An End to Modernity

An End to Modernity is a representation of the Big Bang and the expanding Universe in the form of a chandelier, 11'6" high and 14'4" across, weighing 700 lbs. The center of the sculpture is a 28" sphere of chrome-plated aluminum, hanging at eye-level, 6' above the ground. The sphere supports 230 rods, also made of chrome-plated aluminum, which range in length from 36" to 72". Seventy-five of these rods terminate in lamps, which represent quasars. The remaining 155 terminate in clusters of hand-formed glass disks and hand-blown glass globes, which represent clusters of galaxies. There are 932 galaxies and a total of more than 2500 parts.

The structure of *An End to Modernity* follows a series of rules developed by the artist, Josiah McElheny, and astronomer David Weinberg of Ohio State University, designed to represent scientific knowledge about the history of the Universe. The particular pattern of rods, clusters, and lamps was generated by a series of computer programs that created a random realization of these rules. The rods emanate from the central sphere in randomly chosen directions, subject to the mechanical constraints of a minimum hole spacing on the sphere and non-interference between clusters at the rod ends. Rod lengths are randomly selected in the range 36"-72", with a mild bias towards longer lengths, and the additional constraint that the envelope of the sculpture is an ellipsoid with an aspect ratio of 5:4. This ellipsoidal shape becomes evident when one views the sculpture from a distance, and its form echoes common visual representations of the world, the galaxy, and the cosmos.

Glass disks represent the most common form of galaxies, like the Milky Way, in which most stars follow well aligned circular orbits around the galaxy center. Glass spheres represent elliptical galaxies, in which stars follow randomly oriented orbits that fill a spherical or ellipsoidal volume. Elliptical galaxies are thought to form from the collisions of disk galaxies, in which chaotic gravitational tugs scatter stars onto disordered orbits. They are rarer than disk galaxies overall, but the most massive galaxies in the Universe are predominantly elliptical. The glass disks and spheres come in three sizes, ranging from 1.5" to 2.75" in diameter. Each galaxy is supported by its own thin aluminum rod, and the galaxies of an individual cluster emerge in random directions from a drilled sphere of chrome-plated stainless steel. The steel spheres themselves have no particular physical significance.

The structure of *An End to Modernity* is based on a mapping between space and time in which the central aluminum sphere represents the Last Scattering Surface, half a million years after the Big Bang, and the outer edge represents the present day, some 14 billion years later. Between these two boundaries, every 7.2" represents a factor of two expansion of the cosmos. The rules that govern the clusters and lamps depend on the length of the supporting rod, and hence the cosmic epoch at its termination point.

Specifically, the rods are divided into four zones, each 9" in depth. Zone One (36"-45") represents the era of "first light," when the first galaxies and quasars formed. Zone Two (45"-54") represents the end of the "dark ages," when ultraviolet light from these galaxies and quasars reached the intensity required to ionize most of the hydrogen atoms in the Universe. Zone Three (54"-63") represents the "quasar era," in which supermassive black holes shone brightly and grew rapidly by swallowing gas from their host galaxies.

This is also the era in which the largest galaxies experienced most of their growth and star formation. Zone Four (63"-72") represents the "large scale structure" era, marked by the clumping of galaxies into extended, filamentary superclusters under the influence of their mutual gravity. Smaller galaxies continued to grow rapidly during this era, but the quieter evolution of massive galaxies led to slower growth of supermassive black holes. Astronomers usually refer to cosmic epochs in terms of the "redshift", denoted z, which describes the stretching of light that reaches Earth from objects at that epoch. In these terms, Zone One corresponds to the redshift range $z = 31$ to $z = 12.5$, Zone Two corresponds to $z = 12.5$ to $z = 4.65$, Zone Three corresponds to $z = 4.65$ to $z = 1.38$, and Zone Four corresponds to $z = 1.38$ to $z = 0$.

Zone One clusters contain 1-3 galaxies, all of them disks of the smallest size. Zone Two clusters contain 3-5 galaxies, again all small disks. Zone Three clusters contain 5-8 galaxies and come in two types. The poorer clusters, with five or six members, have a random spatial distribution of disk galaxies, some small and some intermediate in size. The richer clusters, with seven or eight members, have a two-component structure, with four galaxies in a compact, spherically distributed core and the remaining galaxies lying along an extended filament. This structure reflects the typical pattern of large scale clustering in the Universe, with dense clumps residing at the intersections of filamentary superclusters. The dense clumps tend to have a larger fraction of elliptical galaxies, while the extended filaments are populated mainly by disks. In the Zone Three clusters, the filaments are populated by small and intermediate disks, while the dense clumps have a mixture of disks and spheres, including, for the first time, some objects of the largest size.

Continuing these trends, the Zone Four clusters are the largest and most complex, with 8-15 members. The poorer clusters, with eight or nine members, have a filamentary distribution, a mix of all three sizes of disks, and a small fraction of large spheres. The richer, 10-15 member clusters again have a two component structure, with half of the galaxies in a dense central clump and half in an extended filament. The fraction of elliptical galaxies steadily increases as the Universe gets older, allowing more time for galaxies to collide and for star formation to consume all of the available gas. The richer Zone Four clusters incorporate in detail the observed correlations between galaxy shapes, sizes, and environments. Most of the largest galaxies reside in the central clumps, where galaxy collisions have been most common, and most of them are spheres. The smallest galaxies in the dense clumps are all spheres, while the smallest galaxies in the extended filaments are all disks, again following observed trends. Intermediate sized galaxies are predominantly disks in the filamentary environment and an even mix of spheres and disks in the dense clumps.

The evolutionary trends of the observed quasar population are represented by both the number and brightnesses of the quasar lamps, which come in three different wattages. Thirty of the 75 lamps occupy the Zone Three "quasar era," and they are equally distributed between the intermediate and bright wattages. There are fifteen quasar lamps in each of the remaining zones. All of the Zone One lamps are faint, reflecting the small size of black holes at the earliest epochs. The Zone Two and Zone Four lamps are equally distributed between the faint and intermediate wattages, with bright lamps absent in the

former case because the largest black holes have not yet had time to grow and in the latter case because they are no longer rapidly swallowing gas.