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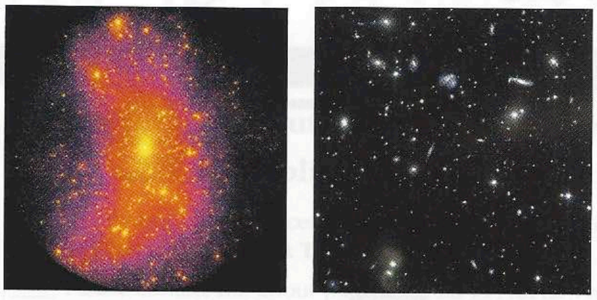
Northwest Collaboration to Explore Structure of the Universe

by John Armstrong

Look into the sky on any clear night, and the Universe is full of bright points of light: the visible gas and dust clumping together into planets orbiting stars, stars traveling in galaxies, and galaxies clustering like beads on a string, weaving through the void.

But on scales larger than any cluster of galaxies, matter in the Universe is smooth and evenly distributed—what cosmologists call homogeneous and isotropic.

The complexities we see in the spiral arm of a galaxy or the patterns in the galactic clusters give way to space uniformly filled with matter. The Universe is so well behaved at these enormous scales that astrophysicists now can use one number—the Hubble parameter—to characterize the expansion rate of the Universe and another to represent the average density of this matter.



(Left) The invisible Universe. This simulation of dark matter would be invisible to earth-bound observers, since we see only the luminous stars making up the galaxies. Source: Canadian Computational Cosmology Collaboration. (Right) The visible Universe: What we can see with our telescopes. Photo: Canadian Computational Cosmology Collaboration

"What used to be the holy grails of cosmology are getting nailed down," says University of Victoria astronomy professor Arif Babul, commenting on these fundamental parameters. These are the numbers that describe the Universe in which we live, "but once you know the Universe you live in, how do you go about getting the structure"—like galaxies and planets?

With massive computers, that's how. Babul, along with members of the Canadian Computational Cosmology Collaboration, or C4, plans to tackle this problem of structure formation with high-speed computers, using the microchip to simulate the creation of the macroscopic world. Babul and his colleagues will use state-of-the-art supercomputers to shed light on the formation of the visible matter in the Universe.

Somewhat perversely, most of our Universe is constructed from stuff we can't see. This invisible "dark matter" makes up about 90% of all matter in the Universe and, except for gravity, it doesn't interact much with the other 10%. But it does form the gravitational structure of all the visible galaxies in the Universe. The other matter—the stuff we can see—is primarily composed of gas and dust, which forms stars and planets, something of interest to Earth-bound astronomers.

"Right now, the state-of-the-art models dark matter," says UVic postdoctoral researcher and C4 collaborator Joachim Stadel. However, the group hopes to extend this by looking at how dust and gas interact with the gravitational structure imposed by the dark matter. By looking at the gas dynamics, "we can make [the model] physically realistic," he says.

"You can't get anything reasonable without getting the physics in there," says Babul.

"Getting the physics in there" is the challenge the group hopes to overcome with better computational methods and increased computing power. C4 boasts some of the largest computer clusters in the world, capable of simulating the creation of the Universe in a couple of months, according to Stadel.

With the creation of C4, the Pacific Northwest is a growing center of cosmology research, according to Babul, thanks to strong groups at the University of Washington and University of Victoria.

"What we hope to do is turn the Northwest into a powerhouse of cosmology," says Babul. The C4 group formed from an earlier cooperation between University of Washington and University of Victoria faculty members to develop a computer code to simulate the formation of galaxies in the Universe.

Over a year ago, according to Babul, the Canadian government called for collaborations with "national components and international ties."

"We already had an excellent collaboration with Washington. Why not tap into this fund to make something bigger and better?" asks Babul. Since that time, the collaboration has expanded, much like our own Universe, to include researchers from McMaster University in Ontario, University of Durham in England, and the Max Planck Center for Astrophysics in Germany.

> ***"With the creation of C4, the Pacific Northwest is a growing center of cosmology research"***
> ***— Arif Babul***

The collaboration continues to attract funding from both the United States and Canadian governments, says Babul, including the Canadian Foundation for Innovation, which provided grants for the group's massive computer systems.

In all, the collaboration has been building for seven years. According to Tom Quinn, UW professor of astronomy, the flux of staff and researchers through the two universities helps "keep the focus in the Northwest."

For Babul, the biggest challenge is finding funds for staff. But that's where the collaboration comes into play. "We have international support for staff through visiting scientist roles," says Quinn.

In addition to computing resources and researchers in theoretical astrophysics, the Northwest has a "local cadre of world class observers," says Babul, allowing the group to verify their computer simulations.

"This is a really exciting development for UVic and Washington," says Babul. When studying the formation of the Universe "borders don't mean much to us." ■

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