Astronomical Visualizations from the Research Frontiers

Randall H. Landsberg
Director of Education & Outreach KICP
Director of Public Outreach Dept AA
Agenda

I. Astro Viz Intro
   • What is Going on: Research & Public
   • Why Interesting

II. Very Quick - Cosmology Primer

IV. Chicago-centric Science Examples
   • Viz & Pictures of Experiments

V. Pretty Pictures as Time Permits
Visualization & Electronic Media

- **Appropriate/Real**
  - Authentic Artifacts (esp. in Astronomy = Observational Science)
  - Transport People to Inaccessible Places/Energies/Scales

- **Fast**
  - Days/Hours Vs Years for Physical Exhibits

- **Flexible**
  - Infinite Dynamic Range (quarks to the cosmos)
  - Interactive
  - Make for One Media - Adapt for Others
  - (Easy & Inexpensive to Install)

- **Needed (Hardware Revolution w/o Content)**
  - Museums, Web Pages, New Technologies
  - Full Digital Domes
    - Planetaria now = Visualization Theaters
  - Technology in the Classroom
Cosmus - Cosmology
Museum Effort:
R. Landsberg, M. SubbaRao, D. Surendran

• Visualization of Current/KICP Science
  - REAL Data
  - Software
  - New Platforms – e.g., Side-by-Side Stereo & PSP
• Connecting Museums, Educators & Researchers
• Web Repository of “Products” – Freely Downloadable
  - 3D Interactives
  - 2D Interactives
  - Stereo Photos
  - Movies & Animations

http://astro.uchicago.edu/cosmus
Cosmus Visuals

- **Visualization of Data Sets**
  - **Interactives & Movies**
    - SDSS/WMAP Observations
    - Cosmic Ray Showers Simulations
      - Over Malargue, Over Chicago
    - LSS Dark Matter Simulations
    - Black Hole Center of the Galaxy
    - Supernova Explosions
  
- **Virtual Visits & Remote Contacts**
  - Experiments & Exotic Locations
  - Stereo Photos & Photo Essays
    - Auger
    - Veritas
    - SDSS/APO
    - Mars
    - SZA
    - South Pole
GeoWall 3D

- Side by Side Stereo Projection
  - Different Views for Right & Left Eyes
- Components (Off the Shelf Hardware <$10K)
  - CPU w/Dual Video Output
  - 2 DLP Projectors
  - (Adjustable Rack for Projectors)
  - 2 Polarizing Filters (linear or circular)
  - Crossed Polarizing/3D Glasses
  - Polarization Preserving Screen
- Software (mostly freeware)
  - Partiview, Walkabout, Immersaview, Wallview, PokeScope
Mini Modern Cosmology Primer
Makeup of Universe Today

Visible Matter
(stars 0.4%, gas 3.6%)

Dark Matter
(suspected since 1930s
known since 1970s)

Dark Energy
(suspected since 1980s
known since 1998)

Also:
radiation (0.01%)
Universe Observed Today: Matter
Sloan Digital Sky Survey Mapping the Observable Universe

3D Map 25% Sky
Large Scale Structure of the Universe
>180M Celestial Objects - Photometry
>1M galaxies/quasars – Spectroscopy
Survey
Geometry
On the Sky:

Northern Survey:
~1/4 the sky

Southern Survey:
3 slices

(Look away from the Milky Way)
Apache Point Observatory
Southern New Mexico
SDSS 2.5-meter telescope
SDSS Digital Camera

Top to bottom:

$g'$  
$z'$  
$u'$  
$i'$  
$r'$

filters

Drift Scan Mode

120 Megapixels

Cooled to $–200$ degrees
Spectroscopic Plates for Redshift Survey 640 Fibers per Plate
sdss DR 4 Movie
Dark Matter - Direct Mapping/Detection

Galaxy Cluster Abell 2218
HST • WFPC2
NASA, A. Fruchter and the ERO Team (STScI) • STScI-PRC00-08
$Z = 40.52$
Dark Energy (Map Maker) I
arrival at South Pole
Video
Dark Energy II
Particles from Space
Ultra High Energy Cosmic Rays

- Pierre Auger Observatory (Malague, Argentina)
- VERITAS (AZ)
• Gamma Ray Telescope - Arizona
• Seven - 36 feet dishes w/ 315 mirrors each
• Will search for very high energy gamma rays from:
  - black holes
  - pulsars,
  - gamma-ray bursts
  - supernova remnants
  - globular clusters
  - galaxies including our own
Auger Observatory - Pampas of Argentina

- Ultra-High Energy Cosmic Rays \([10^{20}\text{eV}]\) expect \(1/\text{km}^2/\text{century}\)
- Size of Rhode Island
- Lead by Jim Cronin – Noble Laureate
- \(10^{20}\text{eV}\) impact produces \(10^{11}\) particles over \(20\text{km}^2\)
purple-gammas
yellow -electrons-positrons
red muons
green pions
cyan neutrons
blue protons
Black Hole - Center of Milky Way Galaxy

- DATA
  - Observation of Central Stars
  - Multiple Years
  - Using AO
- From Motions & Freshman Physics Deduce - SUPER MASSIVE OBJECT
- Can Predict Future Orbits
- Andrea Ghez (UCLA)
- Basis for Textbook Problems
Year: 1995.2

The Acceleration of Stars Orbiting the Milky Way's Central Black Hole

Data: Andrea Ghez, Jessica Lu (UCLA)
Visualization: Dinoj Surendran, Randy Landsberg,
Mark SubbaRao (UChicago / Adler / KICP)

UCLA Galactic Center Group
Where to Look for This Eye Candy

- **Cosmus Website**
  - [http://astro.uchicago.edu](http://astro.uchicago.edu) cosmus
- **YouTube**
- **GoogleVideo**
- **South Pole Telescope Website (SPT)**
  - [spt.uchicago.edu](http://spt.uchicago.edu) or google spt
- **KICP NSTA Website**
  - [http://kicp.uchicago.edu/nsta](http://kicp.uchicago.edu/nsta)
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• Dinoj Surendran (UC CS)
The End