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IS THE UNIVERSE UNFOLDING AS IT SHOULD?

Yes, it is—
in the sky and on a computer screen near you

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Navarro, in front of an image from the Millennium Run.

by Shannon McCallum

Ask University of Victoria astrophysicist Julio Navarro what he did during his recent research sabbatical and he'll fill your head with terms like dark matter, galaxy clusters and black holes.

Oh, and he might mention how he helped create the universe.

A virtual universe, that is. Navarro is a member of the Virgo consortium, an international team of astrophysicists who earlier this year developed the largest computer simulation ever of the structure and growth of the universe. Known as the "Millennium Run," the simulation charts how the cosmos may have evolved since the Big Bang 13.7 billion years ago.

The consortium fed current information on the composition of the universe and the basic laws of physics to one of the largest supercomputers in Europe. One month and 500,000 trillion calculations later, out popped a universe that looks very much like our own.

According to current theory, the universe is a very strange place indeed. The matter we humans are familiar with makes up a scant five per cent of the universe. About a quarter is invisible "cold dark matter," which can only be observed by its gravitational effects on surrounding objects. The remaining 70 per cent is "dark energy," a mysterious force field that is causing the universe to expand at an ever-increasing pace.

"The amazing thing about the Millennium Run is that it shows for the first time that you can cook up a universe like the one we observe with very simple ingredients, even though we don't exactly understand the true nature of these ingredients," says Navarro, who helped conceive and design the simulation.

"For example, if we don't include dark energy, we produce a universe that looks quite different from ours. This tells us our theories are on the right track."

Simulations such as the Millennium Run are crucial for understanding what the universe is made of, where its structure came from, and how it evolved into the galaxies we see today. When combined with observational studies, simulations provide astronomers with powerful tools for probing the mysteries of the universe.

"Our simulation can guide future observational surveys," says Navarro. "For example, it can indicate where and when the earliest black holes would have appeared, so we can tell observational astronomers where to point their instruments.

"Furthermore, we now have a duplicate universe that we can experiment with, instead of passively observing."

The simulation also raises new questions about the Milky Way galaxy, home to our own solar system. This is why Navarro, a world leader in the study of galaxy structure and dynamics, is developing a new project—the Billennium Run—to simulate a single galaxy such as the Milky Way.

"As much as we think we know about the universe, we're always finding new problems to work on," says Navarro. "The universe does not give up its secrets easily."

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This article was written by Shannon McCallum, a student in the faculty of graduate studies, as a participant in the UVic SPARK program (Students Promoting Awareness of Research Knowledge).

SPARK

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UVic science and engineering researchers lead all comprehensive universities in Canada in size and number of science and medical grants per faculty member.

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- The Big Bang is the primeval explosion that most astronomers think gave rise to the universe as we see it today. The age of the universe is calculated by projecting the motion of galaxies backwards through time.
- Galaxies are clouds of stars, interstellar dust, gas and dark matter bound together by gravity. The observable universe contains an estimated 40 to 50 billion galaxies. Typical galaxies contain 10 million to one trillion stars, such as our sun.
- Julio Navarro is one of three UVic scientists to be named one of the world's most "highly cited researchers" by Thomson ISI. Citations are footnotes or references published within a scholarly paper that acknowledge the work and findings of others. Citation is an important way to measure a researcher's influence over time.
- In a 2003 *National Geographic* article, Navarro described how collisions may alter the appearance of a single galaxy as it makes its way through some 12 billion years of cosmic history. It's predicted that the Andromeda galaxy, for example, is now hurtling toward our Milky Way galaxy at about 300,000 miles an hour. But don't panic; it will take several billion years before the big collision.
- To see movies and graphics from the Millennium Run simulations, go to www.mpa-garching.mpg.de/galform/press/.