

*MSR eScience 2012 Workshop, Chicago, Oct. 2012*

# **Novel Approaches to Data Visualization**

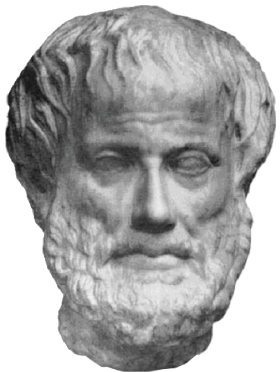
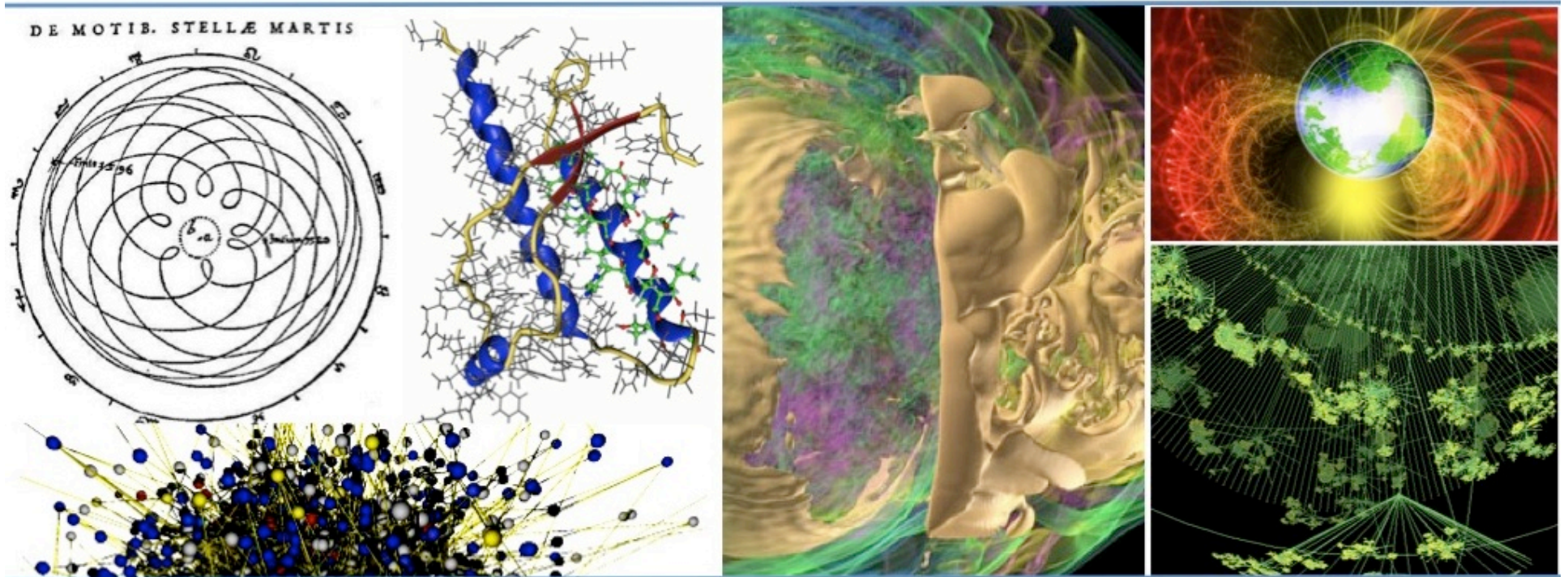
## **Opening Remarks**

**S. G. Djorgovski (*Caltech*)**

*Dark Matter Simulation*

*Neurons*

# Effective visualization is the bridge between quantitative information and human intuition

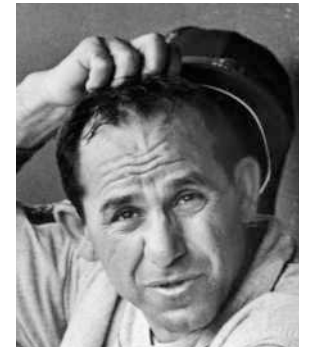


***Man cannot understand without images***

*Aristotle, De Memoria et Reminiscentia*

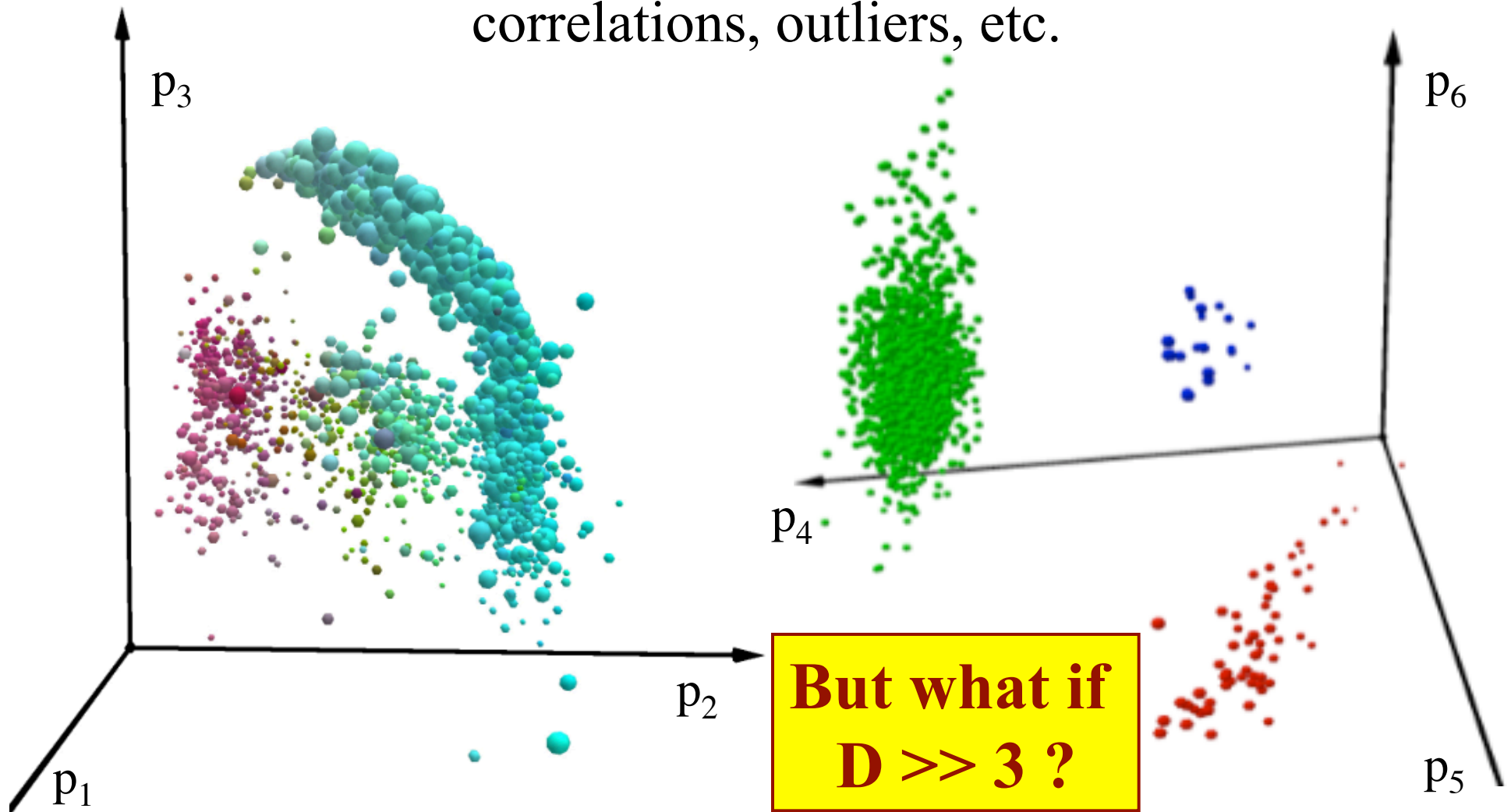
***You can observe a lot just by watching***

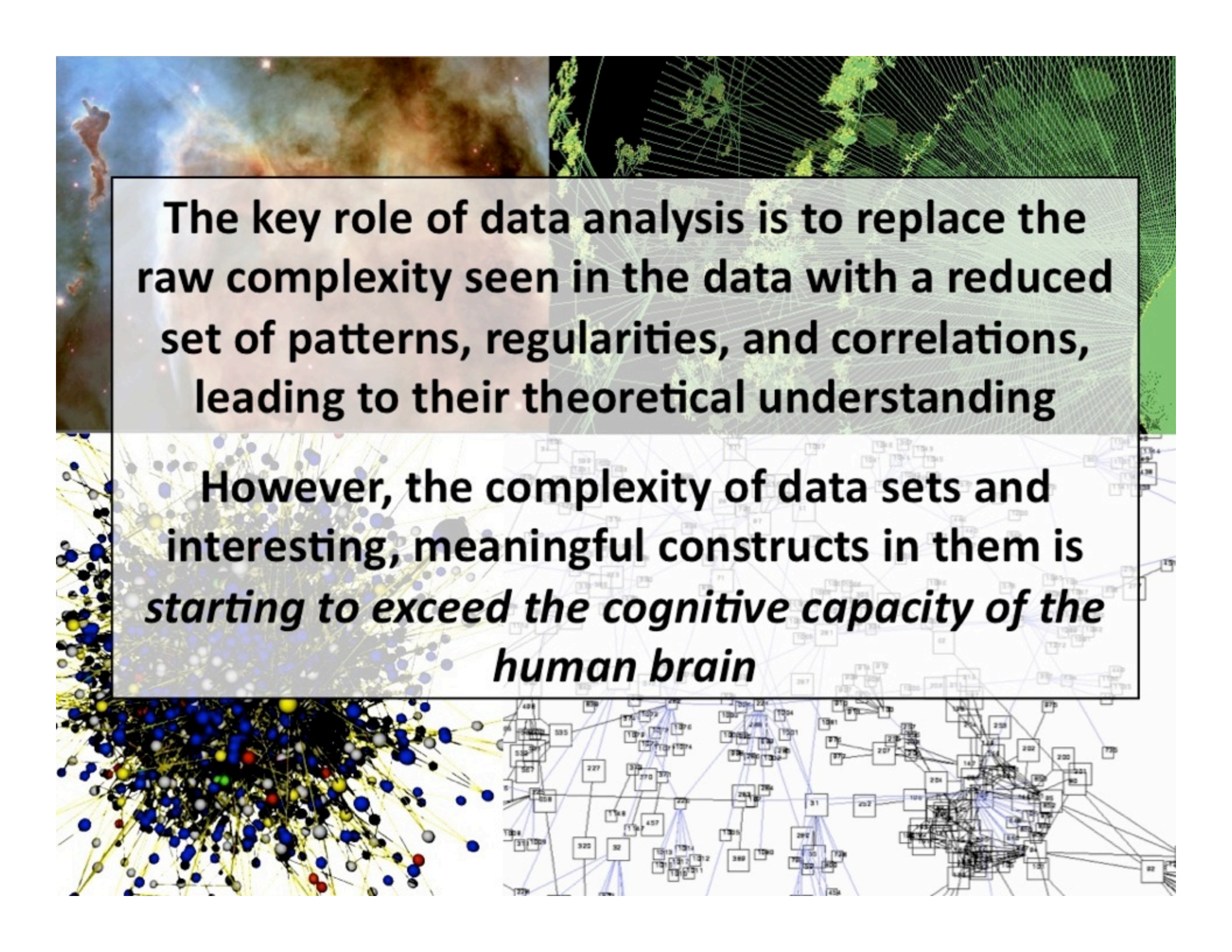
*Yogi Berra, an American philosopher*



# Example: Visualizing Parameter Spaces

Measured or derived physical parameters of objects form a multi-dimensional parameter space, with clustering, correlations, outliers, etc.



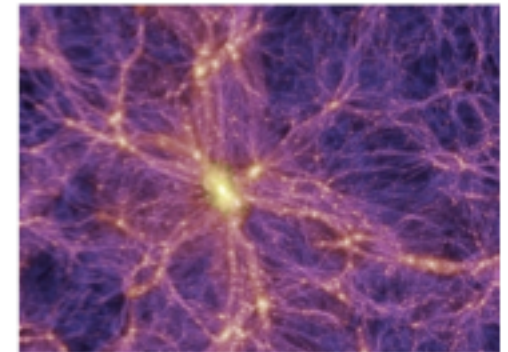


The key role of data analysis is to replace the raw complexity seen in the data with a reduced set of patterns, regularities, and correlations, leading to their theoretical understanding

However, the complexity of data sets and interesting, meaningful constructs in them is *starting to exceed the cognitive capacity of the human brain*

# Key Challenge: Visualizing Complexity

- Hyperdimensional structures (clusters, correlations, etc.) are likely present in many complex data sets, whose dimensionality is commonly in the range of  $D \sim 10^2 - 10^4$ , and will surely grow
- It is not only the matter of *data understanding*, but also of *choosing the appropriate data mining algorithms*, and interpreting the results
- We are biologically limited to perceiving  $\sim 3 - 12(?)$  dimensions



**What good are the data if we cannot effectively extract knowledge from them?**

*“A man has got to know his limitations”*

Dirty Harry, another American philosopher



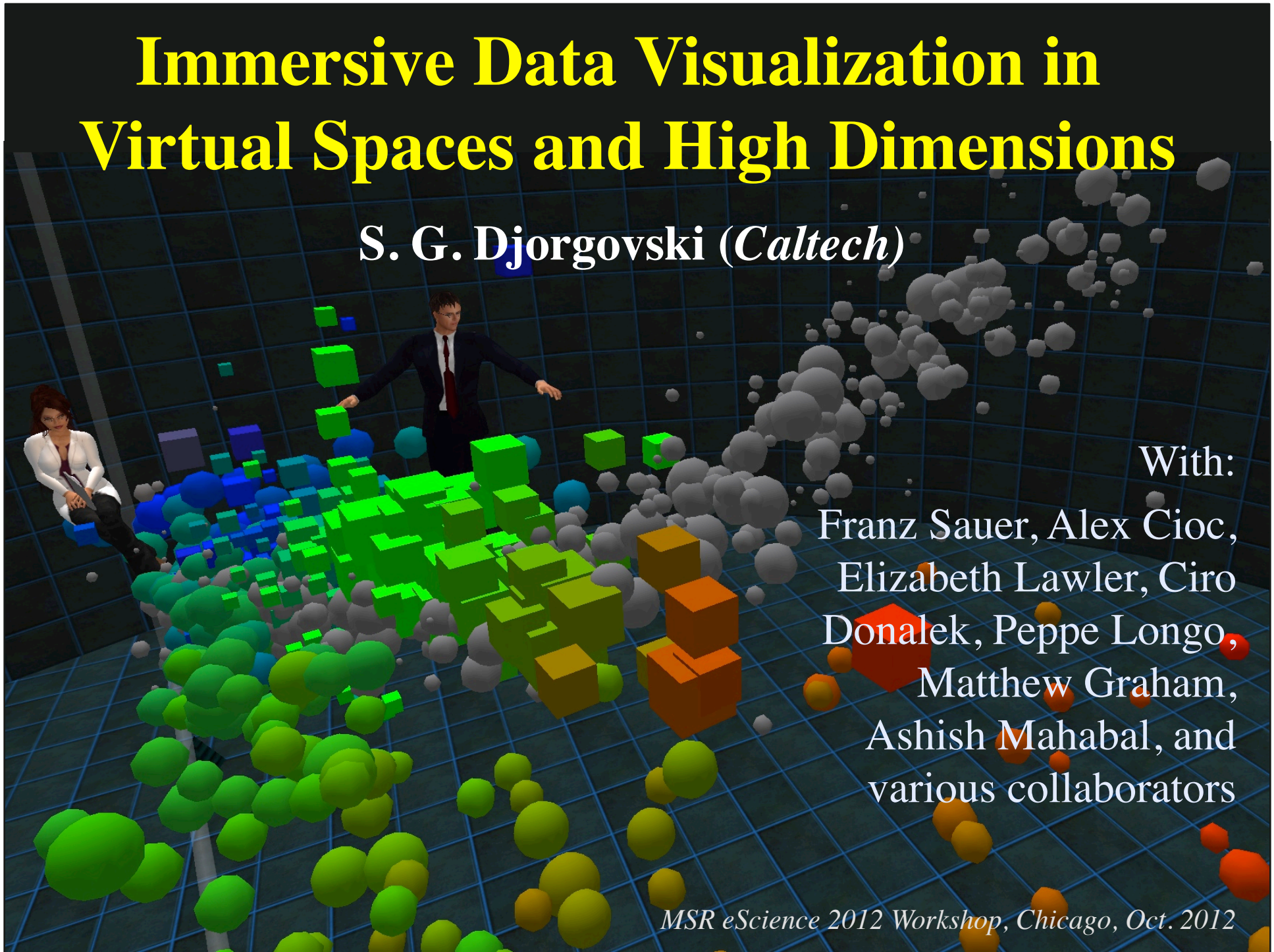
# Immersive Data Visualization in Virtual Spaces and High Dimensions

S. G. Djorgovski (*Caltech*)

With:

Franz Sauer, Alex Cioc,  
Elizabeth Lawler, Ciro  
Donalek, Peppe Longo,  
Matthew Graham,  
Ashish Mahabal, and  
various collaborators

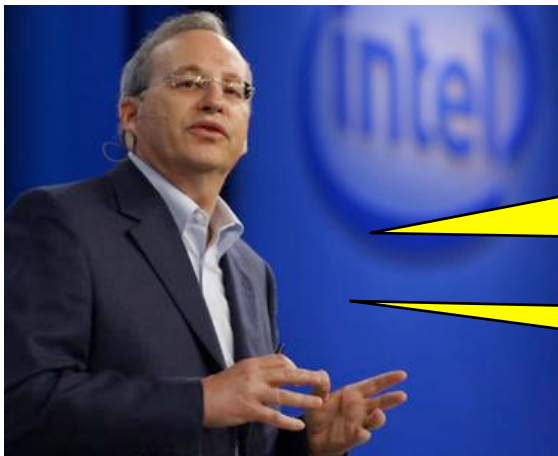
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# Immersive VR and the Emerging 3D Web



## ... and the future of the Web:



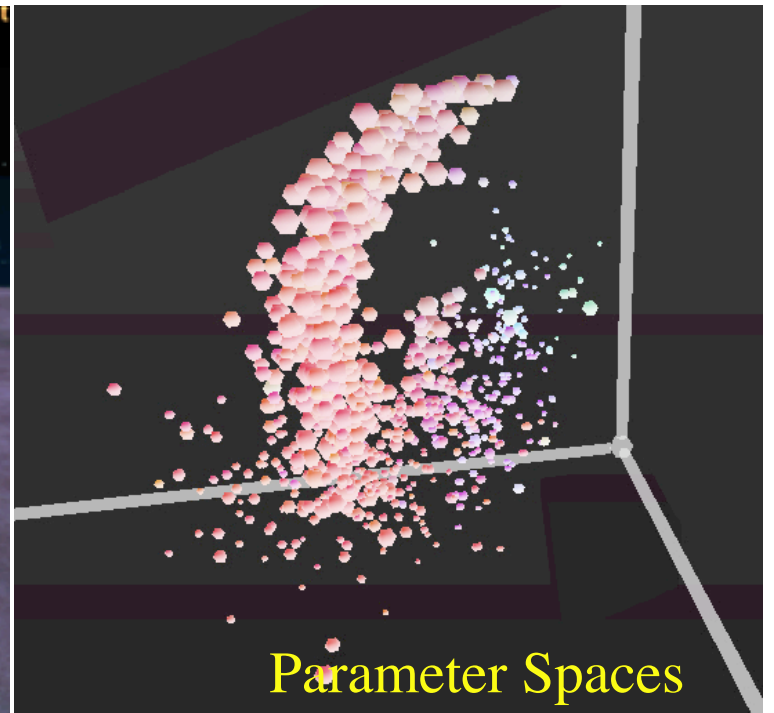
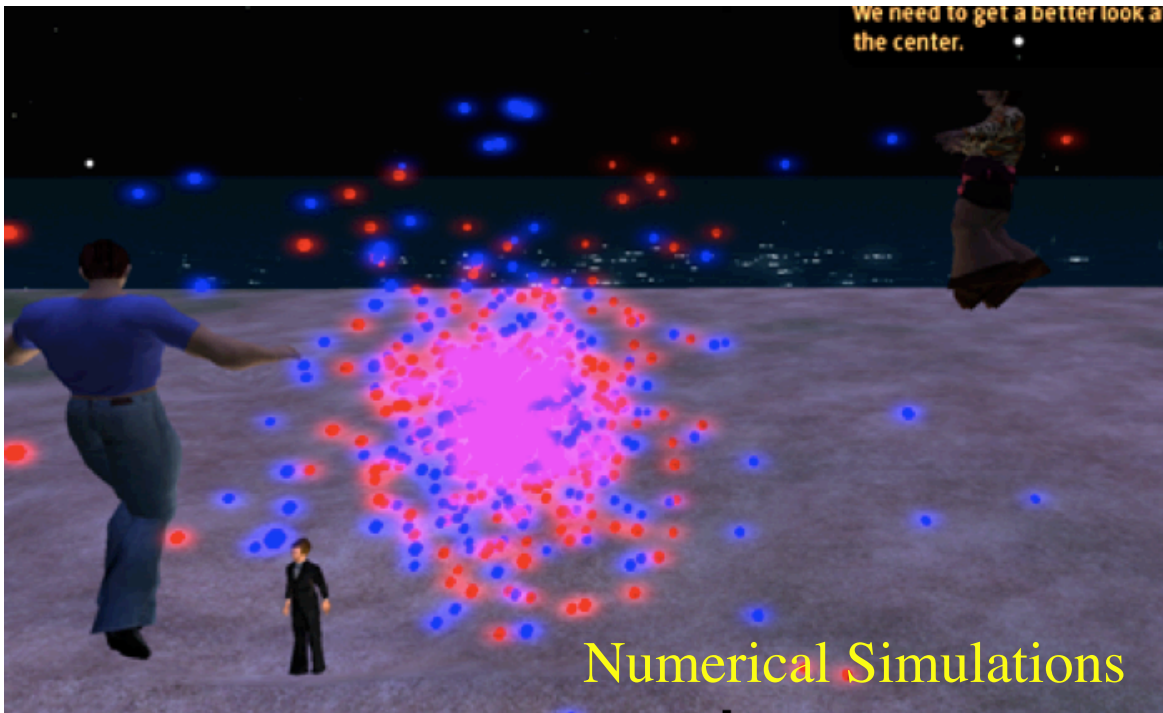
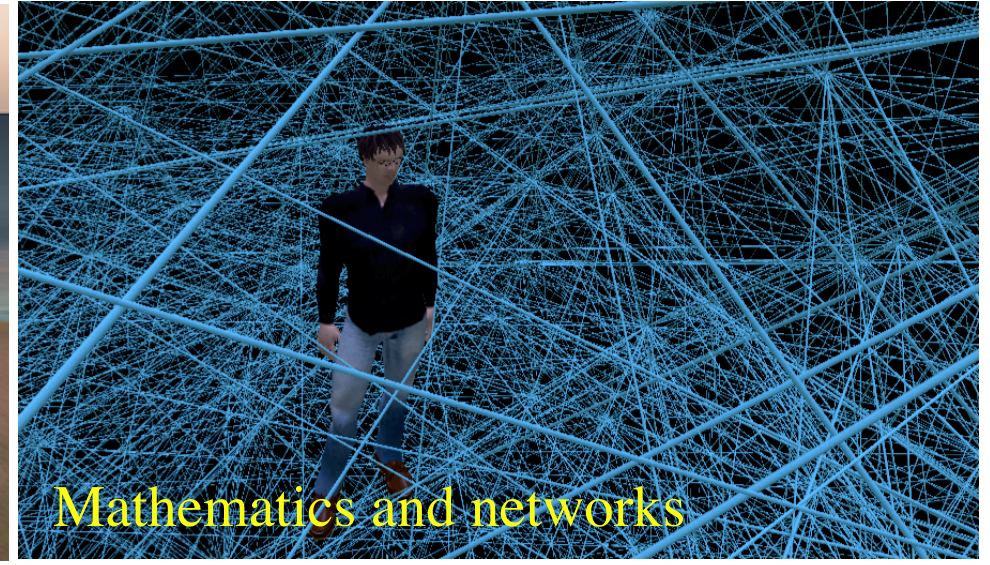
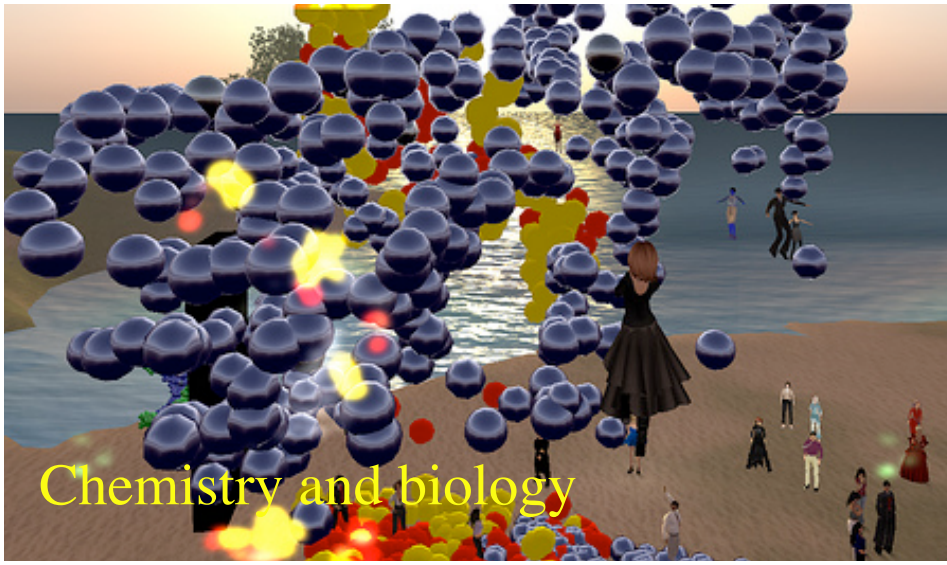
Justin Rattner, Intel CTO, in a keynote talk at the SC'09:

“... There is nothing more important to the long-term health of the HPC industry than the 3D Web...”

“... the 3D Web will be the technology driver that revitalizes the HPC business model ...”

*We are exploring these emerging technologies for scientific purposes, data visualization in particular*

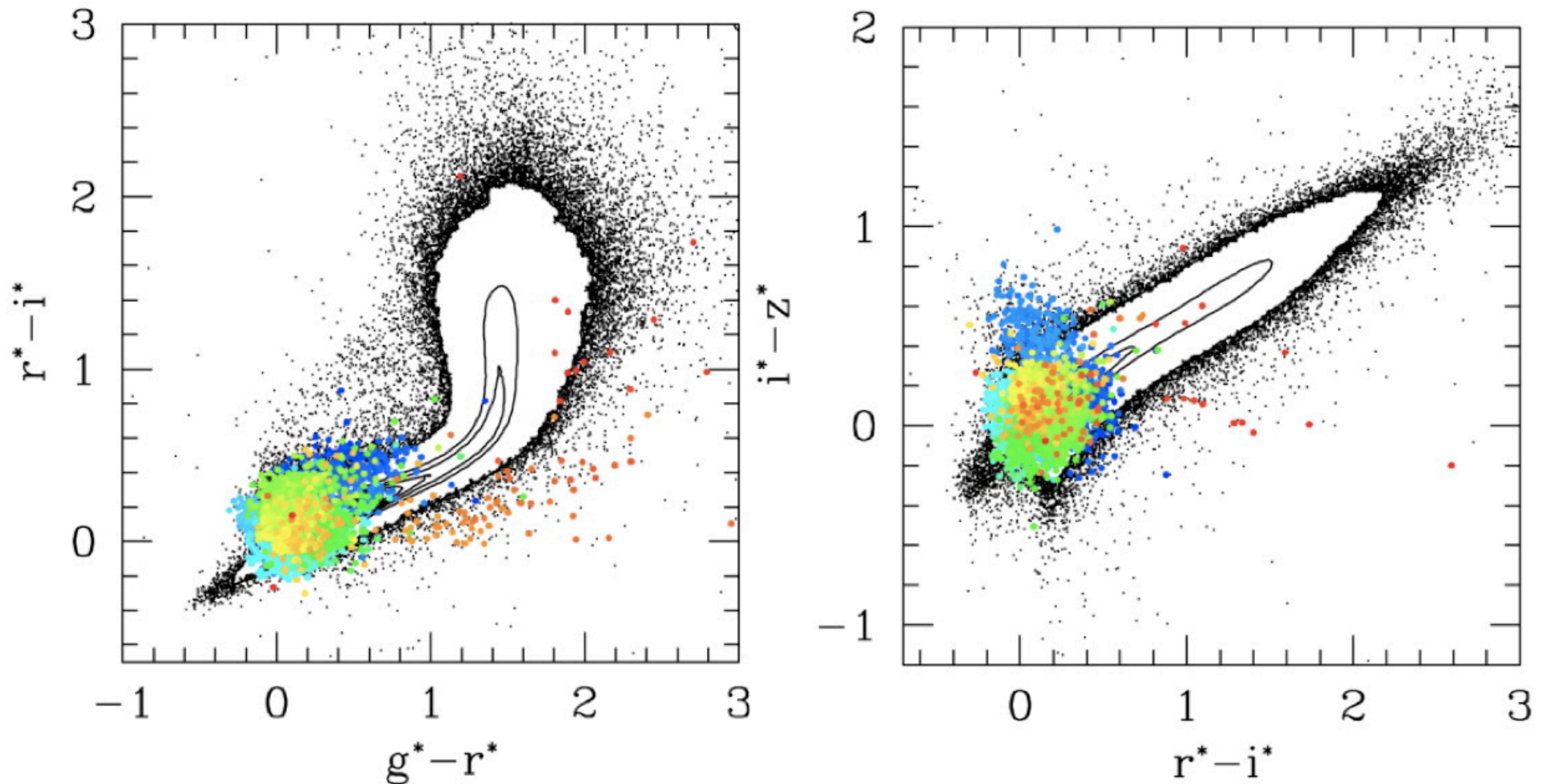
# Immersive Data Visualization



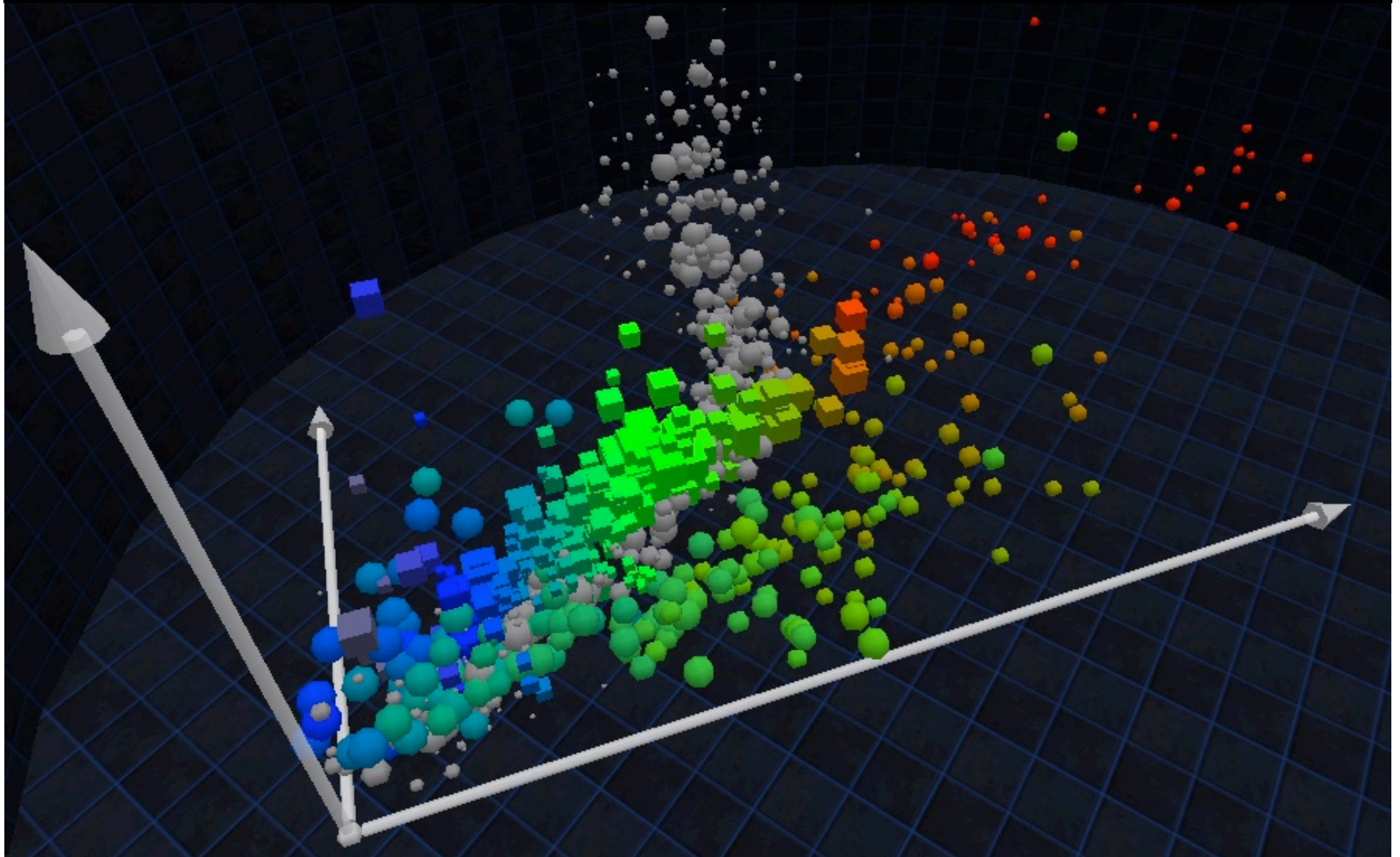


# Quasars in a Color Parameter Space: A Traditional Multi-2D Representation

Quasars (colored dots) project over the normal stars (black dots)



# Quasars in a Color Parameter Space: An Immersive 3D Representation



# Interactive Data Visualization

Experiments in Intel's  
*ScienceSim* world

Data points linked to web resources

The screenshot displays the ScienceSim environment. On the left, a 3D visualization shows a cluster of red, semi-transparent rectangular blocks representing data points. A yellow arrow points from this cluster towards the right. On the right side, a web browser window is open, displaying the SDSS (Sloan Digital Sky Survey) website. The browser address bar shows the URL: <http://cas.sdss.org/astrodr6/en/tool>. The page title is "SDSS J094705.50+004204.0". The main content area shows a table with columns for Type, RA,dec (Decimal and Hexagesimal), and ObjID. The table contains one row of data for the galaxy SDSS J094705.50+004204.0. Below the table, there is a section for "Column names link to glossary entries" and a "Summary" section. A small image of the galaxy is shown, along with a table of photometric data (u, g, r, i, z bands) and a table of spectroscopic data (run, rerun, camcol, field, obj, rowc, col). The ScienceSim interface includes a menu bar at the top with options like File, Edit, View, World, Tools, Help, and Advanced. A toolbar at the bottom contains buttons for Communicate, Fly, Snapshot, Search, Build, Map, Mini-Map, and Inventory. A text box in the bottom left corner provides details for a selected object:

cube:  
Identifier: 587725074458804431  
Spatial Location: < 6.259955, 3.655669, 2.316938 >  
Size: 0.264872  
Color: < 0.681749, 0.050000, 0.050000 >  
Opacity: 0.904609  
Website: <http://cas.sdss.org/astrodr6/en/tools/explore/obj.asp?id=587725074458804431>

At the bottom right, a small figure of a person is visible, interacting with the environment. The interface also includes a "MICA Director Curious George" label and a "Data R Touch F" label.

(F. Sauer, E. Lawler, S.G. Djorgovski)

# Data Browser Using Unity 3D

The screenshot shows a web browser window titled "Unity Web Player | test10". The address bar contains the file path: `file:///Users/cirdok/Desktop/CaltechUnity/Webplayer/test10/test10.html`. The browser's bookmark bar shows folders like "Most Visited", "Simiro", "Notizie", "AstroInformatics", "Social", "Casa", "CitSci", and "VAO".

The main content area displays a 3D visualization of 100,000 points in a dark blue environment with a cloudy sky. The points are colored in shades of green and red, forming a dense, elongated cluster. A vertical red line is visible in the scene.

On the left side, there is a control panel with the following elements:

- Disconnect** button
- Visualize** button
- Points** button
- Set Number** button
- URL of the data set** text input field
- Load** button

On the right side, there is a vertical stack of buttons:

- Clear All** button
- 'Blink'** button
- Capsules** button
- Spheres** button
- Cylinders** button
- Cubes** button
- Broadcast** button

At the bottom left, there is a text input field with the placeholder text "Type Parameter Change Here" and a **Set** button next to it.

Text overlays on the image:

- Top right: **Standalone or Web browser** (yellow text)
- Bottom left: **(A. Cioc, C. Donalek, S.G. Djorgovski)** (white text)
- Bottom center: **100,000 points plotted in ~ 15 sec on a laptop** (yellow text)

# Data Browser Using Unity 3D

Unity Web Player | test10

file:///Users/cirdok/Desktop/CaltechUnity/Webplayer/test10/test10.html

Google

Most Visited Simiro Notizie AstroInformatics Social Casa CitSci VAO Bookmarks

Unity Web Player | test10

IP Address: 131.215.194.169

Disconnect

Visualize

Points

Set Number

URL of the data set

Load

Clear All

'Blink'

Capsules

Spheres

Cylinders

Cubes

Broadcast

Type Parameter Change Here

Set

Data selection, zoom-in, navigate, overplot, reproject, etc.

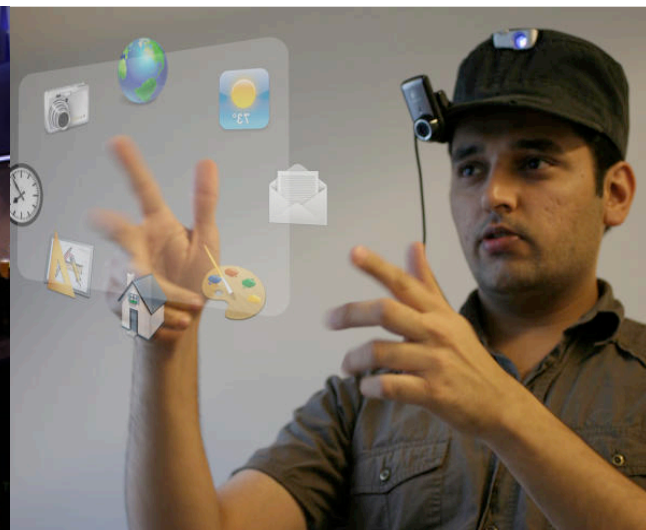
More functionalities now being added

# Data Browser Using Unity 3D

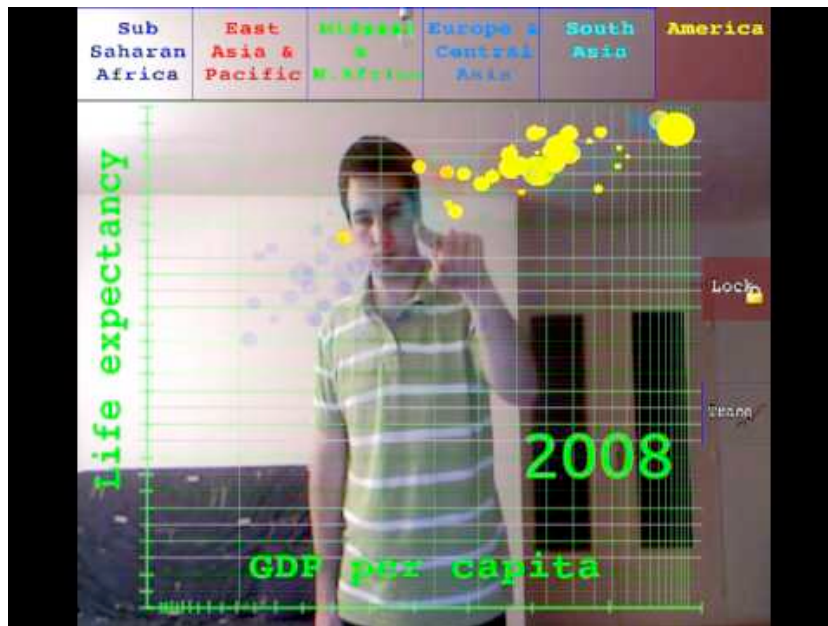
The image shows a Unity Web Player interface for a data browser. The browser window displays the URL `file:///Users/cirdok/Desktop/CaltechUnity/Webplayer/test10/test10.html`. The main 3D view shows a scatter plot of data points in red and green against a dark blue background with a cloudy sky. A red crosshair is visible. The interface includes a control panel on the left with buttons for 'Disconnect', 'Visualize', 'Points', 'Set Number', and 'Load'. A text input field for 'URL of the data set' is also present. On the right, there are buttons for 'Clear All', 'Blink', 'Capsules', 'Spheres', 'Cylinders', 'Cubes', and 'Broadcast'. At the bottom, there is a text input field labeled 'Type Parameter Change Here' and a 'Set' button. A yellow text overlay in the bottom right corner reads 'Multi-user, collaborative'. A tooltip in the 3D view shows coordinates: `(0.09575844, -0.2360096, -0.1416779)`. The IP address `131.215.194.169` is displayed at the top of the 3D view.

# 3D Interfaces

- 3D displays (multiple technologies)
- Haptic interfaces (Kinect, Sixth Sense, ...) to capture expressions, body language
- Increasingly photorealistic avatars
- Now driven by the games/movie industry, but likely to become a standard interface to the immersive/augmentative VR web



# From Science Fiction to (Virtual) Reality



Oculus RIFT

★ 2012 ★  
BEST OF  
E3  
NOMINEE

Truly Immersive Virtual Reality





# Summary

- Visualization is a key need for discovery and understanding
- The 3D Web is coming, and probably sooner than you think

Enabling technologies: 3D video, games, virtual worlds, haptic interfaces

- 3D, interactive, collaborative visualization is far more intuitive than the traditional 2D approaches – greater insights?
- Up to a dozen dimensions can be encoded effectively (more if we add sonification to visualization)
  - ✧ That is still not enough for the hyperdimensional data spaces that we are dealing with – *a key limitation*
- Working tools already on the *OpenSim/SL* platform; *Unity 3D* based, web-browser data visualization tool coming soon
- Cost is very low (hardware); zero cost for virtual worlds