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# The birth of galaxies

## The Big Bang and the birth of galaxies

If the universe shows us an expansive motion, it is natural to suppose that, if we would be able to rewind at the same speed the tape of this expansion, all the matter that composes the Universe would come back to form the first cluster, very dense and really hot. This experiment of thought encouraged, in the Forties, the physicist G. Gamow to elaborate the Big Bang or standard model theory. According to his theory, about 15-20 billions of years ago, the Universe was characterized by an incredibly high temperature and density state, concentrated in a very small place.

In an infinitesimal time, it started to expand itself to an enormous speed, decreasing temperature and density, until it reached the current dimensions and aspect.

This model allows to explain several observations, like the universal abundance of lighter atomic nuclei (hydrogen, helium, deuterium, lithium) and the existence of a cosmic microwave background radiation. But let's try to examine the evolution of our Universe dividing it into phases, to make easier our comprehension of this phenomenon.

***Phase 1***

This first phase is extended from the instant t=0 to the instant t=5,39 x 10-44 (also called Time of Planck). In this phase, probably, the four interactions of the physics, strong and weak nuclear, electromagnetic and gravitational, were probably unified. In this instant, temperature was incredibly elevated (T= 1032 K) while the Universe itself was just a mathematical singularity.

***Phase 2***

The gravitational interaction breaks apart from the other three fundamental interactions, still unified according to the Great Unification Theory or GUT.

In the present moment, the Universe is full of radiation of mutual interaction, that means in thermal balance, with electrons and neutrinos.

***Phase 3***

Little by little, with the decreasing of temperature (T=1027 K), the bariogenesis process starts, which causes the prevail of the matter on the antimatter. The Universe is made of quarks, leptons and corresponding particles, gluons and bosons.

***Phase 4***

We observe the separation of the electroweak interaction in weak and electromagnetic. The Universe is dominated by quarks, leptons, photons, neutrinos and dark matter.

***Phase 5***

Only at 10-4 s after the Big Bang, protons and neutrons are generated, which remain in thermodynamic balance with electrones and neutrinos.

***Phase 6***

About 0,7 s after the Big Bang, neutrinos separate from the remaining part of the matter, creating a neutrinos fossil reaction that we still can see.

***Phase 7***

When the Universe has got about 3 minutes of life, the formation of light nuclei, like 2H, 3He, 4He and 7Li is completed. At the end of these first three minutes, the Universe is dominated by the presence of protons, neutrons, light nuclei, neutrinos and dark matter.

***Phase 8***

When the Universe was 300.000 years old, the radiation separated from the matter. This radiation arrived till us, actually named cosmic microwave background radiation. From this moment, it is possible to make direct observations, because the Universe becomes transparent to this radiation.

***Phase 9***

After some hundreds billions of years, temperature decreases until 4000 K. Small fluctuations of density may start to attract gravitationally the surrounding matter, creating protogalaxies (giant clouds of extremely cold gas), and then of galaxies and cluster of galaxies. After 4 billions years, the first stars appeared.

## Cluster and supercluster of galaxies

he structure of our Universe seems like a kind of sponge. As a matter of fact, the measurement of the placements of thousands of galaxies showed us that they are not equally arranged. On large-scale, the Universe is composed by groups of galaxies, called clusters, creating all together giant and flat thickenings. They are divided by immense and empty regions.
Moreover, many galaxy clusters are involved in overall motions towards other large clusters, called attractors, because of their gravitational force.
The birthplace of this large-scale structure seems to be hidden in very small unhomogenities in the initial matter distribution. After the Big Bang, on a chronological time of billions of years, the gravitational forces would have condensed the matter, creating at first the galaxies, then clusters and superclusters, and in the end the larger structures, like the attractors.
Before 1989, scientists supposed that supercluster represented the largest structures in the whole Universe, equally placed everywhere in the Universe. Instead, in 1989, Margaret Geller and John Huchra discovered a real wall of galaxies, extended for more than 500 millions of light years, large 200 millions, with a thickness of 15 millions. They called it "Great Wall".

## The Hubble’s Law

In 1929, Hubble saw 18 galaxies, also estimating their distance. He also discovered that all the galaxies seem to move away from us. In fact, the radiation emitted by these galaxies moved towards the red, in the electromagnetic spectrum: this is called redshift. This phenomenon has a simple explanation: whenever a source moves away from us, the number of oscillation per second decreases, so the wavelength seems to raise and we are used to say that the light turns to red. While a source comes towards us, the number of oscillations per seconds increases, and so the wavelength decreases and the light seems moved to the blue (blueshift). Hubble also showed that the movement was directly proportional to the speed of the bright source; he found a precise correlation between the distance of the galaxies and their recession speed, then called the Hubble’s Law, based on this formula: **v = H d** where H is the Constant of Hubble, v is the galaxies departure speed and d their distance. The Universe, as matter of fact, is subject to an expansion movement and the Earth takes part to this inexorable motion, without being its centre.
In conclusion, it does not exist a privileged observer: the speed with the galaxies are moving away increases with the distance, from every place we can be. An other observer, placed in whatever point of a different galaxy, would exactly find the same law achieved by Hubble.

## Quasar

The Quasars (Quasi-stellar Radio Source) are really far galaxies, the furthest we saw, able to emit an enormous quantity of energy, above all on the radio frequencies.
Looking with a telescope, they appear like bright dots, with a stellar aspect (from which it derives the definition, Quasi-stellar Radio Sources), while their spectrum shows bands considerably inclined to the red color (redshift).
If we suppose that this redshift is due to the Doppler effect, this would mean that these objects are coming away from us with high speeds, superior than 35000 km/s, too elevated for a normal star. In conclusion, we are talking about really far extragalactic sources. Considering their distance and their apparent brightness, we can also find the enormous power radiated by these objects, hundreds times more than the most sparkling galaxies.
The engine of these quasars is not the nuclear reactions inside the single stars: the power we observed is not the addition of the energy contribution of all the stars of this galaxy. Scientists are almost sure that this powerful engine is powered by a giant black hole placed in the galactic nucleus. Around this black hole there is an accretin disc of gas and stars in extremely quick rotation. The matter, falling on this black hole, creates an enormous power of radiation.