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# Cosmos between matter and light
## A general guideline to a cosmology in space and counterspace

### Cosmological Principle

In the beginning of the 20th century, modern cosmology was established on the base of the *Cosmological Principle* of Astrophysics. When Albert Einstein (1879–1955) began applying his general theory of relativity to cosmology, he made a daring assumption: Over very large distances the universe is homogeneous, meaning that every region is the same as every other region, and isotropic, meaning that the universe looks the same in every direction. In other words, if you could stand back and look at a very large region of space, any one part of the universe would look basically the same as any other part, with the same kinds of galaxies distributed through space in the same way. On the basis of Einstein's field equations of general relativity, Alexander Friedmann (1888–1925), Georges Lemaître (1894–1966), Howard Percy Robertson (1903–1961) and Arthur Geoffrey Walker (1909–2001) developed the *Standard Model* of modern cosmology describing the evolution of a homogeneous and isotropic expanding or contracting universe. The *Big Bang Theory* of the universe was born.

Up to the present, the Cosmological Principle and its models were and are used to describe the structure and evolution of the universe and to interpret observational data. It still remains an assumption for which there are on one side supporting arguments and on the other side contradictory observations.

### Structures of the universe from small to large scales

The homogeneous mass distribution in the universe on largest scales is given as one supporting argument for the Cosmological Principle. Standing on the ground of the Earth and looking into the clear sky we see the Sun, the Moon, the planets, the constellations of the zodiac, the remaining constellations, the Milky Way and the comets. From this naturally given point of view the cosmos is neither homogeneous nor isotropic.

Nicolaus Copernicus (1473–1543) removed the exceptional position of the Earth at rest in the centre of the universe. In his epochal book, *De revolutionibus orbium coelestium*[1], published just before his death in 1543, he introduced the heliocentric system with the Sun in the centre and the Earth revolving around the Sun and rotating around its own axis. On the scale of up to 30 astronomical units[2] the Earth belongs to the planetary system of our Sun.

Our planetary system is surrounded by billions of stars and completely encircled by the band of the Milky Way. In the 18th century astronomers discovered that the stars in the sky together with the Sun—the star of our own planetary system—are part of an enormous disk of stars, the Milky Way Galaxy. One of the first to come to this conclusion was William Herschel (1738–1822). But where within this disk is our own Sun? Until the 20th century the prevailing opinion was that the Sun and planets lie at the Galaxy's centre. During the First World War, Harlow Shapley (1885–1972) determined the diameter of the Milky Way Galaxy and recognised later on that the Sun revolves around the centre of the Milky Way. Just as Copernicus showed that the Earth was not at the centre of the solar system, Shapley and his successors showed that the solar system lies neither in nor even near the centre of the Galaxy. Modern-day measurements determine the diameter of the Milky Way Galaxy to 50 kiloparsecs[3] and the distance between the Sun and the centre of the Galaxy to 8 kiloparsecs.

There are millions of galaxies in the universe. The Andromeda Nebula and the two Magellanic Clouds near the South Pole are the only galaxies in the vicinity of the Milky Way Galaxy, which can be seen by naked eye observation. Galaxies form clusters and superclusters that are separated by immense voids, creating a vast foam-like structure. Before 1989 it was

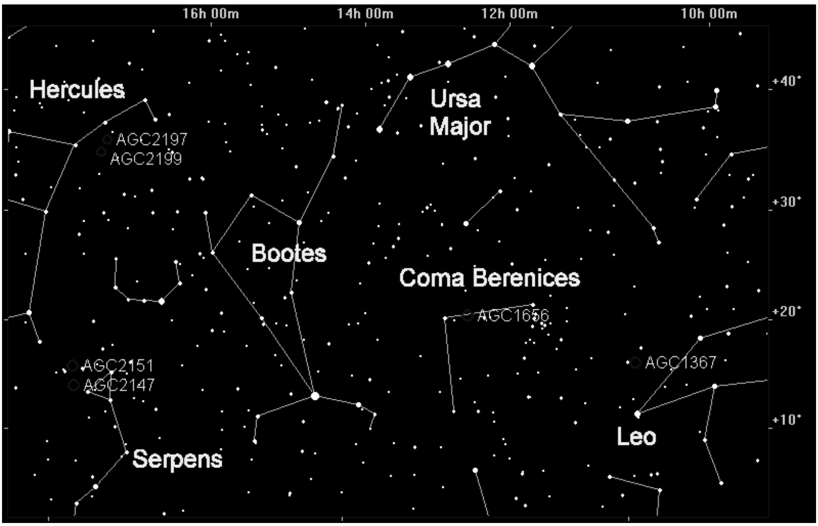


**Figure 1: Constellations between Hercules and Leo. The (Abell) galaxy clusters (AGC) are marked.**

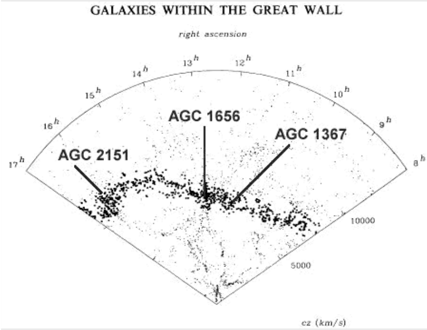


**Figure 2:**
**Margaret Geller and John Huchra analysed the first three sections of the Harvard-Smithsonian Center for Astrophysics redshift survey in the late 1980's, they discovered the largest known structure in the universe: the Great Wall. This giant sheet or filament of galaxy clusters stretches across eight hours of right ascension from Leo to Hercules (see also Figure 1).**

commonly assumed that galaxy clusters were the largest structures in existence, and that they were distributed more or less homogeneously throughout the universe in every direction. However, in 1989, based on red shift survey data, Margaret Geller (* 1947) and John Huchra (* 1948) discovered the *Great Wall*, a sheet of galaxies more than 500 million light years long and 200 million light years wide, but only 15 million light years thick. See Figure 1 and 2. In April 2003, another large-scale structure was discovered, the *Sloan Great Wall*. One of the biggest voids in space is the *Capricornus Void* with an estimated diameter of 230 million light years. In August 2007, the *Eridanus Supervoid* was discovered at a diameter of about one billion light years. It is much larger than any other known void and represents a challenge for current theories of the origins of the universe and particularly for the Cosmological Principle.

## Hubble Law

The motions of distant galaxies reveal that they are moving away from us and from each other. The recessional velocity of the galaxies is observed from the Earth by measuring their red shifts. The shift in colour toward the red end of the spectrum is caused when a source of light or of colour is moving away from the observer.

The equal recessional velocities of the galaxies in every direction as well as the isotropic cosmic microwave background of 2.725 Kelvin[4] support the Cosmological Principle.

The *Hubble Law* relates the recessional velocity of a galaxy to its distances from the Earth: If a galaxy is twice as far away, it is receding twice as fast; if it is three times as far away, it is receding three times as fast; and so on … This property of the Hubble law is called proportionality in mathematics and also supports the Cosmological Principle.

## Cosmology in space and counterspace

When John Huchra was asked in 1987 about the difference between theory and observation he said:

> *… So theorists and observers need to interact; they need to guide each other. Sometimes the theory paces the observations. That was certainly the case when we started doing the redshift survey stuff back in the mid-70s—the theory was way ahead. The theory of what there ought to be was way ahead of what the observations were. We had no data. Right now, temporarily, the situation is reversed. Right now we have more data than the theorists are happy trying to explain. (Lightman and Brawer, p. 390–391.)*

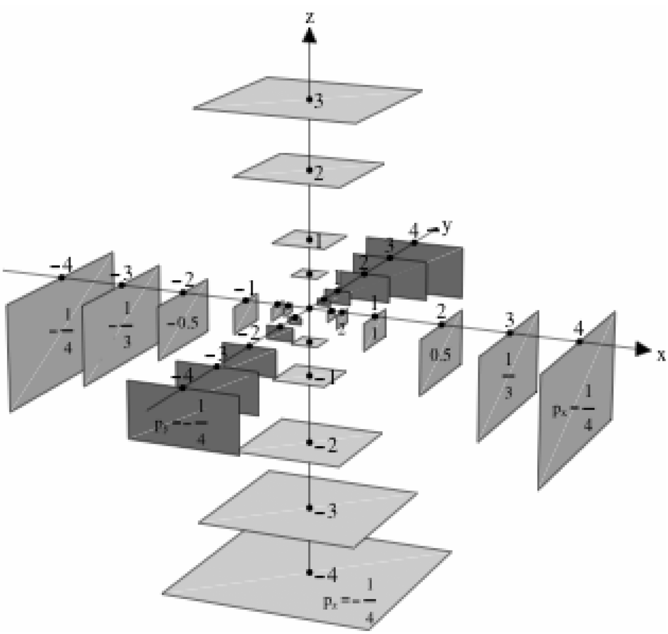


**Figure 3:**
**Coordinate system in space. If a point (or a cube) moves along a fixed line in equal steps into any fixed direction, it will approach the infinitely distant plane of space. Compare with Figure 4. [(x, y, z) are the coordinates of a point, (px,, py, pz) are the coordinates of a plane. The coordinates of points and planes are reciprocal to each other: px=1/x, py=1/y, pz=1/z.]**

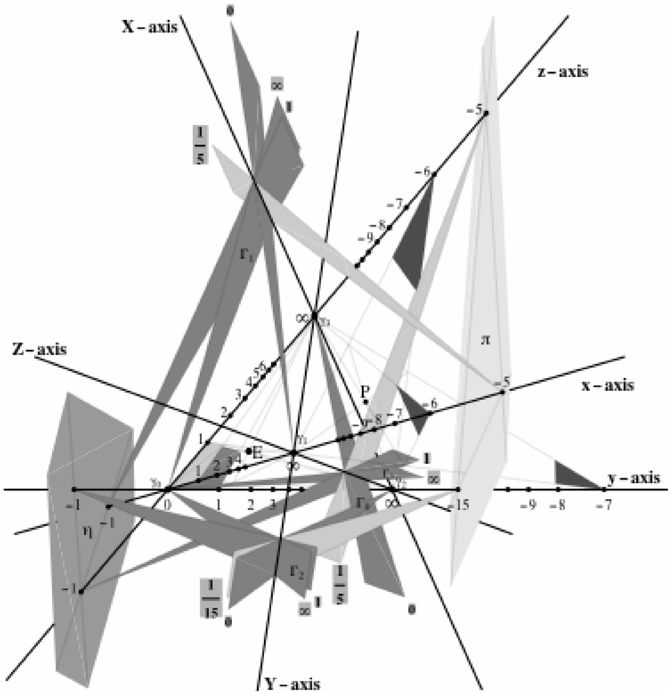


**Figure 4:**
**Projective coordinate system in space. The projective point-coordinates are indicated along the x-axis, the y-axis and the z-axis. *Γ*0 represents the plane at infinity in the space of points. If a point (or a cube) moves along a fixed line in equal steps into any fixed direction, it will approach the infinitely distant plane of space, i.e. *Γ*0. [The projective plane-coordinates are indicated around the X-axis, the Y-axis and the Z-axis, and are put on a gray background. γ0 represents the point at infinity in the space of planes.]**

It seems that the data of the observers are still challenging the current theories of the origins of the universe. The standard model of cosmology is almost 90 years old. It could be that the time is now ripe to improve cosmology by taking up the new impulses of projective geometry. These are characterised by the facts, that projective geometry a) includes the infinitely distant elements of space and b) is shaped by the principle of duality. Both, duality in the sense of projective geometry and the infinitely distant elements of space play an inferior role in the current standard model of cosmology.

Nevertheless it is interesting to see that the Cosmological Principle relates to the plane at infinity without being aware of it. In the framework of projective geometry it becomes clear that any homogeneous structure of the universe distinguishes the infinitely distant plane. See Figure 3 and 4. This can be understood as a hint to not only describe the evolution of the universe from the point of view of space where points are elementary and planes two-dimensional, but complement it with a description from the point of view of counterspace where planes are elementary and points two-dimensional. All current theories are only using points as elements.

## Points represent matter—planes represent light

It is clear for points that they can represent the centres of masses of an atom, of a molecule or of any other physical body. So points are related to the matter of the universe. But what may planes represent in the universe? If we move from a central point, let's say the Earth, into every direction to infinity we end up in the plane of infinity. The Hubble Law indicates that the entities, which recede from the Earth, become more and more light-like the farther away they are. Following this gesture we could say, that the plane at infinity represents the origin of light in the sense that there exists no physical body but only pure light.

## Darkness as a form of light

This of course is challenging our understanding of light, since we do not observe bright light but darkness in the depths of the universe. Modern natural sciences do not distinguish between no light and darkness as Goethe did it in his Theory of Colours. Our proposal here is that we find pure light in the form of darkness at infinity.

The task is thus to formulate the evolution of the cosmos between matter and light by using not only the point of view of space but also the point of view of counterspace.

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## Noter

1: *On the Revolutions of the Celestial Spheres*

2: 1 astronomical unit = 1 AU = average distance from the Earth to the Sun = 149.6 million kilometres.

3: 1 kiloparsec is a measure of distance equal to 1000 parsecs, or about 3000 light years.

4: The microwave background appears slightly warmer than average toward the constellation of Leo and slightly cooler than average in the opposite direction toward Aquarius. The difference to the average of 2.725 Kelvin is only 0.0033 Kelvin or less.