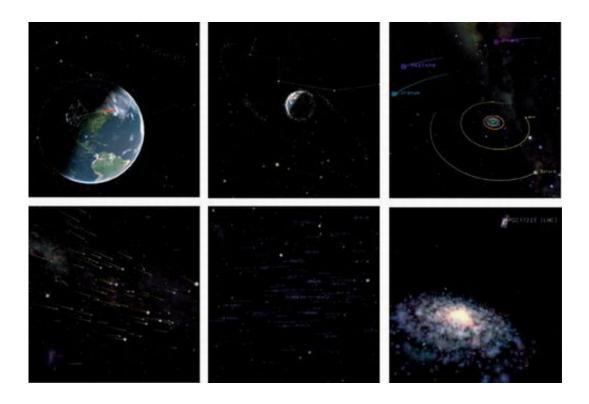# In 'forty jumps,' scientists model scales of quarks to quasars

January 18 2007

From the top left and moving across, this powers-of-ten journey shows Earth (red line represents the ISS) (10^7 m), Earth and satellites (10^8 m), solar system (10^{13} m), Pleiades (10^{18} m), extrasolar planets (10^{18} m), and the Milky Way and Large Magellanic Cloud (10^{23} m). Image Credit: Andrew Hanson, et al. © 2006 IEEE.

Comprehending the smallness of a quark or the hugeness of the observable universe is a challenge that most of us find difficult, yet captivating. Placing vastly different scales side by side to explore their

relationship amounts to a task not even computers have mastered efficiently. Recently, scientists Chi-Wing (Philip) Fu and Andrew Hanson have developed a visualization system of the universe that may help scientists, educators and film viewers better understand size on a journey through the universe.

"Graphics displays have faced a limitation due to their digital nature," Hanson explained to *PhysOrg.com*. "For example, handling large ranges in detail is out of the range of standard hardware, such as accelerated graphics cards. With this new system, we can create an accurate, interactive experience, with continuous scaling over different scale ranges. You can wander continuously throughout the universe without any anomalies."

Fu and Hanson's work tackles several problems that past systems have faced: focusing on objects at different distances, depth perception, and speed. As Hanson explains, it's a bit like looking at a ladybug on your nose with the galaxy in the background. To improve these areas, the scientists developed a graphics software system that provides a continuously scalable visualization in three dimensions.

Base 10 Logarithms of Scales of Typical Objects in the Physical Universe in Units of Meters

Typical objects	Powers of 10 (meters)
Observable Universe (Quasars, etc.)	27
Super-clusters	25
Clusters of galaxies	24
Size of Virgo cluster	23
Distance to Andromeda galaxy	22
Milky Way diameter	21
Distance to Orion arm	19
Distance to the nearest stars	17
Size of the solar system	13
Venus, Earth, and Mars	11
Earth-Moon distance	9
Earth diameter	7
San Francisco	4
Human scale	0
Micro-Organisms / Hair Thickness	-4
Size of a red blood cell	-5
DNA Structure	-8
Carbon Nucleus	-14
Quarks	-16
Planck length	-35

Hanson and Fu designed their software by extending the powers-of-ten framework, shown for common objects in this table. Image Credit: Andrew Hanson, et al. © 2006 IEEE.

Because a normal "zoom" feature would take an impractical amount of time due to the vast precision required, Fu and Hanson used a new approach: power-scaled coordinates (PSC). The scientists were inspired by a film called "Powers of Ten" by Eames and Eames, which itself was based on the 1957 children's book *Cosmic View: The Universe in Forty Jumps* by Boeke.

"We asked ourselves, 'how do you provide that experience [of the

film]?'" said Hanson. "We extend that 'powers of ten' framework by making this system interactive instead of pre-computed and pre-stored."

Fu and Hanson's PSC system works by representing coordinates and vectors using logarithmic scaling methods, enabling the system to handle all scales in a single context for interactive control by the user. One of the novel PSC-based ideas in the architecture is a "depth rescaling method," which can project objects across extreme scales with the needed precision by distorting the vertices of distant background objects.

Also, to accelerate the rendering of objects during navigation, the system uses "environmental caching" and "object disappearance" to develop pre-rendered backgrounds and ignore objects that are not large or luminous enough to appear on the screen. On a desktop computer, the program achieves interactive speeds.

The content of the system—stars, galaxies, supernovae, etc.—comes from an extraordinary collection of data from exploration systems such as the Sloan Digital Sky Survey, the Bright Star Catalogue, Hubble and other telescopes. In their study, Fu and Hanson present a "powers-of-ten journey," starting, e.g., from Earth (10^7 m) up through the solar system (10^{13}), the Pleiades cluster (10^{18}), the Andromeda galaxy (10^{23}), and beyond (see figure).

Like previous computer graphics programs studying outer space, Fu and Hanson predict that this system could not only have use for astronomers and physicists studying the universe, but for educational and commercial purposes, as well. IMAX shows and planetarium presentations have excited young enthusiasts with their realistic animations, and as computational power continues to grow, the public can also benefit from Fu and Hanson's scale visualization technology.

"Our motivation was to create a framework for a real-time digital planetarium," said Hanson. "With this framework, we've created a series of layers of objects across an enormous scale range, all on a single screen."

Citation: Fu, Chi-Wing and Hanson, Andrew J. "A Transparently Scalable Visualization Architecture for Exploring the Universe." *IEEE Transactions on Visualization and Computer Graphics*, Vol. 13, No. 1, January/February 2007.

Citation: In 'forty jumps,' scientists model scales of quarks to quasars (2007, January 18) retrieved 19 April 2024 from
https://phys.org/news/2007-01-forty-scientists-scales-quarks-quasars.html