UVic KNOWLEDGE
RESEARCH AND DISCOVERY AT THE UNIVERSITY OF VICTORIA

DESKTOP GALAXIES:
Computers Model the Cosmos

By Kirsten Rodenhizer

Albert Einstein said the most incomprehensible thing about the universe is that it is comprehensible. For UVic astrophysicist Dr. Arif Babul the universe is becoming more comprehensible each day. In fact, he believes astronomers are on the brink of explaining the origin of the universe.

"Since the beginning of human civilization we have been wondering how the universe came into being, how life evolved...how it all came together," says Babul. "We are living on the threshold of being able to answer those questions. It's a euphoric feeling."

Babul researches how our universe evolved from an extremely smooth state into a rich network of galaxies. He describes poetically the texture of the universe, comparing it to a spider's web with delicate filaments, a bejeweled necklace or frothy bath water.

In the last two decades astronomers have been using more and more powerful tools to observe the universe. The Hubble Space Telescope captures light that has traveled across the universe for billions of years, revealing clues about the early formation of galaxies, stars and planets. The deeper into space astronomers probe, the closer they get to the point of origin—the "big bang."

Babul uses such observations to help develop theories of how the universe evolved and tests them with computer-based numerical simulations. Current theories suggest that the observed structures started out as tiny ripples that grew larger with time.

"Although the big picture is quite compelling, the details are not yet fully understood. If you use computer simulations to build a galaxy like our own Milky Way, current theories suggest there ought to be 1,000 satellite galaxies swirling around it," says Babul. "But when we look we barely see 10. Understanding the details of galaxy formation is the next frontier."

Babul, who was raised in Toronto and earned his PhD in astrophysics at Princeton University, also studies the formation of galaxy clusters—massive swarms of as many as 1,000 galaxies that also emit copious X-rays.

Using UVic's new "Beowulf Cluster" (39 off-the-shelf PCs interconnected to function as a massively parallel supercomputer) as well as computing power available through colleagues at the University of Washington, the University of Massachusetts, Harvard University and Ohio State University, Babul and collaborators are carrying out some of the largest, most complex numerical simulations of galaxy clusters ever undertaken.

The scientists create model universes and compare simulated galaxy clusters with actual clusters to gauge the accuracy of their theories.

Babul

"We're finding that although our model works well in a broad-brush sense, there appear to be elements missing from the picture," says Babul. "Our goal is to discover the missing physics and come up with creative solutions other people haven't thought of."

Babul receives a large portion of his funding from NSERC (Natural Sciences and Engineering Research Council of Canada) and he notes astronomy research has broad benefits.

"Astronomers are constantly innovating and pushing the 'high-tech' envelope. The resulting products—ultra-sensitive detectors, advanced data-mining tools or highly sophisticated simulation software—find a number of other practical applications that generate tremendous economic returns."

For Babul, however, astronomy is fundamentally a curiosity-driven endeavour. It seeks to answer questions about the past, present and future of the universe—questions that strike a chord deep within the human psyche.

"One cannot help but be amazed at progress we have made in the last hundred years, yet with every step forward we are confronted with the realization of just how vast the universe is and how little we know. Nothing can be more humbling."

A class to stretch & bend the mind

It's a course "guaranteed to stretch and bend your mind in unimaginable ways."

Dr. Babul's physics course for non-science students (Physics 303: Origin of Space, Time and Matter in the Universe) shares the "wild, weird, exciting and often bizarre world" at the frontiers of physics and astronomy, a world of black holes and wormholes, of warped space and time.

"Since the very beginning, people have been fascinated with questions about time and space, about the fundamental nature of matter, about creation," says Babul. "And now that we are starting to put some pieces of the puzzle into place, I believe that it is extremely important that scientists share our discoveries and our excitement with society as a whole. This course is my contribution."

Participants in the course are encouraged to be creative by producing, for example, Web pages, a coffee table book, or sculptures that reflect some of the notions underlying the story of the big bang.

A display case in the Elliott Building contains elaborate group projects including twine woven inside wooden rings to accurately represent the shape of the universe.

FACTS FROM THE EDGE

- **UVic's Climenhaga Observatory**, on the roof of the Elliott Building, is a campus landmark distinguished by the happy face painted on its dome. Pranksters first painted the eyes in 1969, a smile was added later. The happy face is repainted regularly.
- **The observatory is named** for Dr. John L. Climenhaga, founder of the UVic physics department. The 0.5-metre, computer-controlled telescope system is mainly used for observing variable stars (stars that periodically change brightness) and for searches for planets beyond our solar system.
- **37 variable stars and six asteroids** have been discovered at the Climenhaga Observatory.
- **83 per cent of UVic astronomy PhD holders** remain in astronomical research or teaching—the highest ranking among Canadian, American, Australian and Dutch graduate programs, according to a study published last year by the American Astronomical Society.

SHARPEN YOUR KNOWLEDGE

- Visit Arif Babul's Web site at **http://almuhit.phys.uvic.ca/~babul/Arif/**
- The Dominion Astrophysical Observatory in Saanich has public outreach information on the Web at **www.hia.nrc.ca/outreach/**
- See the latest Hubble Space Telescope images from deep space at **www.stsci.edu**
- A great site for general astronomy information is hosted by the Royal Observatory Greenwich at **www.rog.nmm.ac.uk/**

ON THE EDGE OF YOUR SEAT

President's Distinguished Lecture:
Dr. Jeremiah Ostriker, Princeton University
August 25, 7:30 p.m.
University Centre, Farquhar Auditorium.

Dr. Ostriker is Provost of Princeton University and former director of the Princeton Observatory. He is considered one of the world's leading theoretical astrophysicists and co-authored the first study to advance the theory of "dark matter," now a major topic in cosmology. Free. Info: 721-7700.

UVic writing grad Kirsten Rodenhizer wrote this story as a participant in the SPARK program (Students Promoting Awareness of Research Knowledge), funded by the Natural Sciences and Engineering Research Council of Canada.

SPARK
Students Promoting Awareness of Research Knowledge

EDGE/WISE Seeing in the dark

Another of Arif Babul's projects that calls for creative thinking is the study of dark matter. One of the key mysteries in astronomy, this invisible matter may account for 80 per cent or more of all matter in the universe.

When light beams travel through the universe, they bend and deform when they encounter the gravity of matter formations. By studying light distortions in images of distant galaxies, Babul can estimate the properties of the formations the light traveled past.

"We ask, what did it take to stretch or bend the light, and then use that information to map dark matter."

Babul compares mapping dark matter to mapping a mountain range. "If you were looking at the mountains and could only see the snowcaps, those snowcaps would be like the galaxies and the rest of the terrain would be the dark matter."

Babul is gathering radio telescope images of distant galaxies from large sections of the sky and analyzing them for possible distortions.

"We are the first to look at matter distribution on scales as large as this," he says. "The preliminary results suggest that dark matter formations are distributed much as we predicted, but they are much larger than we originally thought."