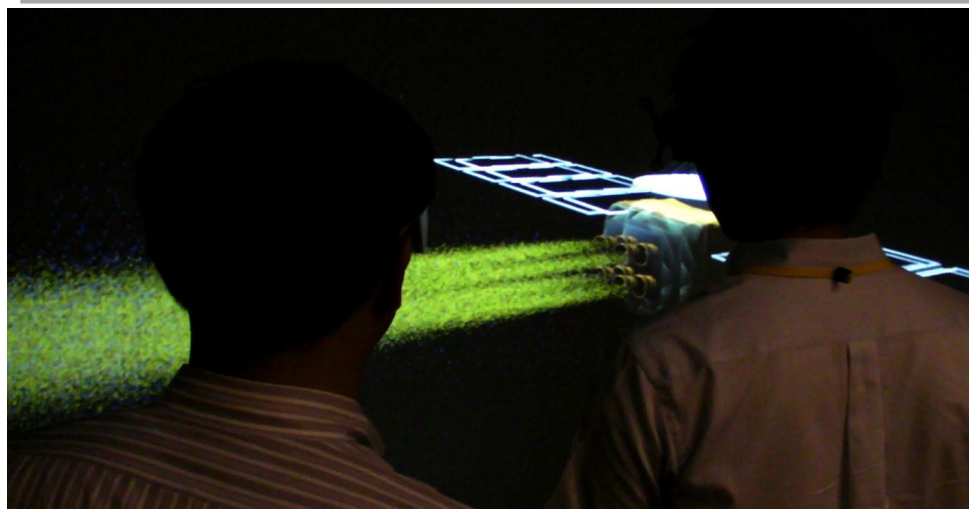
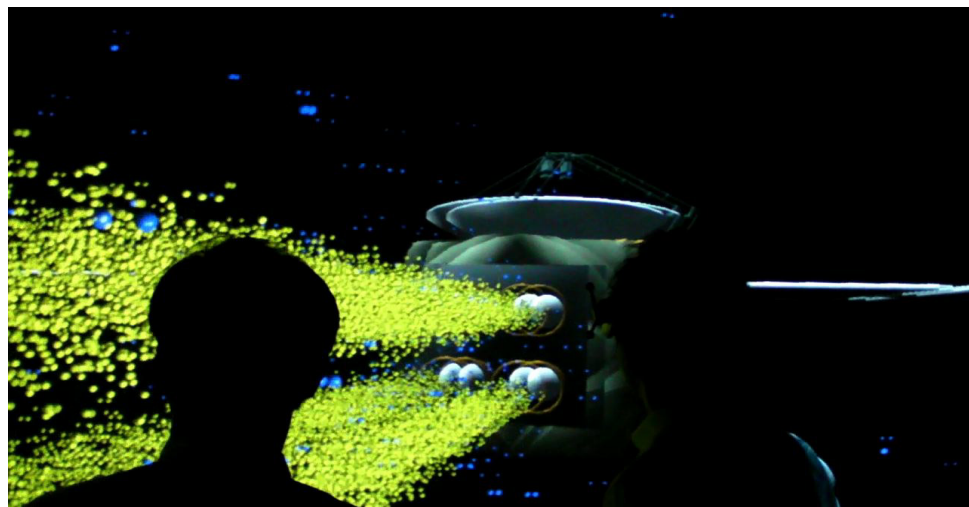
- Data
 - Author:
A. Hashimoto, Y. Miyake, H. Usui
 - Kind: Plasma particle simulation
- Description
 - A propulsion method for space probes
- Decoration
 - 3-D model of a virtual space probe

IonJetEngine

- Visualization
 - Position & velocity of each particle
 - $O(10^4 \text{ -- } 10^5)$ of particles (ions & electrons) in a beam.



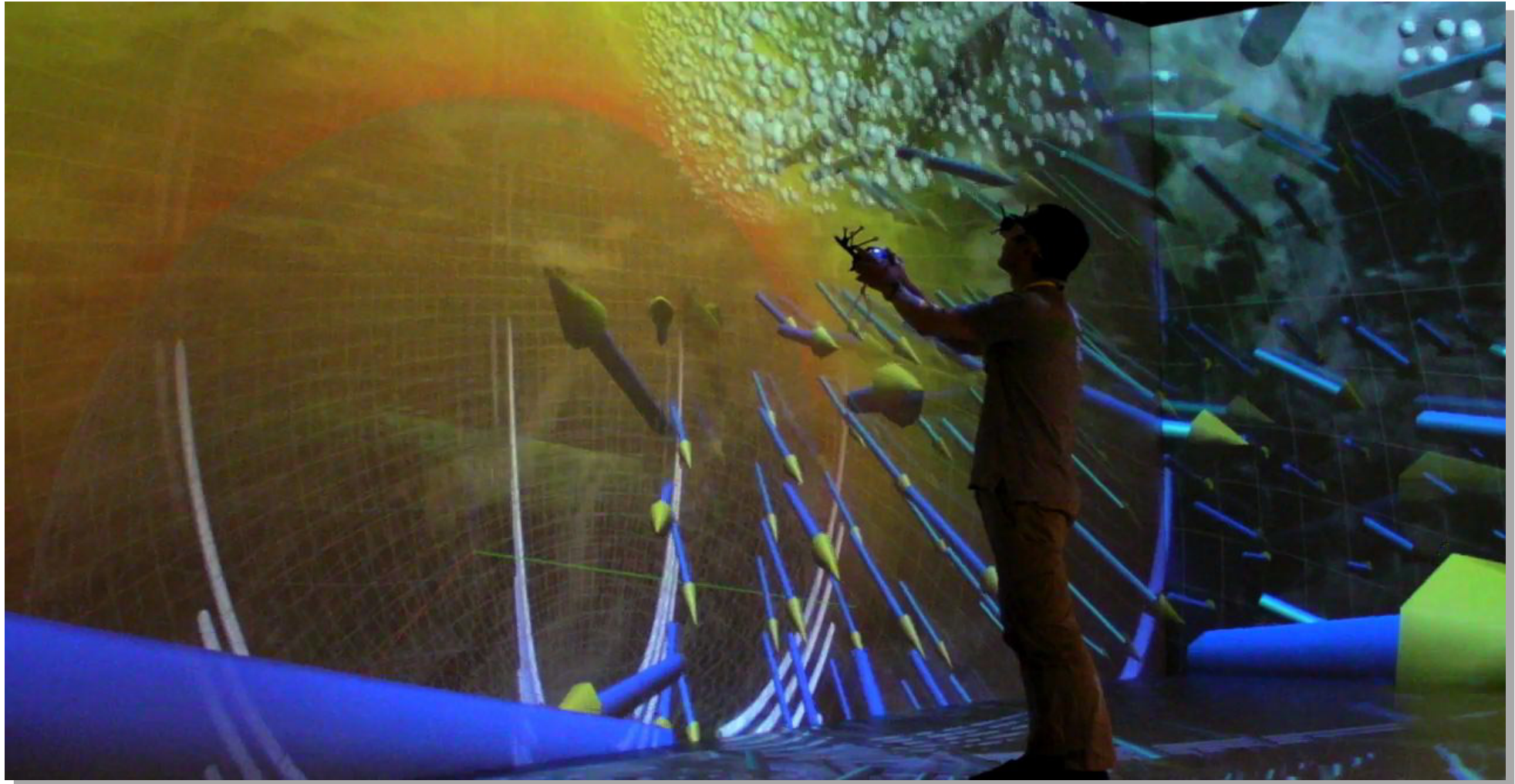
IonJetEngine



GeomagField

- Data
 - Author: A. Kageyama
 - Kind: MHD simulation in spherical shell
- Description
 - Convection motion in the Earth's core, that is the generator of the geomagnetic dipole field.
- Decoration
 - Dipole magnetic field lines and geosurface.

GeomagField



Summary

- VR visualization of frozen-in vector fields.
- π -CAVE: Newest & largest CAVE in Japan
- Multiverse: An application framework for CAVEs.