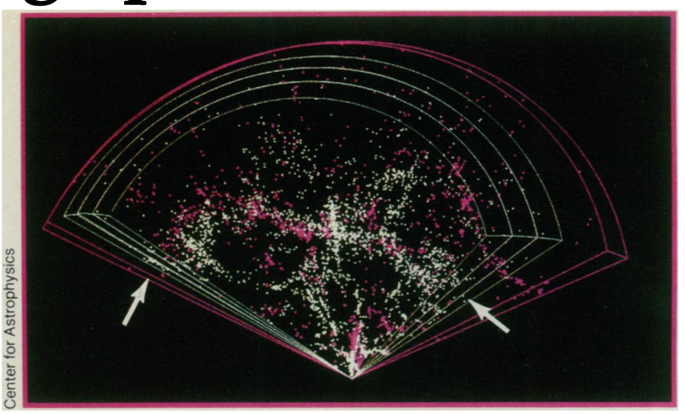
Cosmic Cartographers Find 'Great Wall'

Two astrophysicists mapping the locations of galaxies have found the largest structure known in the universe – a thin sheet of galaxies half a billion light-years long. Dubbed the "Great Wall," it lies 200 to 300 million light-years from Earth and challenges the prevailing view of how matter became distributed in the universe, they say.

Astronomers have long assumed that on a very large scale, any place in the universe should contain the same amount of matter as any other location. Just as a choppy ocean looks smooth from a space shuttle, the universe as a whole should appear uniform, despite occasional small structures like galaxies.



Computer image gives 3-D view from the "top" of the "Great Wall" (between arrows) and the nearly empty "bubbles" it outlines. White dots show galaxies in three adjacent areas; pink dots depict a fourth region. Earth lies at the vertex.

The astronomical survey, conducted by Margaret J. Geller and John P. Huchra of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., looks at larger slices of the universe than any previous survey. Even at this scale, galaxies group together in surprisingly coherent arrangements, they report in the Nov. 17 SCIENCE.

Guided by a two-dimensional map made in the 1960s, Geller and Huchra have mapped more than 11,000 galaxies in a wedge of the northern celestial hemisphere, measuring the redshift of each galaxy brighter than magnitude 20.5 to pinpoint its location in three dimensions. The redshift indirectly indicates an object's distance from Earth. Their ongoing survey now covers 1/100,000 of the volume of the visible universe – comparable to a world atlas describing only Rhode Island.

Stretching dramatically across the map is the Great Wall, a galaxy cluster 500 million light-years long, 200 million light-years wide and 15 million light-years thick. The vast bubbles it outlines – nearly empty stretches of space 150 million light-years in diameter – are equally important. "It may make more physical sense to regard the individual voids as the fundamental structures" of the universe, Geller and Huchra write. These voids threaten one theory describing the nature of dark matter – the hypothetical material that caulks the gap between the amount of material astrophysicists detect in the universe and the much greater quantity they know must exist. Without dark matter to make up the difference, gravity couldn't hold stars and galaxies together.

Most astrophysicists believe dark matter is slow-moving, or "cold." In this standard model, galaxies form at denser regions of dark matter, as foam gathers at the tip of a wave, Geller and Huchra say. But the vast size of the newly mapped voids doesn't match the calculated distribution of cold dark matter, they report. Thus, the theory is missing "something profound," Geller says.

Not so, responds theoretical astrophysicist James E. Gunn of Princeton (N.J.) University. "I think [the new finding] actually poses no problem at all," he says. Last summer, Gunn and two graduate students modeled the growth of a universe containing cold dark matter. Their computer models simulated large voids and "remove any doubt" that these structures are compatible with the theory of cold dark matter, Gunn says.

Since Geller and Huchra reported their first results nearly four years ago (SN: 1/18/86, p.38), many other astrophysicists have started their own mapping projects, some scrutinizing different regions of space and others looking at already-mapped regions in more detail, Geller says. But until surveyors map a region vast enough to show conclusively whether matter is evenly distributed, she says, they cannot accurately describe the structure of the universe. – *A. McKenzie*

Quasar illuminates the most distant past

A team of astronomers has identified the most distant object now known in the universe – a quasar that was already emitting vast quantities of light only a billion years after the Big Bang. The discovery that such an object existed so early in the universe's history imposes severe constraints on theoretical models of how the universe evolved and how galaxies formed.

The astronomers determined the object's distance by measuring its light spectrum. As seen by Earth-based observers, light from distant objects is shifted to the red end of the spectrum. The more distant the light source, the greater this change in wavelength appears.

The record-breaking quasar, one of five high-redshift quasars recently found by Donald P. Schneider of the Institute for Advanced Study in Princeton, N.J., James E. Gunn of Princeton University and Maarten Schmidt of the California Institute of Technology in Pasadena, has a redshift of 4.73. It is so far away that its light takes more than 10 billion years to reach the Earth. The astronomers report their discovery in the December ASTRONOMICAL JOURNAL.

The discovery of a quasar with such a high redshift suggests that galaxies with massive black holes at their cores already existed when the universe was less than 7 percent of its present age. Moreover, the fact that astronomers have so far detected no obvious differences between light spectra from nearby and more distant quasars implies that galaxies in the distant past contained roughly the same materials as later galaxies.

"Considering how far away and therefore how far back in time these things are, it tells you that the elements were already in place in abundances similar to those we seem to see in our own neighborhood," says Patrick S. Osmer of the National Optical Astronomy Observatories in Tucson, Ariz.

These findings increase the difficulty of reconciling the extraordinary smoothness of the cosmic background radiation – heat left over from the creation of the universe – with the lumpiness of matter as it now appears in the form of galaxies (see adjacent story). By shortening the time in which the transition from smoothness to lumpiness must take place, the new observations effectively rule out a variety of theoretical models for the development of structure in the universe. For many cosmologists and astrophysicists, it's back to the thinking phase. – *I. Peterson*