

FullDome ...and beyond!

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IMPA

Outline

- Basic Concepts
 - Mathematical Fundamentals
 - Computational Framework
- Omnidirectional Video Production
 - Augmented 360 Panoramas
- Immersive Interactive Visualization
 - IMPA's Dome

Math Fundamentals

- Plenoptic Function
- Light Fields
- Parametrization and Projections
- Omnidirectional Images

Plenoptic Function

*Complete description of Visual Information
in a 3D environment*

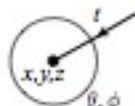
- $I_\lambda = P(x, y, z, \theta, \phi, t)$

Holographic Image



- $P : \mathbb{R}^3 \times \mathbb{S}^2 \times \mathbb{R} \mapsto \mathcal{E}$

6D Phase Space



Light Field

A Slice of the Plenoptic Function

- Structured Sampling of P

- example: *Camera*



x, y, z fixed



Image



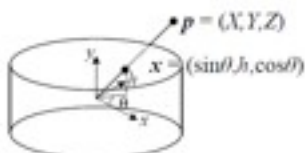
Ray Space

Panoramic Surfaces

Generalized Support for Visual Information

- Data Representation

- example: *Cylindrical Panorama*



Parametrizations

Maps 2D Surface to Planar Domain

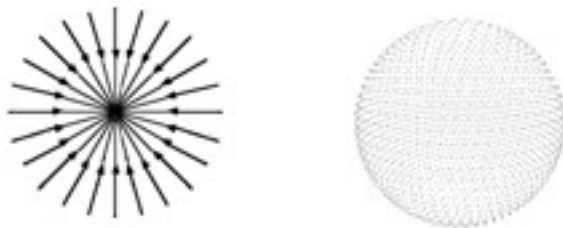
- Coordinate Systems
 - example: *Cylindrical Mapping*



Omnidirectional Image

The Set of All Rays incident at a point (x,y,z)

- Spherical Light Field = 360 degrees



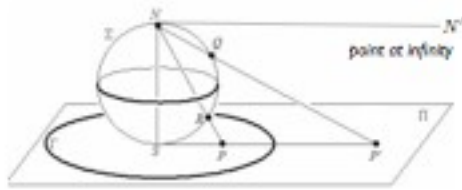
Representation of Choice

360° Image Formats

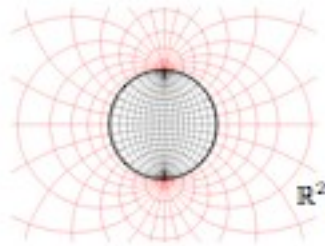
- Parametrizations of the Sphere
 - Stereographic
 - Lat-Long
 - Cube Map
 - Azimuthal

Stereographic Projection

- Conformal Mapping (preserves angles)



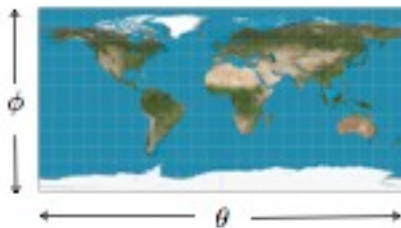
singularity



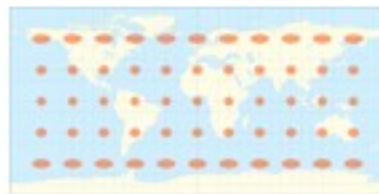
infinite plane

Equiarectangular Projection

- Latitude-Longitude Mapping (e.g., Flickr)



natural coordinate system



distortion toward poles

Most Convenient Format

Cube Mapping

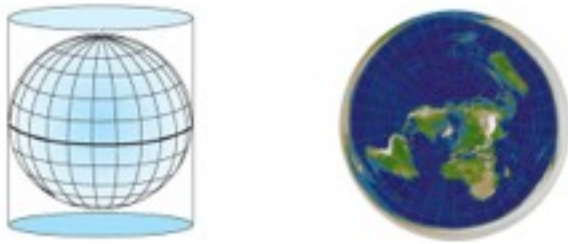
- 6 Perspective Projections



suitable for CG rendering

Azimuthal Projection

- Hemispherical Mapping



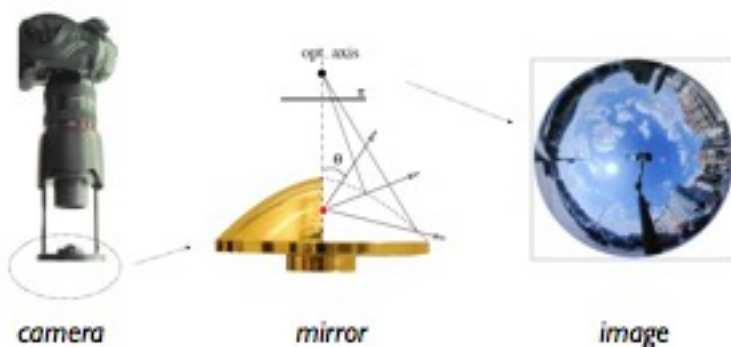
Dome Master standard

Omnidirectional Cameras

- Catadioptric
- Dioptric
- Multi-Camera

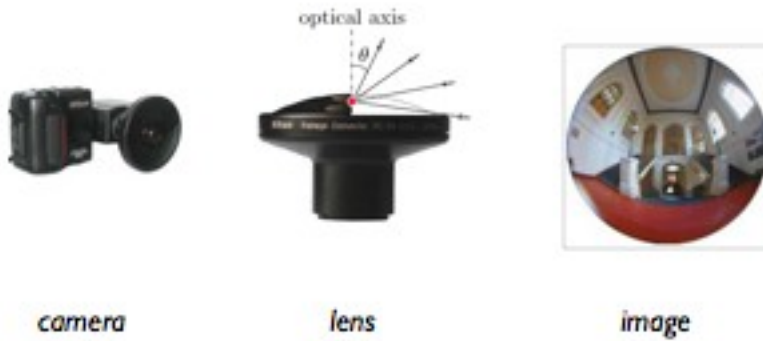
Catadioptric Cameras

- Mirror-Based (parabolic or hyperbolic)



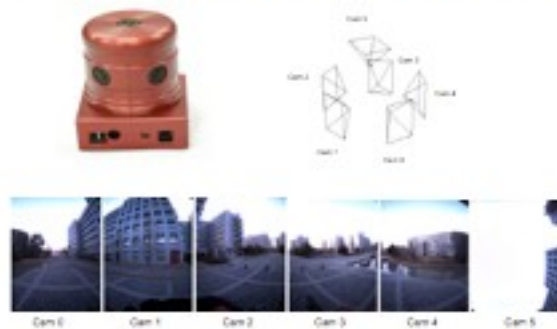
Dioptric Cameras

- Fish Eye Lenses



Multi-Camera Systems

- Point Grey's Ladybug (6 Perspective Cameras)



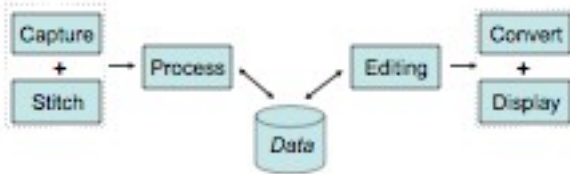
Practical Option

Production

- Assuming
 - Equirectangular Representation
 - Multi-Camera System
- Pipelines
 - Live Action
 - Computer Graphics

Live Action Production

- Pipeline

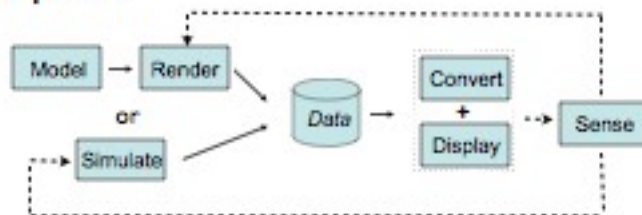


- Tools

- After Effects, ..
- Premiere / Final Cut / ...
- xRes / Digital Sky / ...

(Interactive) CG Production

- Pipeline



- Tools

- Blender
- LuxRender
- etc...

Augmented 360° Panoramas

*Photorealistic Rendering of Omnidirectional Images,
combining Real and Synthetic Scenes*

- Current Research at VISGRAF Lab
- Collaboration with
 - Aldo Zang
 - Dalai Felinto

HDR RGB-D Panorama

- Radiance

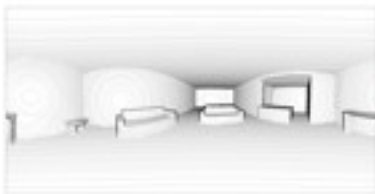


- Depth



Environment Model

- Derived Data:



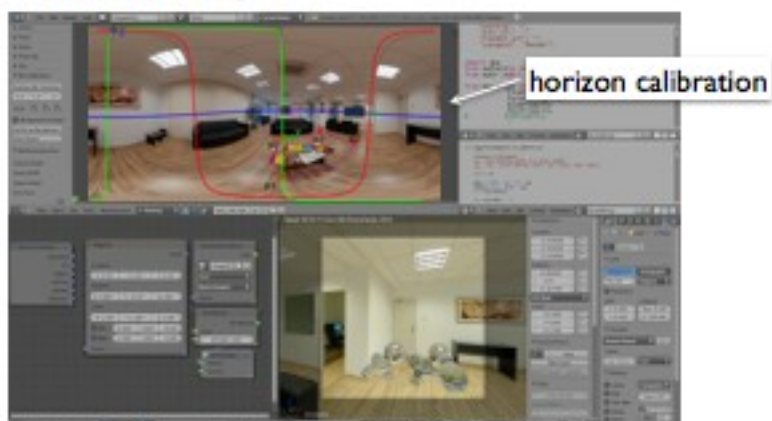
Scene Geometry



Light Map

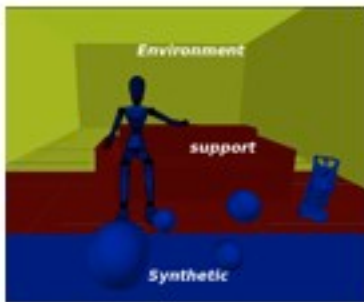
CG Integration

- Blender Plugin



Synthetic Objects

- Insertion into the Scene



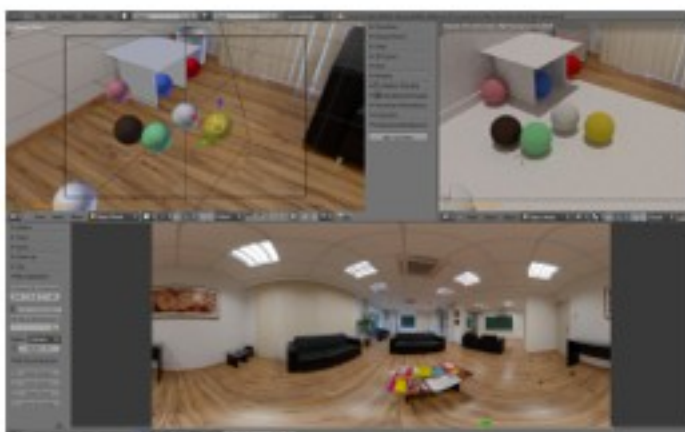
Augmented Reality

- Full Simulation of Real-Virtual Interaction



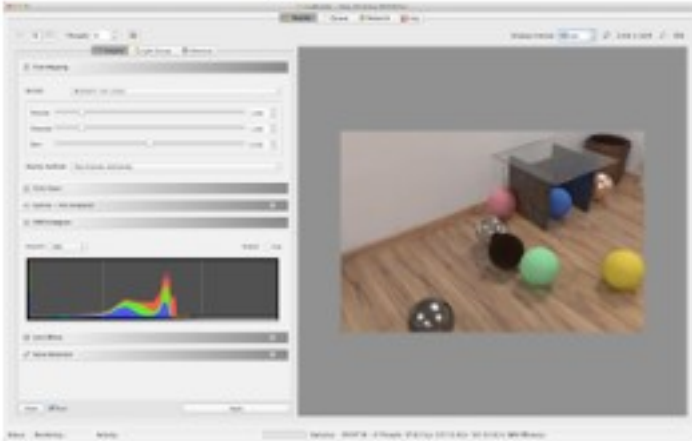
Photorealistic Rendering

- Blender to LuxRender



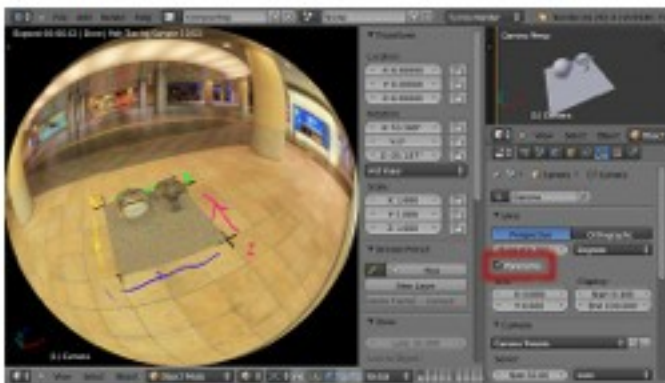
ARLuxRender

- Lux Render Plugin



Fish Eye Output

- Cycles



Final Results

- Equirectangular



- Dome Master



Technique pipeline

- Environment capture
- Scene modeling
- Depth map
- Illumination setup
- Synthetic elements
- Integration and rendering

Applications

- What can we do with this technology?
 - Special Effects for FullDome
 - Realistic Lighting Simulation
 - Real-Time Augmented Reality

Authoring Issues

- Passive
 - Movies
- Interactive
 - Google Street View
- Immersive
 - AR Cinema

Emerging Technologies

Film Language

- Conventional Cinema
 - HD Television
 - Theater Panavision
- 360 Degrees Dome
 - Omnimax
 - Dome Master

Conventional Cinema

- Camera Moves

Track



Pan / Tilt



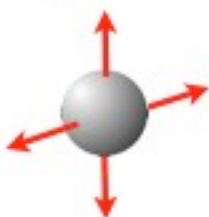
Zoom



Full Dome

- Camera Moves

Track



yes

Pan / Tilt



no

Zoom



?

360° Image Transforms

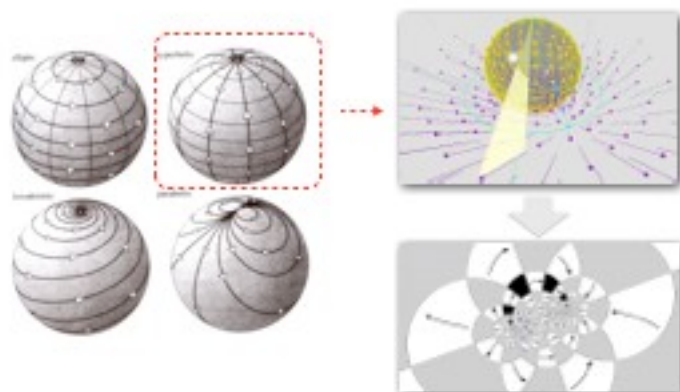
Complex Plane Transformations for Manipulation and Visualization of Spherical Panoramas

- Current Research at VISGRAF Lab
- Collaboration with
 - Leonardo Koller Sacht

Möbius Transformations

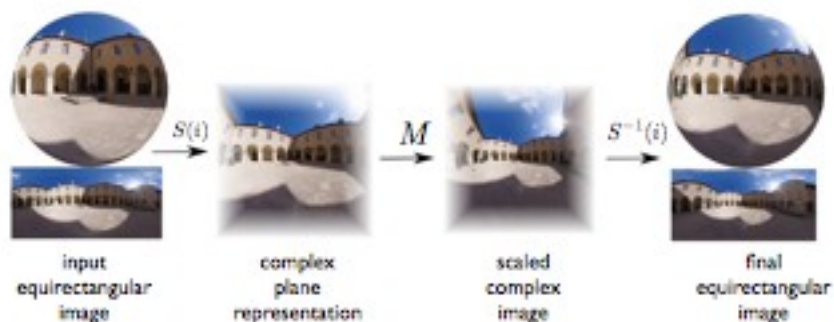
- Complex Map

$$M : \mathbb{C} \mapsto \mathbb{C}$$



Transformation Pipeline

- Hyperbolic Möbius Mapping (i.e., *scaling*)



Example

- Extreme Zoom



Comparison

- Alternative Projections



input panorama

Control of Perspective



equirectangular

projective

mercator

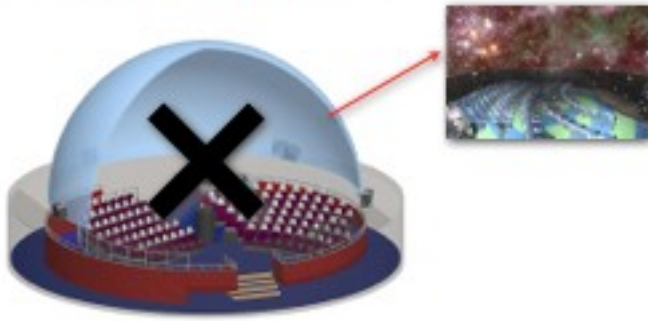
möbius

Video 1

Different scales applied to an equi-rectangular image

More than Meets the Eye

► *Beyond Full Dome Theater!*



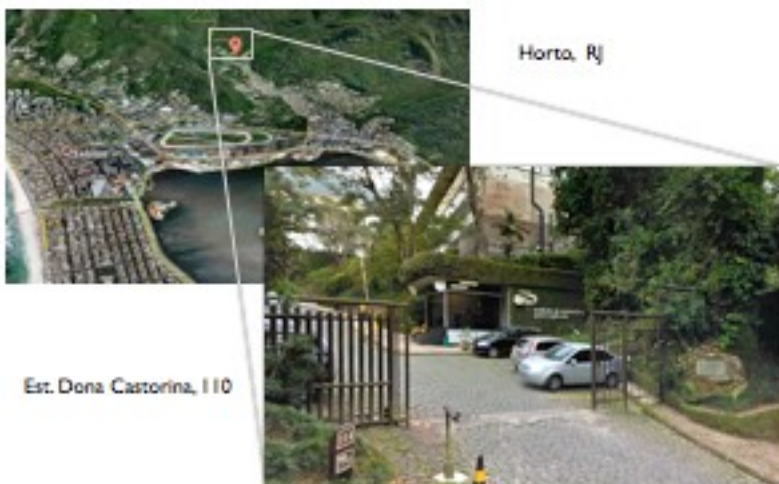
- Active / Dynamic / Reconfigurable ..

IMPA's Dome

*Immersive Visualization of Spherical
Interactive Panoramic Content for Augmented Reality*

- Experimental 360° Playground
 - Complete I/O Setup
 - Real-Time Rendering
- ★ Planned for 2014

Location



Horto, RJ

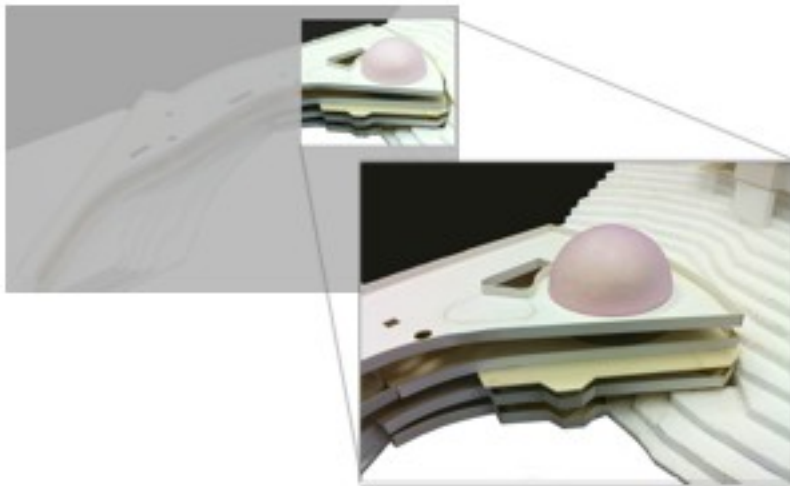
Est. Dona Castorina, 110

Environment

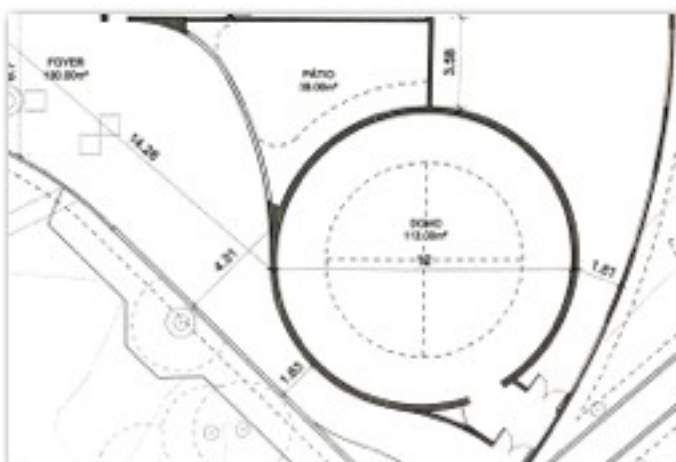
- Integrated with IMPA's building and Nature



Mockup



Floor Plan

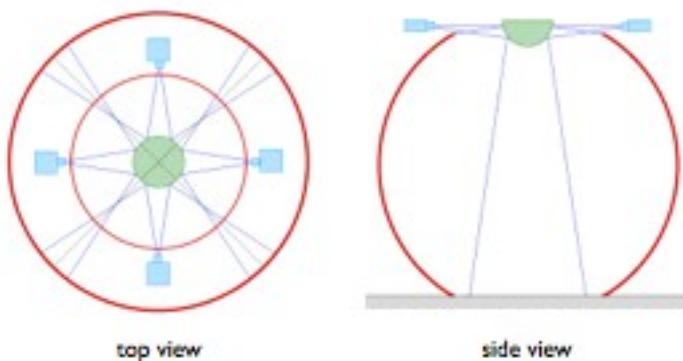


Specifications

- Size: 8 meters diameter
- Projection: $360^\circ \times 140^\circ$
- Sound: 7.2 Surround
- Reconfigurable Viewing Space
- Tracking: Head and Full Body
- Depth Cameras: RGBD

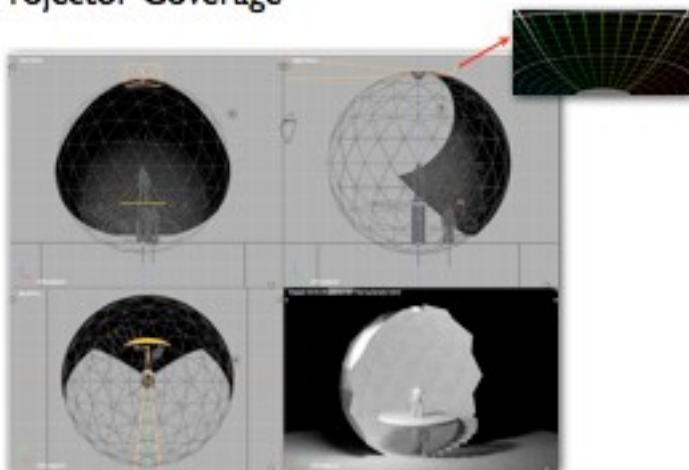
Projection

- Hemispherical Mirror + 4 Projectors



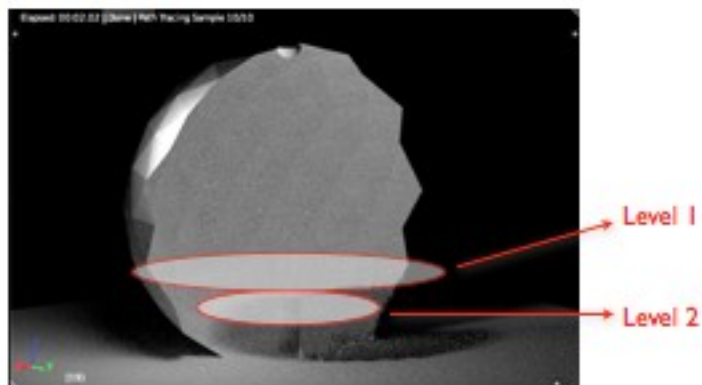
Simulation

- Projector Coverage



Reconfigurable Floor

- Two-Level Base



Level 2 - FOV

- Center View (~140° Vertical Field ofView)



Level 2 - FOV

- Border View



Envisioned Applications

- 360° Cinema
- Full Scale Games
- Immersive Visualization
- Parallel Reality
- Interactive Exploration

Future Research

- Authoring Systems
 - Integrated Media
 - Natural Interfaces
- Production Techniques
 - Live Action + CG
 - Real Time Simulations

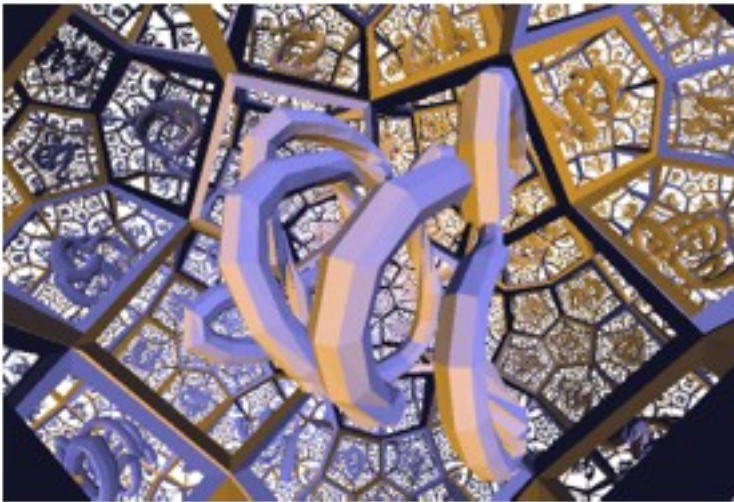
Some Examples

- *Relativistic Visualization*
 - 2007
 - collaboration with:
Marcelo Cicconet
- *Exploring 3D Manifolds*
 - current work
 - collaboration with:
Pierre Berger, Pierre-Yves Fave,
Alex Bordignon, Sergio Krakowski

QUANDO UMA CÂMERA ATRAVESSA
UMA CENA COM VELOCIDADE DA ORDEM
DE ALGUNS DÉCIMOS DA VELOCIDADE DA LUZ



Hyperbolic 3D Orbifold



Questions?