Astronomy

From San Diego at a meeting of the American Astronomical Society.

Modeling the whole universe

They've got the whole world in their computer.

For the first time, cosmologists have harnessed enough computing power to model the entire observable universe. Beginning 1 billion years after the Big Bang, when the cosmos was almost perfectly smooth and uniform, the simulations trace the action of gravity as tiny fluctuations in density of matter that develop into a spidery network of huge filaments and voids.

The models depict the growth of huge clumps of matter over volumes of space hundreds of times bigger than the largest new telescope surveys will examine. Indeed, the project previews the biggest structures that the Sloan Digital Sky Survey and other huge surveys may discover, says August E. Evrard of the University of Michigan in Ann Arbor.

Astrophysicists believe that stars and galaxies comprise but a small fraction of the cosmos. The vast majority of matter is thought to be in some invisible, undescribed form called dark matter. The new simulations follow a type of slow-moving dark matter, cold dark matter, whose ability to gather into clumps is believed to hasten the formation of galaxies. Unlike ordinary matter, which is sensitive to electromagnetism and other natural forces, dark matter is influenced only by gravity.

Previous simulations had tracked the development of some 2 million chunks of dark matter, each millions of time larger than the most massive galaxies. These models painted with so broad a brushstroke that they could not portray details of the cosmic structures. Evrard came up with the idea of running more accurate simulations by using in parallel all 512 workstations of one of the most powerful supercomputers, located at the Garching Computing Center of the Max Planck Society in Germany. It took a year of preparation and months of running time for an international team of scientists known as the Virgo Consortium to perfect the models.

In a second set of simulations developed by the consortium, cold dark matter takes a back seat to the energy associated with the cosmological constant (SN: 5/30/98, p. 344). This term in Einstein's equations of general relativity acts to accelerate the expansion of the universe. Recent observations of distant supernovas and the clustering of galaxies support the existence of the cosmological constant. A preliminary analysis of the new model shows an abundance of distant, massive clusters, in good agreement with the observations.

Evrard notes that none of the simulations show the locations of clusters of galaxies or other luminous material, although such objects are often assumed to form within the densest concentrations of the dark matter. To directly incorporate galaxy formation, the models would have to include effects other than gravity, notably gas pressure, heat, and radiation.

The new models are "a stunning technical tour de force," says Richard Mushotzky of NASA's Goddard Space Flight Center in Greenbelt, Md. "Researchers have been struggling for many years now to model the [entire] universe. . . . Whether it changes our understanding of the universe or not, we just don't know yet." —*R.C.*

Virgo Consortium

Model of the universe, presented here as four diagonal strips with time running from left ot right, shows the development of structure from early times, when the cosmos was just 1 billion years old (top left), to the present (bottom right).

So cool, and some are still stars

"Oh, Be a Fine Girl (Guy), Kiss Me."

That line may get your face slapped in a singles bar, but it's an old standby in astronomy textbooks.

In the stellar realm, those words of wisdom are a mnemonic device for the sequence of letters OBAFGKM. Each letter stands for one of the seven standard classes of stars, in order of descending temperature. At birth, O stars rank as the most massive and the hottest, while those in the M class have been thought to be the least massive and the coolest.

After surveying 1 percent of the sky at the near-infrared wavelength of 2 micrometers, researchers report that they have discovered a class of heavenly bodies cooler than M stars. The 20 newly identified bodies, dubbed L dwarfs, have less than one-third the temperature of the sun and less than one-tenth its mass, note J. Davy Kirkpatrick of the California Institute of Technology in Pasadena and his colleagues.

Spectra of the L dwarfs, taken with the Keck II Telescope on Hawaii's Mauna Kea, reveal that six are failed stars known as brown dwarfs. Another four may also be brown dwarfs. The other 10 are presumably bona fide stars.

Astronomers knew that such low-mass stars existed but hadn't classified them as a distinct type. The spectra reveal, however, that L dwarfs have atmospheres rich in iron hydride and chromium hydride. In contrast, M stars are rich in metal oxides. The L dwarfs therefore constitute a new class.

"This is the first new spectral class in more than 50 years and will mean that . . . astronomy textbooks will have to change," notes Gibor S. Basri of the University of California, Berkeley. The number of observed L dwarfs within an estimated few tens of light-years of the sun suggests that "there are gobs of them out there," says Kirkpatrick. Some may lie nearer the sun than does Proxima Centauri, the closest known star.

To include the L dwarfs, Kirkpatrick suggests a new mnemonic: "Oh Be A Fine Girl (Guy), Kiss My Lips." —*R.C.*

Revving up a neutron star

Like souped up lighthouses, millisecond radio pulsars rotate hundreds of times a second, sending out a radio beacon that sweeps across the sky. Ever since the first millisecond pulsars were discovered in the early 1980s, astronomers have suspected that these compact beasts—rapidly whirling neutron stars—acquired their spin during an earlier stage of evolution, when they stole matter from a companion star.

Such activity should reveal itself by the emission of X rays, generated when the stolen material heats up and spirals onto the neutron star. The intensity of X rays should fluctuate at a rate related to the neutron star's spin.

After 15 years of searching, astronomers have finally confirmed that scenario. Recent observations with the Rossi X-ray Timing Explorer spacecraft revealed a pair of stars whose X-ray emissions vary in intensity every few thousandths of a second. One of the stars is a neutron star.

Astronomers suggest that the X rays will be generated only as long as material continues to fall onto the neutron star. They propose that when the transfer is complete and the star has revved up to its maximum spin, the system will switch on as a millisecond radio pulsar. Radio waves cannot be detected before then because they cannot penetrate the infalling material.

Frederick K. Lamb of the University of Illinois at Urbana-Champaign cited the findings in an overview talk but had not taken part in the study. In an upcoming Nature, Rudy Wijnands of the University of Amsterdam and the Center for High Energy Astrophysics in Amsterdam and Michiel van der Klis of the University of California, Berkeley detail the discovery. In an accompanying article, Deepto Chakrabarty and Edward H. Morgan of the Massachusetts Institute of Technology interpret the results. —*R.C.*