The Multi-Bang Universe: The Never-Ending Realm of Galaxies

Mário Everaldo de Souza

Departamento de Física, Universidade Federal de Sergipe, 49.100-000, Brazil

Abstract A new cosmological model is proposed for the dynamics of the Universe and the formation and evolution of galaxies. It is shown that the matter of the Universe contracts and expands in cycles, and that galaxies in a particular cycle have imprints from the previous cycle. It is proposed that RHIC's liquid gets trapped in the cores of galaxies in the beginning of each cycle and is liberated with time and is, thus, the power engine of AGNs. It is also shown that the large-scale structure is a permanent property of the Universe, and thus, it is not created. It is proposed that spiral galaxies and elliptical galaxies are formed by mergers of nucleon vortices (vorteons) at the time of the big squeeze and immediately afterwards and that the merging process, in general, lasts an extremely long time, of many billion years. The origin of quasars is explained and the evaporation rate of RHIC's liquid is calculated. It is concluded that the Universe is eternal and that space should be infinite or almost.

Keywords Big Bang, RHIC's liquid, Galaxy Formation, Galaxy Evolution, LCDM

1. Introduction

The article from 1924 by Alexander Friedmann "Über die Möglichkeit einer Welt mit konstanter negativer Krümmung des Raumes" ("On the possibility of a world with constant negative curvature of space") is the theoretical milestone of the Big Bang Theory [1] whose basis is the expansion of the Universe which was firstly proven by the observations of Edwin Hubble in the late 1920s when he discovered that the galaxies were receding from each other [2]. It is important to recognize, however, that Hubble's law had been proposed by G. Lemaître in 1927 [3]. And thus Lemaître can also be considered as one of the fathers of the Big Bang Theory.

Primordial nucleosynthesis is the great achievement of the Big Bang Theory whose first developments were carried out in the seminal article by Alpher, Bethe and Gamow [4] in 1948. And the most important support for the Big Bang Theory was the accidental discovery of the Microwave Background Radiation by Wilson and Penzias in 1963 [5]. In summary, these are the three evidences for the Big Bang Theory: the universal expansion, the Cosmic Microwave Background (CMB) radiation and Primordial or Big Bang Nucleosynthesis (BBN). Since then there have been several improvements in the measurements of the CMB spectrum and its anisotropies by COBE [6], WMAP [7], and Planck 2013 [8].

Problems with the Big Bang theory began in 1986 with the surprising discovery by Geller, Huchra and de Lapparent [9] of the bubbles formed by galaxies enclosing enormous regions almost devoid of matter in a slice of the local Universe. This foam-like structure was confirmed in 1989 by Geller and Huchra [10] that unraveled large-scale clustering of galaxies stretching in the form of gigantic filaments and sheets over 170 Mpc by about 15 Mpc. Broadhurst et al. [11] extended the observation of this foam-like large-scale structure to higher redshifts. Their observations revealed regularly spaced voids covering a distance of 2000 h-1 Mpc in the directions of the north and south galactic poles.

2. Some Relevant Information

For the understanding of the main proposals of this article it is very important to first bring to light some information on the Lambda-CDM Model (LCDM), dark matter, dark energy, CMB, galaxies at high redshifts, galaxy formation, black holes at the cores of galaxies, the inner structure of nucleons and RHIC liquid.

2.1. On the Components of the LCDM Model and Some of its Problems

Dark matter was firstly suggested by Cornelius [12] in his analysis of the stellar velocities in the Milky Way, but the strong support for dark matter came from the work of Rubin et al. [13] on the orbital velocities of stars in 21 spiral galaxies. Since then the role of dark matter in astrophysics has been much more extended. According to its proponents, besides its role in the dynamics of spiral galaxies, dark matter would be important in the dynamics of galaxy clusters [14,15], in galaxy formation [16], in the formation of large-scale-structure [16], and would provide 26.8% for the mass of the Universe in order to have a closed Universe, according to the Standard Cosmological Model, the so-called Lambda-CDM (LCDM) [17]. These references above on dark matter are just examples of a vast literature on the subject and some of these are pioneering articles.

On the existence of dark matter in spiral galaxies de Souza [18] has shown that the constancy of the tangential velocity in the spiral arms of spiral galaxies can be explained by the outward expulsion of matter from their centers. And this constancy generates their splendid spiral structure which can be a logarithmic spiral within certain conditions. And Kroupa et al. [19] have shown that dark matter does not exist in the Milky Way's neighborhood, and thus it sure does not exist in galaxy clusters because all galaxies should have a common origin in terms of composition. Kroupa [20] and also Famaey and McGaugh [21] raise many important issues on the existence of dark matter and show that the LCDM model is plagued with too many flaws. The flaws are so serious that I dare to say that they completely invalidate the model. And there are many other problems not raised by these above authors such as the rotation of cosmic voids analyzed by Lee and Park [22] that have shown that the angular momenta of neighboring voids are strongly correlated to one another. Another trouble for LCDM is the alignment of galaxy spin axes with cosmic filaments [23,24,25,26]. This alignment has also been observed at redshift $z \sim 1.3$ with quasars [27]. In this case it means an alignment across billions of light years.

The Large-Scale Structure is not well described by LCDM as actual voids are emptier and actual superclusters are more massive than those from LCDM simulations [20,28]. And besides LCDM cannot account for massive clusters at high redshifts [28,29,30,31].

The LCDM model is also in trouble because in a recent article Nielsen et al. [32] have found no acceleration of the universal expansion from the careful analysis of the data of 740 supernovae. Also Planck 2013 [33] found no evidence for dynamical dark energy. It is obvious that the cosmological constant cannot exist because if it existed it would mean a dynamical vacuum and a vacuum field, but without its corresponding particles. As we know from Particle Physics, fields and particles are the two sides of the same coin.

2.2 There is no Need of Dark Matter for Closing the Universe

In a recent article [34] that has been accepted for publication de Souza shows that the baryonic mass in galaxies is enough for closing the Universe if we consider that the universal expansion in the local Universe happens by means of the expansion of voids. Of course, this evidences an explosive past history for the Universe which will be detailed later on.

2.3 Galaxy Formation by Hierarchical Clustering did not Happen

It is easy to arrive at this conclusion. It is enough to take a look at the Hubble Deep Field North (HDFN) [35] and Hubble Deep Field South (HDFS) [36]. The HDFN has galaxies with z up to 3.216. Visually we see just some interacting galaxies and we do not see any formed galaxy merging with another one. Let us recall that merging means collision and that hierarchical clustering means merging at different redshifts, that is, from time to time. A collision between two galaxies lasts a very long time and is a spectacular disruptive and bursting event as we observe in some Arp's objects [37]. The HDFS spans in redshift from 0 up to 2.2 and we can see just a couple of interacting galaxies, but not merging in the sense of hierarchical clustering. In both fields we see that many high-redshift spiral galaxies have already well developed arms.

The same reasoning holds for the Hubble Ultra Deep Field [38] and the Hubble Extreme Deep Field (XDF) [39] in which we see well developed elliptical and spiral galaxies at high redshifts. The XDF has about 5500 galaxies and visually we do not observe merging of galaxies.

Except at the right beginning of the universal expansion, large-scale merging did not happen because as galaxies have been going away from each other due to the fact that the Universe is expanding, galaxy merging only happens occasionally. Therefore the size increase in all spiral galaxies [40] with time cannot be attributed to hierarchical merging which means lots of merging at different times. Darg et al. [41] have found only 3003 merging galaxies in the Local Universe from the SDSS with redshifts $0.1 > z > 0.005$ from which only 39 refer to multiple merging [42]. It is important to recognize that these mergers should have initiated a very long time ago. We will see later on that all spiral galaxies were formed by merging but a different kind of merging and at a quite different time. And we will see why their sizes increase with time. And also we will see that most elliptical galaxies were also formed by merging.

2.4 Spiral Galaxy Formation by Collapse from a Gas Cloud Makes no Sense

It is enough to recognize that in this case the stars of a spiral galaxy would have approximately the same age and would be very old stars, and moreover all galaxies would have the same shape instead of the large variety of shapes that spiral galaxies exhibit. We would not have barred spirals at all, for example. And we would not have young stars close to the centers of spirals.

It is also important to perceive that in the collapse scenario of galaxy formation galaxy size would not increase with time [40].

2.5 Black Holes do not Exist in the Cores of Galaxies

Mersini-Houghton [43] has shown that neutral stellar black holes do not exist due to Hawking radiation backreaction. Besides this facet there is the very strong repulsion between two nucleons at distances shorter than 0.5 fm, and thus, when nucleons get very squeezed together they form other states of matter as are found in the inner layers of neutron stars. Also the RHIC fluid [44] has been formed due to interactions between nucleons that take place at very short distances. Later on we will discuss more on these states of matter. Another aspect is the assessment of the separation between negative and positive charges that take place during collapse due to the large differences in masses between electrons, and protons and nuclei. Of course these complex motions cause the buildup of strong electromagnetic fields in the collapsing star. We have to assess the influence of these fields during collapse for the case of very massive stars. These fields may affect the motions of the infalling positive particles, protons and nuclei as the collapse does not happen at once, and happens at least in two main stages with respect to time as recently shown by NASA in a video of a supernova explosion. Therefore, just the condition from the gravitational metric for the black hole formation without taking into account other interactions is not realistic at all.

Let us analyze some properties of supposed massive black holes at the cores of the galaxies: Milky Way, Andromeda, NGC 4261, NGC 4258 and NGC 1275. It has been suggested by many researchers that these galaxies harbor massive black holes at their cores [45, 46, 47]. But Wang et al. [48] report an outflow of gas from the accretion disk of the supposed black hole at the Milky Way's core. This means that there is no black hole after all. The supposed black hole contains about 4.31 million solar masses and has a radius of about 22 million km. This means a density of 2×10^{5} kg/m^3 which is almost identical to the density at the center of the Sun which is 1.5×10^{5} kg/m^3. For comparison neutron stars have densities between 3.7×10^{17} and 5.9×10^{17} kg/m^3. As to Andromeda (M31, NGC 224) the supposed black hole has a mass of 100 million solar masses contained within a volume with a radius of one third of a light year [49]. Therefore, the density of its "black hole" is just 1.3×10^{-9} kg/m^3. The size of the supposed black hole of NGC 4261 has a radius of about 5.9×10^{12} m and contains about 1.2 billion solar masses [50]. This means a density of only 300 kg/m^3 which is much less than that of the Milky Way's core. In the cases of NGC 4258 and NGC 1275 the densities are ridiculously small. The supposed black hole of NGC 4258 has a mass of 35 million solar masses within a radius of about 0.3 pc [47]. These numbers yield the density of about 2×10^{-11} kg/m^3. For comparison the air density at sea level at 15oC is 1.225 kg/m^3. And for NGC 1275 the supposed black hole has a radius of about 25 pc and contains about 100 million solar masses. Therefore, the density is just 1.13×10^{-16} kg/m^3. I summarize the results in Table 1 below.

Therefore, let us say it loud: there are not black holes at the centers of these galaxies and what exist at their cores are just large concentrations of mass whose origin will come to light along this article. All the other galaxies with supposed black holes follow the same trend. Scientists that develop researches in the centers of galaxies should immediately change the nomenclature and call these objects with a different name. As it is a very massive object at the centers of galaxies, they could be called CEMUO (from CEntral Massive Unkonwn Object) for example. But as along this article the nature of this central object will be revealed, the object may be called a CEMO (from CEntral Massive Object).

Table 1. Supposed black hole densities in five galaxies. For reference, the mean neutron star density is 4.8×10^{17} kg/m^3, mean Sun density is 1.408×10^{3} kg/m^3, mean Sun core density is 1.5×10^{5} kg/m^3, air density at sea level at 15 ^oC is 1.225 kg/m^3, mean Earth density is 5.51×10^{3} kg/m^3 and Mars air density close to the surface is 0.020 kg/m^3.

Galaxies	Supposed Black Holes Density (kg/m^3)
Milky Way	2×10^{5}
Andromeda	1.3×10^{-9}
NGC 4261	300
NGC 4258	2×10^{-11}
NGC 1275	1.13×10^{-16}

2.6 Galaxies with Double and Multiple Nuclei

Ultraluminous infrared galaxies (ULIRGSs) with multiple nuclei are quite common [51]. Borne et al. [52] have suggested that the origin of the multiple nuclei is multiple mergers. However, taking into account the probability of merging and evolution of compact groups, “The expected rate of such mergers is, however, too low to reproduce the number of ULIRGs with multiple nuclei” [51].

The case of galaxies with two nuclei is more common. Gimeno et al. [53] have produced a catalog with 107 double nucleus disk galaxies which cover a wide range of redshifts. The authors make a very important question in the beginning of their work: “What are the physical processes involved and which are predominant in the generation of double nuclei in disk galaxies?” This article will offer later on a good answer to this question. There are, of course, many other galaxies that do not belong to the catalog. A famous example is Milky Way’s neighbor Andromeda (M31, NGC 224) [49]. And there are also elliptical galaxies with double nucleus such as MCG-01-12-005 [54].

2.7 Galaxies at Extremely High Redshifts

Galaxy formation has been pushed to ever higher redshifts. Combined data from Keck Observatory and NASA’s telescopes Hubble and Spitzer have revealed a galaxy at redshift 7.73 [55]. We clearly see that the galaxy was not formed by collapse because it does not have a spherical shape [56]. In terms of redshift it was in a short time surpassed by other galaxies. Still in 2015 Zitrin et al. have clearly identified a galaxy at $z=8.68$ [57]. And in a cluster of galaxies with redshifts between 6 and 8 Atek et al. have found 250 galaxies [58].

Then the record was broken by a galaxy found at redshift $z=9.6$ [59,60], just 500 million years after the Big Bang. And then came the big surprise: a galaxy at $z=11.11$!! Oesch et al. [61] have found a bright galaxy at $z=11.11$. In time this means 400 Myr after the Big Bang. This galaxy shatters completely the LCDM model because according to the LCDM model galaxies were formed after the first stars shined and the first stars were formed only 560 million years after the Big Bang according to LCDM. Again we see that this galaxy was not formed by collapse [62]. And, of course, the galaxy was formed at a redshift larger than 11.11.

A very important property of high z galaxies is their very small sizes. Bouwens et al. [63] found that “The results of the tests we have performed in the previous two sections strongly suggest that the faintest galaxies accessible from the HFF program are very small, with probable intrinsic half-light radii of < 165 pc at $z\sim6$ and < 240 pc at z $z\sim2-3$”.

The main proposals of this article will solve these puzzles.

2.8 Odd Shapes of Galaxies at High Redshifts

Besides spiral and elliptical galaxies, galaxies at high redshifts have very odd forms. Elmegreen et al.[64] have made an analysis of galaxies in the Hubble Ultra Deep Field larger than 10 pixels (0.2 arcsec) and have found 269 spirals, 100 ellipticals, 114 chains, 126 double-clump galaxies, 97 tadpoles, and 178 clump-cluster galaxies. Chains are nearly straight alignments of a half-dozen clumps [65,66,67], tadpoles are curved thin structures with a big clump near one end [66], and double-clump galaxies have two large clumps. Clump-cluster galaxies are luminous diffuse oval or circular objects without disks and exponential light profiles [68]. These odd galaxy shapes are not found in the local Universe. This means that most of these forms are transformed into spiral and elliptical shapes or irregular shape also. These above mentioned types are represented in Figure 1 below. Straughn et al. [69] have studied tadpole galaxies from the Hubble Ultra Deep Field and have concluded that they are younger than field galaxies and that they are in an active phase of assembly or late-stage merging. Later on we will clarify when the merging began.

Of course these unusual morphologies appear in other galaxy surveys. Williams et al. [70] report them in the Hubble Deep Field North, and Volonteri et al. [71] in the Hubble Deep Field South.

The galaxy in a form of chains of clumps rules out completely galaxy formation by collapse. The same holds for clump-cluster galaxies.

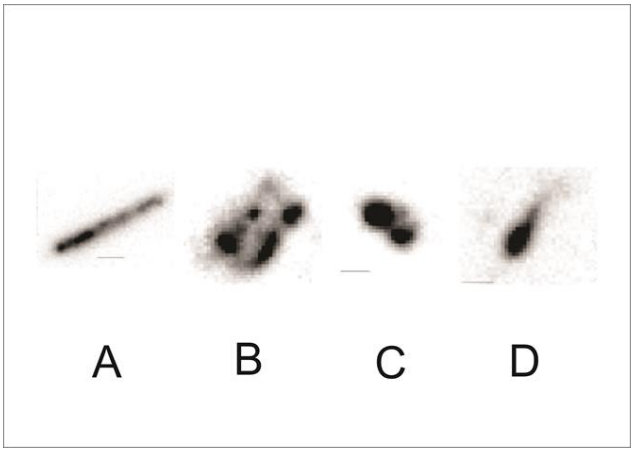

Fig. 1. Odd shaped galaxies at very high redshifts from the Hubble Ultra Deep Field galaxy survey. A is a chain galaxy, B is a clump-cluster, C is a double clump and D is a tadpole.

2.9 Status of the Cosmic Microwave Background Radiation

The final temperature of the CMB spectrum was reported by Mather et al. [72] in 1999 after achieving a better understanding of the FIRAS calibrator. The result is 2.725±0.002 K. This result worsened the precision of the previous result by Fixsen [73] of 2.72548±0.00057 K.

Noterdaeme et al. [74], using rotational levels of carbon monoxide (CO) from the spectra of quasars, have found $T_{CMB}(z) = (2.725 \pm 0.002) \times (1+z)^{1-\beta}$ K with β = − 0.007 ± 0.027, which means that the universal expansion is adiabatic.

The CMB anisotropies have been deeply analyzed by WMAP [7] and Planck [8] missions in the latest years. There is no point in commenting their results as they refer to the LCDM model because temperature anisotropy at a point on the sky (θ, ϕ) can be expressed in the basis of spherical harmonics as

$$\frac{\Delta T}{T}(\theta, \phi) = \sum_{l,m} a_{lm} Y_{lm}(\theta, \phi) \tag{1}$$

in which the variance of the a_{lm} coefficients depends on the cosmological model used, but as shown above in Section 2.1 LCDM does not describe reality at all.

2.10 The Inner Structure of the Nucleon and the Nucleon Hard Core

In 2013 and 2014 de Souza [75,76] presented a structure for the nucleons that complements the quark model of QCD, provides the quantum numbers for the recently found Higgs boson, and proposes new Higgs-like bosons. The model is based on the internal structure of the nucleons as unraveled by Hofstadter [77,78] and Wilson [79] in the late 1950s and early 1960s. The inner structure of the nucleon by de Souza [75], shown in Fig. 2, unravels the inner hard core of the nucleons which has been investigated in many different energy ranges. Lately the hard core has been investigated by Islam et al. [80] at 546 GeV, 630 GeV, and 1.8 TeV and by the TOTEM Collaboration at 7 TeV [81,82] and 8 TeV [83]. In the summary of reference [83] it is said that the measurements at 7 TeV and 8 TeV “are both in good agreement with the extrapolation of the lower energy measurements”. As the strong repulsion (hard core) was seen at 8 TeV, the coupling constant linked to this inner structure is extremely high. And we will see below why it is so high: this structure is the ultimate cause for the expansion of the Universe.

3) The Big Crunch of the Universe

As shown by de Souza [34] the baryonic mass of galaxies is sufficient for closing the Universe. Let us then continue the universal expansion for closing the Universe.

3.1) The First Phase

After reaching its maximum size the Universe will begin having a long lasting phase of getting the clusters and superclusters together. It will have a duration shorter than

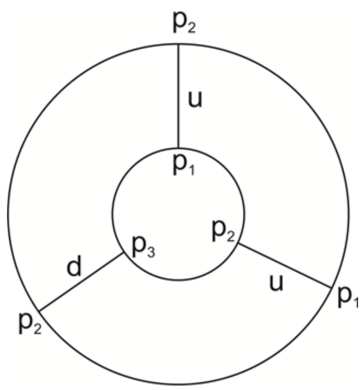

Fig. 2. Pictorial representation of the arrangement of primons in the proton. In the neutron the inner layer is the same, and in the outer layer the p_1 below is replaced by p_3 and this makes the neutron to be udd in terms of quarks.

that of the expansion because the crunching velocities and the gravitational forces will have the same direction among clusters. Galaxies will continue evolving and thus, stars will get old. Galaxies will reach their maximum sizes. The fuel at their centers will get exhausted. Thus in this phase the Universe will become old and dark.

As gravity is a central force, clusters and superclusters will become ever more spherical in shape and will shrink as time goes due to their own gravity. Regular clusters in the Local Universe are spherical already. As galaxies will rush to each other inside clusters their outskirts will be disrupted. But because of the conservation of angular momentum, each galaxy will be reduced to a rotating spheroid and their outskirts will generate a plasma that will rotate inside the cluster according to the cluster's angular momentum. This means that there will be an ionization of the Universe. The whole Universe will glow due to the destruction of stars.

The shrinking of clusters will reach a point at which atoms will have their electrons stripped off. In order to obtain this the distance between atoms has to be about 1 Angstrom because the radius of the hydrogen atom is 0.5 Angstrom. As the visible Universe has about 100 billion galaxies and each galaxy has on average about 100 billion stars like the Sun, thus the visible Universe has about 10^{79} nucleons, and thus, the shrunk visible Universe above will have a radius of just one light year. The Universe becomes dark because photons do not escape and keep interacting with matter. This size marks the end of this phase and the beginning of the second phase. On the number of galaxies above Conselice et al. [84] argue that the visible Universe has about 2 trillion galaxies, but in an article of 2011 Wyithe et al. [85] had already warned that there may exist a distortion in the number of galaxies at high redshift due to gravitational lensing and that "The number counts could be modified by an order of magnitude, with most galaxies being part of multiply imaged systems".

At the end of this phase each galaxy will be reduced to a rotating blob of nucleons, a vortex of nucleons which may be called a vorteon. The vorteons in each cluster will move in a plasma of nucleons and electrons and, thus, Fig. 3 below is a good representation of the vorteons and the fluid inside the cluster.

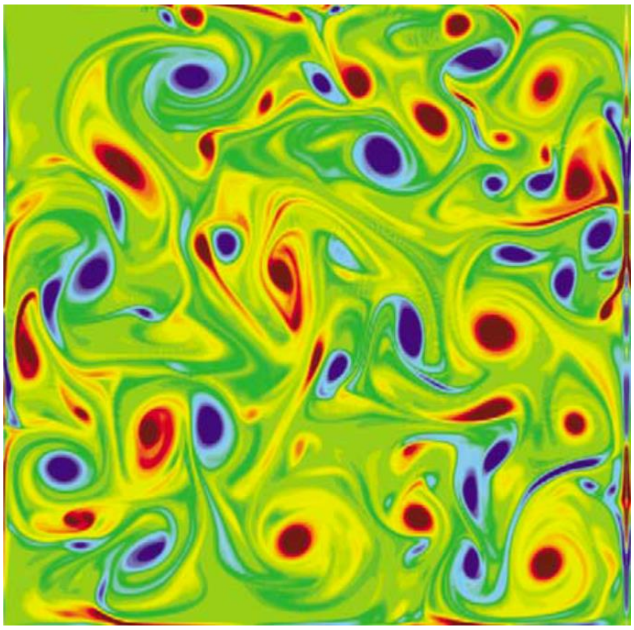

Fig. 3. How the vorteons and the fluid of nucleons and electrons inside each cluster of galaxies will look like after galaxies lose their outskirts due to the shrinking of the cluster by its gravity. Galaxies will be reduced to rotating spheroids of nucleons, which we may call vorteons. In this figure the vorteons are the roundish blue and red bodies. The figure is from an article by Clercx et al. [86] on turbulence in two dimensions in square and circular domains (figure used by permission)

3.2) The Second Phase

It will be a very brief phase. During this phase vorteons will shrink and the fluid will become denser. If we suppose a shrinking velocity close to c we obtain that the second phase lasts only about $(10^{-10}/3\times10^{8})s = 3.3\times10^{-19}s$. The clusters will contain vorteons and a very dense fluid of nucleons and electrons. At the end of this phase each vorteon becomes a spheroid of nucleons in close contact with one another. The density will be about 7.8×10^{17} kg/m^3 and the temperature will be about (1-10) MeV. It is important to emphasize that in between vorteons there will be lower density regions and the densest regions will be at their centers. Of course, the fluid will become more and more incompressible and will be governed by the laws of General Relativity and Hydrodynamics. In classical fluids the more the fluid is incompressible, the more it conserves the vorticity. We will not attempt at this point to propose equations for this state of matter because it is a mixture of a streaming charged fluid of nucleons with vorteons. In the literature we find many good works on relativistic fluids but without vortices (vorteons). But this fluid is hard to describe anyway because of the complicated boundary conditions, and because we do not know much about it. And it lasts a very brief time anyway. A good representation for matter in this phase is Fig 3 with smaller structures.

3.3) The Third Phase: Ultimate Squeeze and Rebirth

Gravity will continue squeezing nucleons against each other, and thus we are forced to ask: Is there a process that can halt gravity from going further? The answer is yes.

With further squeeze the outer layer of primons of the nucleons shrink and cause quarks to disappear. As primons are forced to become closer to each other, they pair up to form bosons and thus, to occupy more available states and to not have any problem with the number of particles occupying the same state. This process absorbs the kinetic energy and, hence, the temperature drops and the system becomes a liquid. There is a similar phenomenon that happens in neutron stars in which nucleons pair up and form a liquid [87,88]. As primons (1/2 spin fermions) pair up, they combine and form a new kind of particle, a sort of spin zero quark, which we may call a quarkon. Take a look at Section 2.10 and Fig 2 above. These are the particles that form the primordial liquid of the Universe. And this liquid has already been obtained on Earth, more precisely, at Brookhaven [89] and at CERN [90]. It has been known as the RHIC's liquid and has almost zero viscosity and is, thus a perfect ideal liquid. QCD had predicted the quark gluon plasma to be a weakly interacting gas of quarks and gluons. Since then some researchers have tried to save QCD and have tried to describe the liquid with QCD, but without success up to now. QCD people have even changed the name to sQGP. In 2006 Pisa1ski [91] has doubted if RHIC's liquid is really a QGP. The simple calculation below shows that the Quantum Physics that will describe RHIC's liquid lies Beyond the Standard Model

We show in this simple calculation that RHIC's fluid has to do with the internal structure of the nucleon.

The velocities of quarkons should be extremely high, so that we can make the approximation $E \approx pc$, and thus from the uncertainty principle we have $pc \approx \dfrac{\hbar c}{2\Delta r}$ and hence, $\dfrac{3}{2}kT \approx pc \approx \dfrac{\hbar c}{2\Delta r}$. The internal structure has a radius of just 0.2 fermi, so that $\Delta r \approx 0.4$ fermi, and thus we obtain

$$T \approx \frac{\hbar c}{3k\Delta r} \tag{2}$$

which yields $T \approx 10^{13}K$ which is quite close to the estimated RHIC's temperature of $4\times10^{12}K$.

In 2012 the ALICE Collaboration announced the record temperature of $5.5\times10^{12}K$ for RHIC's liquid, closer to $10^{13}K$.

Of course, around the big squeeze there is the action of Higgs-like boson that yield quark masses as discussed in the references [75,76].

Before going further let us calculate the size of a vorteon when it became a soup of quarkons and electrons. For order of magnitude we can imagine a vorteon with the Milky Way's mass. The maximum speed of particles at its equator should be c, and thus from the conservation of angular momentum we obtain

$$J = I_0\omega_0 \approx \frac{I_0 c}{R_0} \approx \frac{2}{5}MR_o{}^2 \times \frac{c}{R_o} \tag{3}$$

in which I_o is the inertia moment of the vorteon and ω_o is its angular speed. For order of magnitude we have considered the vorteon spherical. As $M = \dfrac{4}{3}\pi\rho R_o{}^3$, we obtain

$$R_o \approx \left(\frac{15J}{8\pi\rho c}\right)^{1/4} \tag{4}$$

Using the known figure of $J = 10^{67}$ kgm^{2}s for the Milky Way and reducing the nucleon radius to 0.2 fermi, the density becomes $\rho \approx 5\times10^{19}$ kg/m^3, and thus we obtain $R_o \approx 10^9$ m, which is slightly larger than the Sun radius.

With further squeeze the primeval fluid just becomes more compressed and bounces back due to its elastic properties, and portions of the fluid and vorteons will distance from each other. **It is the Multi-Bang: another cycle of the Universe is born.** It is expected that large scale merging between vorteons will take place and that large portions of the fluid will be broken along fluid lines. This agrees well with observations of linear objects such as chain galaxies and tadpoles galaxies observed in the Hubble Ultra Deep Fields and in the Hubble Extreme Deep Field, as analyzed by Elmegreen et al. [64]. This idea was, actually, raised by Gibson [93] in 2010 in a work on turbulence, although his arguments were contaminated by dark matter which does not exist. Thus, at the big squeeze and immediately afterwards there are mergers of 2 vorteons, 3 vorteons and also of more vorteons to some degree, as well as merger of vorteons with linear objects and other objects. The merger between 2 co-rotating vorteons will be dealt with below in connection with galaxy formation and number of spiral galaxies with respect to elliptical galaxies. It is very important to emphasize that the linear objects such as tadpoles and galaxy chains cannot be formed by the theory of galaxy formation by collapse.

We also see that there was an inflation but not an artificial mind-boggling one. Inflation was just a very fast expansion caused by the bouncing back of matter due to its elastic properties which, of course, have to be directly related to the repulsive forces above mentioned. We have no idea on how to calculate the order of magnitude of its duration, but it has to be shorter than $\left(0.2\times10^{-15}/3\times10^{8}\right)s = 6.7\times10^{-25}s$, although numbers such as $10^{-32}s$ and $10^{-36}s$ do not make any sense.

As vorteons are contained in clusters, and there are boundaries among clusters, and clusters rotate with respect to each other, a denser region between two neighboring clusters is developed to which vorteons and other objects are attracted. Therefore, the cluster will become a void in the future and in this way the region between clusters will become a sheet. And that is why voids rotate as found by Lee and Park [22].

This kind of origin for galaxy progenitors explains the alignment of galaxies spins [23,24,25,26,27] above discussed in the end of Section 2.1 as the rotating fluid in each cluster generates many vorteons with spins in the same direction. Also this type of origin for galaxy progenitors explains why many satellite galaxies are located in planes around a host galaxy because it is expected that because of gravity a vorteon will carry around it portions of the fluid that were previously attached to it. In the Andromeda galaxy (M 31) 13 out of 27 of its satellite galaxies belong to a vast, thin, co-rotating plane [94,95] to which Andromeda belongs. Tully [96] further found out that the satellites IC1613, IC10 and LGS 3 belong to the same plane. And according to an analysis by Shaya & Tully [97] eight of the remaining fourteen satellites belong to another plane, and that the two planes are parallel to each other and offset by about 15 degrees. Galaxy Centaurus A presents the same behavior. All except two of its 29 satellite galaxies belong to two parallel planes [98]. Other galaxies exhibit the same trend. M81 [99] and NGC 3109 [100] also present flattened distributions of satellite galaxies around them. And the Milky Way has also a plane where most of its satellites orbit. In this case the plane is almost perpendicular to the Milky Way's disk. This plane began to be evidenced by Kunkel & Demers [101] and Lynden-Bell [102,103]. More details on this subject for these above mentioned galaxies can be found in the excellent paper by Libeskind et al. [104].

4. Galaxy Formation

As shown above the first progenitors of galaxies are the vortices of the RHIC's liquid, that is, vorteons, but let us not forget that, due to angular momentum conservation, as shown above, many vorteons were originated in the previous cycle of the Universe. Therefore, the centers of many galaxies, such as double nucleus spirals of this cycle, contain matter from the previous cycle.

As shown above, at the time of the ultimate squeeze vorteons are very small with radii of the order of just 10^9 m. Of course, in the collapsing matter all kinds of merging among vorteons take place and also all sorts of splitting, tearing and cracking happens in the collapsing fluid, especially along fluid lines. Of course, the initial expansion should be very chaotic and merging should also occur in .the beginning of each cycle. That is why most Milky Way satellites orbit in a plane that is perpendicular to its disk [101.102.103.104]. This means that at the ultimate squeeze a vorteon got separated from the primeval fluid with most of the satellites masses around it and then this vorteon merged with another vorteon with other satellite masses in such a way that their spins were initially perpendicular to each other.

It is proposed below that spiral galaxies and most elliptical galaxies are formed by the merging of vorteons and merging of vorteons with linear objects.

4.1 Formation of Spiral Galaxies and Elliptical Galaxies

By spiral galaxy it is meant a spiral galaxy with well-defined spiral arms. Before dealing with the formation of the spiral structure, let us see first how the bulge is formed. It is formed due to an overall expansion of matter because the nucleons that were tightly bound together get liberated through the surface of the volume as the nucleonic repulsive forces break up at the surface, and thus the nucleons unsqueeze and form a gaseous hydrogen bulge, and thus, the liquid becomes hydrogen gas. It is hence a kind of evaporation. This means that in the beginning the release of matter outwards was very intense and bulges grew fast. And, of course, it should also happen slowly throughout the galaxy's lifetime. That is why galaxies sizes increase with time [105,106].

We can use a simple model just to obtain a general trend. As discussed above the masses of vorteons are evaporated and transformed into the bulge's mass. Therefore, the rate of decrease of the liquid volume is proportional to the liquid surface, that is,

$$\frac{dV_L}{dt} = -\kappa A_L \tag{5}$$

in which V_L is the liquid volume that we consider as a sphere, A_L is its surface area and κ is a constant. It is worth mentioning that this constant can be found by either RHIC or ALICE physicists in the future. Solving this equation in terms of the liquid mass we obtain

$$\frac{dM_L}{dt} = -\lambda M_L^{2/3} \tag{6}$$

where $\lambda = \kappa\left(36\pi\rho\right)^{1/3}$ in which ρ is the vorteon density. Solving for M_L we have

$$M_L^{1/3} = M_o^{1/3} - \lambda t \tag{7}$$

in which M_o is the initial vorteon mass (at t = 0s). Of course, the initial mass of the vorteon is the sum of the gaseous bulge mass and the liquid volume, that is, $M_o = M_V + M_B$. Solving for the bulge mass we obtain

$$M_B(t) = M_o - \left(M_o^{1/3} - \frac{\lambda}{3}t\right)^3 \tag{8}$$

and thus, for small times after the big squeeze, that is, for times $t \ll \left(\frac{9V_o}{\pi\kappa^3}\right)^{1/3}$, we get

$$\frac{dM_B}{dt} = \lambda M_o^{2/3} \tag{9}$$

that shows that the evolution of the bulge depends on the vorteon mass, and thus, on the galaxy mass. Therefore, the more massive a galaxy is, the faster its bulge was developed.

Of course globular clusters in galaxies were created in the beginning of the Universe due to this strong initial expulsion of matter, and that is why they have very old stars.
In order to understand how the mergers of vorteons form spiral galaxies, let us examine the merger of vortices in fluids. Because of the conservation of vorticity in incompressible fluids, two vortices prefer to merge when they rotate in the same direction, that is, when they are co-rotating. Many authors have examined the merger of two co-rotating vortices. The equations that govern the merger of vortices in classical fluids are

As the merging process is extremely complex, computational simulations and experiments are very important. We consider first the merger of two equal co-rotating vortices. A couple of authors have solved this difficult problem. But Mei-Jiau Huang [107] went further and also explained the physics behind the merging process. Fig. 4 below shows, through a numerical simulation, the time evolution of two equal co-rotating vortices [107]. According to Huang "The simulation results suggest that merger is governed by a competition between the self-induced rotation and the mutual attraction of vortices." And in the case of galaxies there is in the beginning of the merger the help from gravity to increase the mutual attraction between vorteons.

In the case of vorteons gravity has an important role only in the initial attraction between vorteons and plays no role in the time development of vorticity because the gravitational field is a conservative field, and thus $\vec{\nabla}\times\vec{E}_G = 0$.

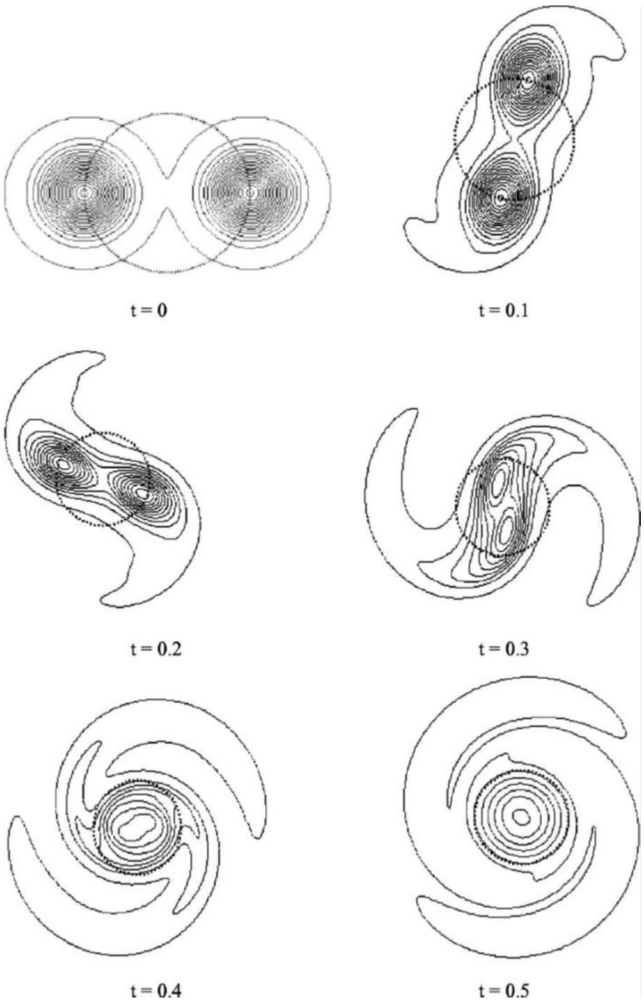

Fig. 4. Time evolution of the vorticity contours during the merging process of two equal co-rotating vortices with equal angular velocities. A circle with constant diameter is plotted for reference. Figure from Huang's article above mentioned, used by permission.

Therefore, the behavior of merger of vorteons is the same as in the case of the mergers of vortices shown above and below. As vorteons expanded fast, in the beginning of the merger the vorteons became mostly composed of hydrogen gas. Therefore, making a parallel between vortices in general and the merger of vorteons, we can propose that the merger of equal co-rotating vorteons generate spiral galaxies with symmetrical arms. Of course, this is not very common in a turbulent flow and that is why just about 10% of spiral galaxies are grand design spirals. It is important to notice that the bar structure is temporary and thus a galaxy like NGC 1300 will become in the future more like the Whirlpool galaxy. This can easily be proven with simulations. Please, take a look at the animation shown at [108]. And, of course, we grasp from this that the merging process between two vorteons takes billions of years to be completed. Having this above in mind we can easily grasp why many galaxies have double and multiple nuclei: they are merging systems. For comparison take a look at Fig. 4 at the stage t=0.2 and compare it with the barred spiral galaxy NGC 1300.

Fig. 5. Barred spiral galaxy NGC 1300.

Other merging results are obtained when the two vortices have different angular velocities. Trieling et al. [109] have carried on simulations and experiments for the merging of two unequal co-rotating vortices. Unequal here means with different angular velocities (Fig. 6). Notice, for example, that for a ratio of $\omega_2/\omega_1 = 0.5$ the merger of the two vortices results in a vortex without spiral arms, it is just a larger vortex in which the mass at its core is the mass from the fast rotating vortex and the mass in its outskirts is the mass from the slower vortex. Making a parallel to the vorteons, we would have in this case the formation of elliptical galaxies, especially ellipticals that are not satellites of other galaxies. It is well known that in general elliptical galaxies have oval contours for the velocity fields of gases such as H1 (hydrogen 1) close to their cores. This would mean that these galaxies were formed by mergers of two vorteons with very different angular velocities. And even ellipticals with very circular velocity fields may have been originated from mergers. Maybe only some elipticals that are satellites of other galaxies were formed from a single vorteon. Of course, the size increase of ellipticals with time came from the merging process and from the expulsion of matter from their centers as shown above with respect to the formation of bulges.

This scenario for the formation of elliptical galaxies agrees well with the analysis of globular cluster in the elliptical galaxy NGC 4261 by Bonfini et al. [110] that found a very strong asymmetry in the population of globular clusters. Also Gomes et al. [111] have found spiral-arm-like features in the outskirts of three elliptical galaxies.

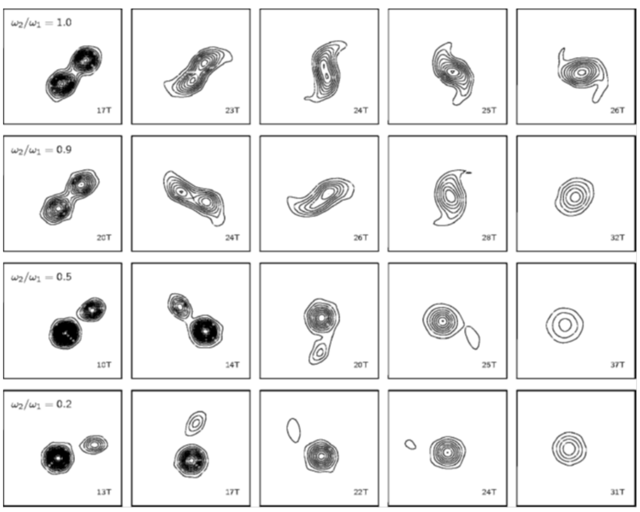

Fig. 6. Mergers of two vortices with equal and different angular speeds. It corresponds to Fig. 16 in the paper by Trieling et al. [109]. Figure used by permission.

This formation for spiral galaxies and elliptical galaxies agrees very well with the findings of Cappelari et al. [112] who found that the majority of elliptical galaxies are not spherical but disc-shaped, and thus, resemble lenticular galaxies, and also disk galaxies when the dust is removed.
Galaxies with asymmetric arms were formed by mergers of a normal vorteon with an oval rotating object. We illustrate this situation in Fig. 7, from the work of Huang [113] on asymmetric merger of vortices.

The merger of a large vorteon with a small vorteon produces a spiral galaxy with thin arms such as in the asymmetric vortex merger analyzed by Amoretti et al. [114]. This is actually, shown in reference [115] in the context of galaxy cannibalism which is a galaxy merger.

A very interesting pattern is created when two or more small vortices merge with a much larger vortex, all of them being co-rotating vortices. It is the Lundgren's spiral vortex. Take a look at the animation of its formation [116]. Therefore, disk galaxies with rings were formed by the merging of a large vorteon with small vorteons, all co-rotating. And thus we can propose that NGC 4622 (Fig. 8) is the result of a merger of a large vorteon with 3 small vorteons in which a small vorteon co-rotate with the large vorteon and the other two small vorteons counter-rotate with respect to

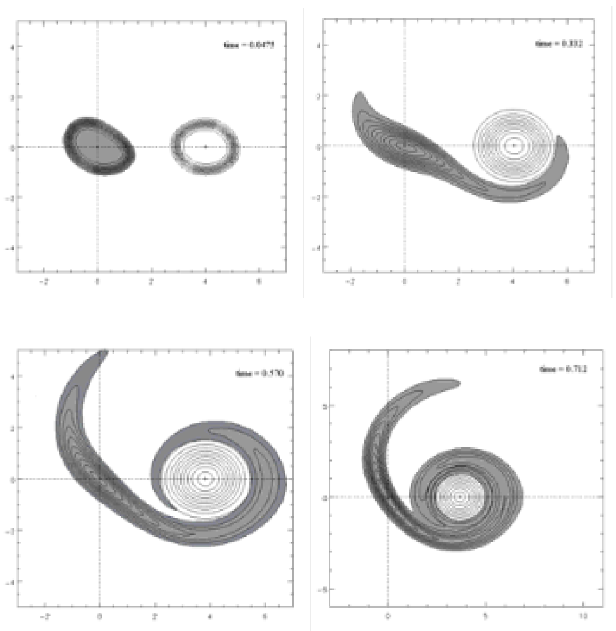

Fig. 7. Illustration of some steps of the time evolution of an asymmetric merger of two vortices. It is part of Fig. 1 of reference [113], used by permission.

the other vorteons. The trailing vorteon should have an angular speed such as that it is smaller than the angular rotation of the large vortex and greater than the angular velocities of the other small vortices.

Spiral arms that do not have well-defined spiral arms, that is, disk galaxies, such as the Sombrero galaxy (NGC 4594), may have been formed from vorteons in the configuration of the Lundgren spiral vortrex. In the animation we see that after a long time the spiral arems become very thin and pack up so that the spiral structure disappears, actually. The should hold for lenticular galaxies and galaxies with rings.

4.2 The Power Engines of Active Galactic Nuclei (AGN)

The RHIC's liquid which gets trapped by gravity in the cores of galaxies at the big squeeze time is the power engine of AGNs. On the surface of the liquid's volume the bonds are weak and this allows nucleons to unsqueeze and become regular nucleons which upon combination with

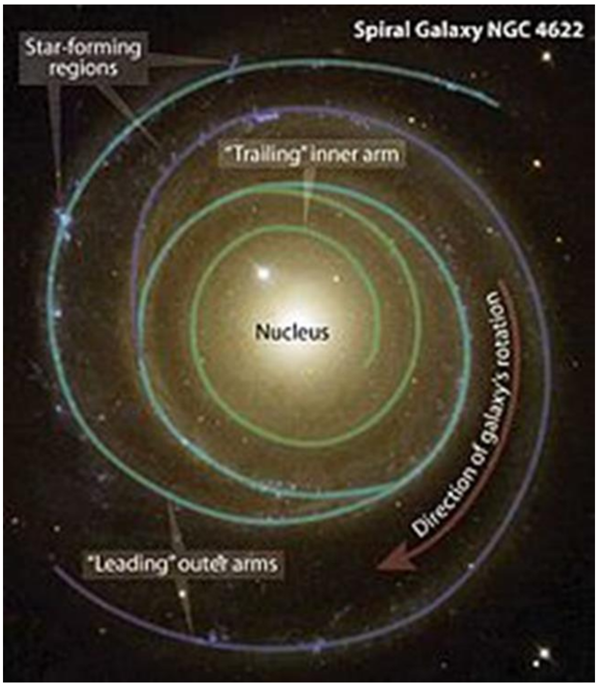

Fig. 8. NGC 4622 looks like a modified Lundgren's spiral vortex and, therefore, should have been formed by the merger of a large vorteon with 3 small vorteons, one in co-rotation with the large vorteon and the other two in counter-rotation with the large vorteon. Picture from Wikipedia.

electrons become hydrogen atoms. The detailed process needs to be accounted for taking into account the temperature and other variables. Also this large volume may attract mass from the surroundings to it. Therefore, there should be a complex interplay of different kinds of masses. The large quantities of hydrogen mass that escape drive star formation at the centers of galaxies. Such expulsions of matter are common in galaxies. Besides these outward flows there is the merging process that should influence a lot these flows. This whole process should be better investigated in the light of the proposals presented herein. We present below some examples of these outflows from the centers of galaxies. These are just a couple of examples of an extremely vast literature on galaxy outflows. For example, in the Milky Way, close to its center, on opposite sides, there are two enormous expanding arms of hydrogen going away from the center at speeds of 53 km/s and 153 km/s [117].

Recent data [118] of NGC 6240, which is considered a typical protogalaxy, show that "approximately 70% of the total radio power at 20cm originates from the nuclear region (less than equal 1.5 kpc), of which half is emitted by two unresolved (R less than equal 30 pc) cores and half by a diffuse component. Nearly all of the other 30% of the total radio power comes from an arm-like region extending westward from the nuclear region". NGC 2992 presents a jet-like structure and a circumnuclear ring [119]. Falcke and Biermann [120] report that there is a large scale emission-like jet going outward from the core of NGC 4258 with a mass of about 4x1035 kg and with a kinetic power of approximately 1042 ergs/s and expansion velocity of about 2000km/s.

Sturm et al.[121] have just reported massive molecular outflows from the centers of ultraluminous infrared galaxies (ULIRGs). As the authors state the terminal velocities in some of these outflows exceed 1000 km/s "and their outflow rates (up to ~ 1200 solar masses per year) are several times larger than their star formation rates". Middleberg et al.[122] report radio observation of the Seyfert galaxies NGC 7674, NGC 5506, NGC 2110 and Mrk 1210, and conclude that "Our results confirm and extend earlier work showing that the outward motion of radio components in Seyfert galaxies is non-relativistic on pc scale. We briefly discuss whether this non-relativistic motion is intrinsic to the jet-formation process ...." Muñoz-Tuñon and Beckman[123] analyze the consequences of mass outflows in the circumnuclear zones of galaxies. They have found "in addition to a ring structure in the gas, there is often measurable expansion with higher radial velocities occurring near the nucleus" and also they show that "radially progressive bursts of star formation can account for a wide range of these observed phenomena and could be related to the presence of liners in the interstellar medium close to the nucleus." On April 2011 Alatalo et al.[124] have reported the discovery of an AGN-Driven Molecular Outflow in the early-type galaxy NGC 1266 which is classified as an S0 without arms. The outflow has a molecular mass of 2.4x107 solar masses. As the authors observe "The star formation in NGC 1266 is insufficient to drive the outflow, and thus it is likely driven by the active galactic nucleus (AGN)".

When a galaxy runs out of RHIC's fluid at its core its AGN begins to have a moderate activity. It should still have some activity due to the large and dense concentrations of nucleons and hydrogen at their cores. When the hydrogen diffuses outwards the galaxy switches off that is a phenomenon observed in may galaxies.

4.3 The Origin and Evolution of Quasars

A quasar is the result of a vorteon that did not merge with another vorteon or with any other piece of the fluid. It is a loner. As shown below RHIC's liquid is evaporated very slowly throughout time and this means that the merging process has a very important role in the liberation of RHIC's liquid at a faster rate because, of course, the merging between two vorteons disturb their cores and thus, the area through which the evaporation takes place, is increased.

Because of the lack of merging quasars remain small and evolve slowly. It is well known that although they are very small they have radiation outputs of galaxies. And they are mostly found at very high redshifts. A quasar is much larger than a vorteon at t=0 which had, then, the size of a typical star. The quasar increases in size due to the evaporation of RHIC's liquid. Considering only approximate spherical shapes, we can say that a quasar is composed of an inner sphere of radius R_L surrounded by a gaseous layer of fixed thickness, so that the gaseous layer is bounded by an external radius R_G. The inner sphere contains RHIC's liquid. As shown below we can obtain important constants of quasars and RHIC's liquid.

Quasars of the Local Universe have already evaporated a lot of their RHIC's liquids, so that we expect to have $R_L \ll R_V$ for them. Considering that the density of RHIC's liquid is the same as the density of the vorteon at t=0, we obtain from Eq. (6) that

$$\rho_o^{1/3} V_L^{1/3} = \rho_o^{1/3} V_o^{1/3} - \lambda t \tag{10}$$

in which ρ_o and M_o are the vorteon density and mass at t=0, and V_L is the volume of RHIC's liquid in the quasar. From this above equation we obtain

$$\lambda = \frac{\rho_o^{1/3}}{t}\left(V_o^{1/3} - V_L^{1/3}\right) = \left(\frac{4\pi\rho_o}{3}\right)^{1/3}\left(\frac{R_o - R_L}{t}\right) \tag{11}$$

and as quasars of the Local Universe had a lot of their RHIC's liquid transformed into gas, we expect to have $R_L \ll R_o$, and thus,

$$\lambda = \left(\frac{4\pi\rho_o}{3}\right)^{1/3}\frac{R_o}{t} \tag{12}$$

As calculated in section 3.3, R_o is about 10^9 m and $\rho_o \approx 5\times10^{19}$ kg/m^3, and t = 13 billion years, and thus we obtain $\lambda = 0.0145$ kg$^{1/3}$/s. It cannot be a universal constant because it depends on the size of the vorteon at t=0. Let us recall that R_o was calculated considering a vorteon with the Milky Way's mass.

Let us now consider the quasar PDS 456 which is a local quasar (z=0.184). Yun et al. [125] have reported that the "host galaxy" of this quasar has a mass of about $9\times10^9 M_\odot$. Host galaxy is, of course the gaseous layer that surrounds the core. Therefore, the total mass of the vorteon that originated this quasar had a total mass of $11\times10^9 M_\odot$ which is roughly 10 times smaller than the Milky Way's mass. As mass scales with $radius^3$ the vorteon of quasar PDS 456 had a radius of about $10^9/\left(10^{1/3}\right) \approx 4.7\times10^8$ m. Therefore, its λ is about 6.74×10^{-3} kg$^{1/3}$/s. According to Almaini [126] in this quasar there is an outflow of matter of 10 solar masses per year, and hence from Eq. (5) we obtain $M_L = 0.911\times10^{39}$ kg $\approx 5\times10^8 M_\odot$ for the mass of RHIC's liquid in the quasar core. And according to Reeves et al. [127] the supposed black hole that lies at the center of this quasar has a mass of $2\times10^9 M_\odot$. Of course, as shown above, black holes do not exist and we see now what is the origin of the large concentration of mass at the center of this quasar.

A mass of $5\times10^8 M_\odot$ contains 5×10^{65} nucleons but as the nucleons radii are reduced to about 0.2 fm, the volume of RHIC's liquid in this quasar has a radius of just 2000 km.

When most of their liquid cores get evaporated, quasars should become E0 elliptical galaxies. This would mean E0 ellipticals without merging features and thus the velocity fields of gases such as H1 and CO would have to be completely circular. This means that the number of quasars at high redshift should approximately correspond to the number of E0 ellipticals of the Local Universe because the number of quasars in the Local Universe is very low.

4.4 Evaporation Rate of RHIC's Liquid

As shown in section 4.1 λ and κ are related by the relation $\lambda = \kappa\left(36\pi\rho_o\right)^{1/3}$ from which we obtain

$$\kappa = \frac{\lambda}{\left(36\pi\rho_o\right)^{1/3}} = \frac{1}{\left(36\pi\rho_o\right)^{1/3}}\frac{\left(\rho_o V_o\right)^{1/3}}{t} = \frac{R_o}{3t} \qquad (13)$$

With the value for R_o of quasar PDS 456 we obtain $\kappa = 3.78\times10^5$ fm/s.

4.5 Merging was the Rule in the Beginning of the Universe

The visible Universe has at least 100 billion galaxies and only about 300000 quasars [128]. Therefore, we conclude that the probability of escape merging in the beginning of the Universe is of the order 10^{-6}.

4.6 Relative Number of Spiral Galaxies to Elliptical Galaxies

Spiral galaxies are fast rotators and most elliptical galaxies are slow rotators, especially the most luminous ellipticals [129], and this is related to the different regions where they are formed. It is well known that "Rich, regular clusters contain mostly elliptical and lenticular galaxies" [130] and spiral galaxies are mostly field galaxies [131], that is, galaxies which do not belong to regular clusters. Let us recall that, as argued above, the clusters in the beginning of the Universe became voids in the Local Universe, and the regions among clusters in the beginning of the Universe became clusters in the Local Universe.

The reason for these facts of the above paragraph has to do with the fact that most spiral galaxies are formed from the mergers of vorteons in clusters and most elliptical galaxies (not including satellite galaxies) are formed from the mergers of vorteons in the regions among clusters, such as region C in Fig.9. As it is well known from Hydrodynamics, in region C the fluid lines have different directions and even opposite direction, so that region C as a whole rotates slower than the clusters, and moreover some portions of the matter in region C in a turbulent flow rotate faster than other portions of C. Hence in region C the angular speeds of vorteons vary a lot, and thus there are mergers between vorteons with very different angular speeds. According to the work of Trieling et al. [109] the results of mergers of vortices with very different angular speeds are, in general, vortices without spiral arms. In region C there are also many vorteons with opposite spins. Therefore, the merging of vorteons in clusters generates spiral galaxies and in the regions among clusters elliptical galaxies are generated. Of course, this means together with their respective satellites. And this fact determines the relative number between spiral galaxies and elliptical galaxies as detailed below.

The relative number between spiral and elliptical galaxies is due to close-packing filling of a volume with smaller volumes (the units). The volume is the Universe and the units are the clusters. For close-packing of a volume with equal spheres, Carl Friedrich Gauss showed that the largest fraction of space occupied by spheres in a lattice, which is achieved by face-centered packing, is [132]

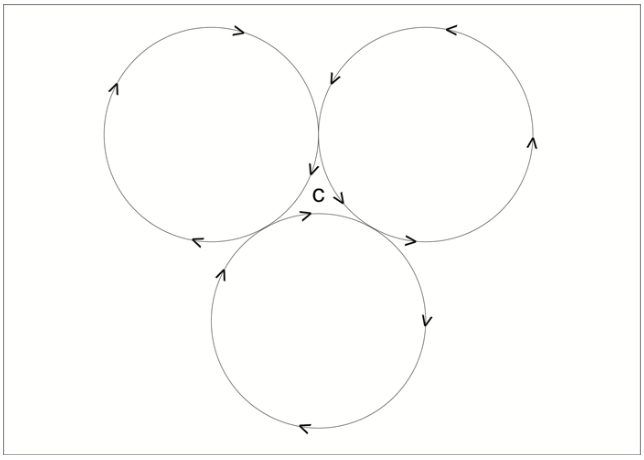

Fig. 9. In the region C among the rotating clusters there are fast and slow vorteons whose mergers generate elliptical galaxies.

$$\frac{\pi}{3\sqrt{2}} \simeq 0.74048\,.$$

It is also important to consider close-packing with ellipsoids, which is more realistic for the Universe as clusters rotate. Bezdek and Kuperberg [133] have proven that for packing with identical ellipsoids the packing fraction is 0.753355… so that, roughly we should have about 75.3% of spiral galaxies and 24.7% elliptical galaxies. This is very close to the numbers in the local Universe where there are 77% spiral galaxies, 20% elliptical galaxies and 3% irregular galaxies [134].

These numbers imply that the Universe is a highly ordered system because in the case of random packing the packing fraction would be only 63.4% [135], and thus we would have only about 63.4% of spiral galaxies. And also, as the actual percentage of spiral galaxies (77%) is very close to 75.3%, this means that the sizes of clusters at the end of each cycle are close to each other, and thus, to their average size.

As discussed above C becomes a cluster later on and the clusters in the beginning of the Universe become voids later on. Therefore, we should have clusters at high z, and that is exactly what has been found [136]. And, for sure, more clusters will be found at higher z.

5. Primeval Stars

They are formed very early in a galaxy from the gas that is expelled from the galaxy's core in all directions and form the galaxy's bulge, the halo and the globular clusters. In the Milky Way the oldest stars are in the bulge, halo and globular clusters. The clear connection among their stellar populations was established by Ortolani et al. [137]: "Within the uncertainties, these bulge globular clusters appear to be coeval with halo clusters, which suggests that the formation of the bulge was part of the dynamical process that formed the halo, and that the bulge gas underwent rapid chemical enrichment, in less than a few billion years." This is quite in line with the galaxy formation above shown.

6. Implications from Primordial Nucleosynthesis

What has been developed above fits perfectly into the theory of formation of the light elements. The only difference is that primordial nucleosynthesis happened in the interiors of galaxies progenitors when the temperatures dropped to about 10 MeV. This means that the merged galaxies progenitors cooled fast, and thus they expanded fast. This fast expansion agrees well with the formation of the primeval stars analyzed above and with well-developed galaxies at high redshifts. As shown by Elmegreen et al. [64] the small objects in the Hubble Ultra Deep Field are embedded in gas. Nucleosynthesis only happens if the distance between nucleons is of the order of one fermi. As the nucleons were extremely squeezed at the time of the big squeeze with radii of the order of 0.2 fermi, this first expansion means 100 times increase in terms of volume. Probably this expansion took place with the speed of light, and thus, nucleosynthesis began just $10^{-23}s$ after the big squeeze. It is important to have in mind that for nuclear fusion to happen it is needed only a critical mass of 0.5 solar mass.

7. Implications for Large-Scale Structure

As it was shown above, the large-scale structure of the Universe is not created, it is a permanent intrinsic property of the Universe. It was also shown that clusters in a particular cycle become voids in the next cycle and thus the core of a spiral galaxy in a cycle may become the core of an elliptical galaxy in the next cycle and so on, forever and ever.

8. Agreement with the Cosmic Microwave Background Radiation

A galaxy such as the Milky Way, which has a diameter of 10^5 ly, was very small at the time of last scattering. Its size today means a subtended angle of just 10^{-5} from the time of last scattering and this completely agrees with what was developed above, as galaxies were very small in the beginning of the Universe as shown in galaxy surveys at high z, and thus, their size imprints do not appear in CMB anisotropies. This is quite in line also with a very perfect CMB spectrum. But as we grasp from what was shown above, space among galaxies was empty or almost empty, and thus the radiation was originated in galaxies.

As shown in section 2.7 Bouwens [63] found that for $z \sim 6$ galaxies have sizes smaller than 165 pc. This would mean a subtended angle smaller than 3.6×10^{-8} rad in the CMB observed today. It is too small to be observed, it is buried in the noise.

9. Infinite Space?

Where do photons and neutrinos go to? That is an extremely important question. These particles participate in many important processes in stars and galaxies throughout the lifetime of a cycle of the Universe. Of course, during the expansion and contraction of matter they are generated and absorbed, but what about those that escape the matter volume? They have to wander about throughout space, bound by the gravity from matter, according to General Relativity, so that they go out from the matter volume and come back eons afterwards, because space-time has to be closed on such a scale. And this means that space is infinite or almost. Therefore, the Universe is eternal with infinite cycles and space is infinite or almost. Homo sapiens will never know.

10. Conclusion

A very plausible model is proposed for the dynamics of the Universe without mathematical tricks and discontinuities of space and time. It is clearly shown that this dynamics is intrinsically connected to the formation and evolution of galaxies. It is proposed that RHIC's liquid gets trapped in the cores of galaxies in the beginning of each cycle and is liberated with time and is, thus, the power engine of AGNs. It is shown that the matter of the Universe contracts and expands in cycles, and that galaxies in a particular cycle have imprints from the previous cycle. Important constants are calculated for quasars and for RHIC's liquid. It is concluded then that the Universe is eternal and that space should be infinite or almost.

REFERENCES

[1] A. Friedman, 1924, "Über die Möglichkeit einer Welt mit konstanter negativer Krümmung des Raumes". Zeitschrift für Physik. 21 (1), 326.

[2] E. Hubble, 1929, "A Relation Between Distance and Radial Velocity Among Extra-Galactic Nebulae". Proceedings of the National Academy of Sciences. 15 (3), 168.

[3] G. Lemaître, 1927, "Un Univers homogène de masse constante et de rayon croissant rendant compte de la vitesse radiale des nébuleuses extra-galactiques", Annales de la Société Scientifique de Bruxelles, A47, 49.

[4] R. A. Alpher, H. Bethe and G. Gamow, 1948, "The Origin of Chemical Elements", Phys. Rev. 73, 803.

[5] R. W. Wilson, and A. A. Penzias, 1967, "Isotropy of Cosmic Background Radiation at 4080 Megahertz", Science. 156 (3778), 1100.

[6] COBE, https://lambda.gsfc.nasa.gov/product/cobe/ spacecraft_ description.cfm

[7] WMAP, https://lambda.gsfc.nasa.gov/product/ map/current/

[8] Planck, https://www.nasa.gov/mission_pages/ planck/overview.html

[9] V. de Lapparent, M. J. Geller, and J. P. Huchra, 1986, "A slice of the Universe", ApJ 302, L1.

[10] M. J. Geller and J. P. Huchra, 1989, "Mapping the Universe", Science, 246, 897.

[11] T. J. Broadhurst, R. S. Ellis, D. C. Koo, and A. S. Szalay, 1990, "Large-scale distribution of galaxies at the Galactic poles", Nature 343, 726.

[12] J. C. Kapteyn, 1922, "First attempt at a theory of the arrangement and motion of the sidereal system". ApJ 55, 302.

[13] V. Rubin, W. K. Ford, Jr, and N. Thonnard, 1980, "Rotational Properties of 21 Sc Galaxies with a Large Range of Luminosities and Radii from NGC 4605 (R = 4kpc) to UGC 2885 (R = 122kpc)", ApJ 238, 471.

[14] F. Zwicky, 1933, "Die Rotverschiebung von extragalaktischen Nebeln", Helvetica Physica Acta 6, 110.

[15] R. Massey et al., 2007, "Dark matter maps reveal cosmic scaffolding", Nature, 445(7125), 286.

[16] J. R. Primack, 2009, "Dark Matter and Galaxy Formation", AIP Conf. Proc.1192, 101.

[17] LambdaCDM Theory, https://lambda.gsfc.nasa.gov/ education/graphic_history/ cdmdensity.cfm

[18] M. E. de Souza, 2013, "A New Model without Dark Matter for the Rotation of Spiral Galaxies: the Connections among Shape, Kinematics and Evolution", Frontiers in Science, 3(2), 71.

[19] P. Kroupa, C. Theis, and C. M. Boily, 2005, "The great disk of Milky-Way satellites and cosmological sub-structures", A&A 431, 517.

[20] P. Kroupa, 2012, "The Dark Matter Crisis: Falsification of the Current Standard Model of Cosmology", Publications of the Astr. Society of Australia, 29 (4), 395.

[21] B. Famaey and S. McGaugh, 2013, "Challenges for ΛCDM and MOND", Journal of Physics: Conference Series 437, 012001.

[22] J. Lee and D. Park, 2006, "Rotation of Cosmic Voids and Void-Spin Statistics", ApJ 652,1.

[23] E. Tempel and N. I. Libeskind, 2013, "Galaxy Spin Alignment in Filaments and Sheets: Observational Evidence", ApJ 775, L42.

[24] Y. Zhang, X.Yang, H.Wang, L.Wang, W. Luo, H. J. Mo and F. C. van den Bosch, 2013, "Spin Alignments of Spiral Galaxies within the Large-Scale Structure from SDSS DR7", ApJ 779, 160.

[25] C. Li, Y. P. Jing, A. Faltenbacher, and J. Wang, 2013, "The Detection of the Large-Scale Alignment of Massive Galaxies at $z \sim 0.6$", ApJ 770, L12.

[26] I. Trujillo, C. Carretero, and S. G. Patiri, 2006, “Detection of the Effect of Cosmological Large-Scale Structure on the Orientation of Galaxies”, ApJ, 640, L111.

[27] D. Hutsemékers, L. Braibant, V. Pelgrims and D. Sluse, 2014, “Alignment of quasar polarizations with large-scale structures”, A&A 572, A18.

[28] N. Padilla, http://ccapp.osu.edu/workshops/Voids/void_talks/ padilla.pdf

[29] P. Rosati et al., 2009, “Multi-wavelength study of XMMU J2235.3-2557: the most massive galaxy cluster at z > 1”, A&A 508, 583.

[30] M. Brodwin et al., 2010, “SPT-CL J0546-5345: A Massive z >1 Galaxy Cluster Selected via the Sunyaev-Zel’dovich Effect with the South Pole Telescope”, ApJ, 721, 90.

[31] R. J. Foley et al., 2011, “Discovery and Cosmological Implications of SPT-CL J2106-5844, the Most Massive Known Cluster at z > 1”, ApJ 731(2), 86.

[32] J. T. Nielsen, A. Guffanti, and S. Sarkar, 2016, “Marginal evidence for cosmic acceleration from Type Ia supernovae”, Scientific Reports 6, Article number: 35596.

[33] P. A. R. Ade et al. (Planck Collaboration), Planck 2013 results. XVI. Cosmological parameters, arXiv:1303.5076 [astro-ph.CO].

[34] M. E. de Souza, 2017, “Dark Matter Does not Exist at all”, accepted for publication in Frontiers in Science, February 2017, http://vixra.org/abs/1612.0304?ref=915.

[35] Hubble Deep Field North (HDFN). http://hubblesite.org/hubble_discoveries/10th/photos/slide40.shtml

[36] Hubble Deep Field South (HDFS) http://spacetelescope.org/images/opo9841e/

[37]Arp's Catalog of Peculiar Galaxies, http://arpgalaxy.com/

[38] Hubble Ultra Deep Field, https://www.space telescope.org/images/heic0611b/

[39] Hubble Extreme Deep Field (XDF) https://www.nasa.gov/mission_pages/hubble/science/xdf.html

[40] A. van der Wel et al., 2014, “3D-HST+CANDELS: The Evolution of the Galaxy Size-Mass Distribution since z = 3”, ApJ 788, 28.

[41] D. W. Darg et al., 2010, “Galaxy Zoo: the fraction of merging galaxies in the SDSS and their morphologies”, Mon. Not. R. Astron. Soc. 401, 1043.

[42] D. W. Darg, S. Kaviraj, C. J. Lintott, K. Schawinski, J. Silk, S. Lynn, S. Bamford, and R. C. Nichol, 2011, “Galaxy Zoo: Multi-Mergers and the Millennium Simulation”, Mon. Not. R. Astron. Soc. 416, 1745.

[43] L. Mersini-Houghton, 2014, “Backreaction of Hawking radiation on a gravitationally collapsing star I: Black holes?”, Phys. Lett. B 738, 61.

[44] U. W. Heinz, 2005, “’RHIC serves the perfect fluid’ - Hydrodynamic flow of the QGP,” arXiv:nucl-th/0512051.

[45] F. Yusef-Zadeh, M. Wardle, R. Schödel, D. A. Roberts, W. Cotton, H. Bushouse, R. Arendt, and M. Royster, 2016, “Sgr A* and its Environment: Low Mass Star Formation, the Origin of X-ray Gas and Collimated Outflow”, ApJ 819(1), arXiv:1601.00116 [astro-ph.GA]

[46] L. Ferrarese, H. C. Ford, and W. Jaffe, 1996, “Evidence for a massive black hole in the active galaxy NGC 4261 from Hubble Space Telescope images and spectra”, ApJ 470, 444.

[47] D. L. Jones, A. E. Wehrle, D. L. Meier, and B. G. Piner, 2000, “The Radio Jets and Accretion Disk in NGC 4261”, ApJ, 534,165.

[48] Q. D. Wang, et al., 2013, “Dissecting X-ray–Emitting Gas Around the Center of Our Galaxy”, Science, Vol. 341, Issue 6149, 981.

[49] J. Kormendy, http://chandra.as.utexas.edu/m31stis.html

[50] Core of Galaxy NGC 4261, http://archive.seds.org/hst/NGC4261C.html

[51] H. Matsui1, T. R. Saitoh, J. Makino, K.Wada, K Tomisaka, E.Kokubo, H. Daisaka, T.Okamoto, and N.Yoshida, 2012, “Origin of Multiple Nuclei in Ultraluminous Infrared Galaxies”, ApJ, 746, 26.

[52] K. D. Borne, H. Bushouse, R. A. Lucas, and L. Colina, 2000, “Evidence for Multiple Mergers among Ultraluminous Infrared Galaxies: Remnants of Compact Groups?” , ApJ, 529, L77.

[53] G. N. Gimeno, R. J. Díaz, and G. J. Carranza, 2004, “Catalog of Double Nucleus Disk Galaxies”, ApJ 128, 62.
[54] R. Nesci, M. Fiocchi, L.Bassani, and P. Parisi, 2015, “Double-nucleus elliptical MCG-01-12-005 in an X-ray emitting cluster of galaxies” (Research Note), A&A 576, A124.
[55] P. A. Oesch, P. G. van Dokkum, G. D. Illingworth, R. J. Bouwens, I. Momcheva, B. Holden, G. W. Roberts-Borsani, R. Smit, M. Franx, I. Labbé, V. González, and D. Magee, 2015, “A Spectroscopic Redshift Measurement for a Luminous Lyman Break Galaxy at z = 7.730 using KECK/MOSFIRE”, ApJ Lett. 804: L30.
[56] EGS-zs8-1 image, **Erro! A referência de hiperlink não é váli-da.**astronomy/science-egs-zs8-1-farthest-galaxy-02770.html
[57] A. Zitrin, I. Labbé, S. Belli, R. Bouwens, R. S. Ellis, G. Roberts-Borsani, D. P. Stark, P. A. Oesch, and R. Smit, 2015, “Lyα Emission from a Luminous z = 8.68 Galaxy: Implications for Galaxies as Tracers of Cosmic Reionization”, ApJ Lett 810, L12.
[58] H. Atek et al., 2015, “Are Ultra-faint Galaxis at z = 6–8 Responsible for Cosmic Reionization? Combined Constraints from the Hubble Frontier Fields Clusters and Parallels”, ApJ 814, 69.
[59] Y. Bhattacharjee, 2012, “Warped Light Reveals Infant Galaxy on the Brink of the 'Cosmic Dawn'”, Science 21, 337, Issue 6101, 1442.
[60] W. Zheng et al., 2012, “A magnified young galaxy from about 500 million years after the Big Bang,” Nature 489, 406.
[61] P. A. Oesch et al., 2016, "A Remarkably Luminous Galaxy at z=11.1 Measured with Hubble Space Telescope Grism Spectroscopy", ApJ 819 (2).
[62] GN-z11 image, https://astronomynow.com/2016/03/04/hubble-team-breaks-cosmic-distance-record/
[63] R.J. Bouwens1, G.D. Illingworth2, P.A. Oesch3,4, H. Atek3, D. Lam1, M. Stefanon1, Extremely Small Sizes for Faint z~2-8 Galaxies in the Hubble Frontier Fields: A Key Input For Establishing their Volume Density and UV Emissivity, arXiv:1608.00966.
[64] D. M. Elmegreen, B. G. Elmegreen, D. S. Rubin, and M. A. Schaffer, 2005, “Galaxy Morphologies in the Hubble Ultra Deep Field: Dominance of Linear Structures at the Detection Limit”, ApJ 631, 85.
[65] L. L. Cowie, E. M. Hu, and A. Songaila, 1995, “Faintest Galaxy Morphologies from HST WFPC2 Imaging of the Hawaii Survey Fields”, APJ, 110(4), 1576.
[66] S. van den Bergh, R. G. Abraham, R. S. Ellis, N. R. Tanvir, B. X. Santiago, and K. G. Glazebrook, 1996, “A morphological catalog of galaxies in the Hubble Deep Field”, ApJ, 112, 359.
[67] D. M. Elmegreen, D. R. Vollbach, E. R. Foster, and T. E. Ferguson, 2005, “On the Origin of Exponential Disks at High Redshift”, ApJ 634, 101.
[68] B. G. Elmegreen, D. M. Elmegreen and A. C. Hirst, 2004, “A Constant Bar Fraction out to Redshift z~1 in the Advanced Camera for Surveys Field of the Tadpole Galaxy”, ApJ 612,191.
[69] A N. Straughn, E. N. Voyer, R. T. Eufrasio, D. de Mello, S. Petty, S. Kassin, J. P. Gardner, S. Ravindranath, and E. Soto, 2015, “A Multiwavelength Study of Tadpole Galaxies in the Hubble Ultra Deep Field”, ApJ 814, 97.
[70] R. E. Williams et al., 1996, “The Hubble Deep Field: Observations, Data Reduction, and Galaxy Photometry”, ApJ 112(4), 1335.
[71] M. Volonteri, P. Saracco, and G. Chincarini, 200, “A Catalogue* of Galaxies in the HDF-South: Photometry and Structural Parameters, A&A Suppl. Ser. 145, 111.
[72] J. C. Mather, D. J. Fixsen, R. A. Shafer, C. Mosier, and D. T. Wilkinson, 1999, “Calibrator Design for the COBE Far-Infrared Absolute Spectrophotometer (FIRAS)”, ApJ 512, 511.
[73] D. J. Fixsen, 2009, “The Temperature of the Cosmic Microwave Background”, ApJ 707, 916.
[74] P. Noterdaeme, P. Petitjean, R. Srianand, C. Ledoux, and S. López, 2011, “The evolution of the Cosmic Microwave Background Temperature⋆ Measurements of TCMB at high redshift from carbon monoxide excitation”, A&A 526, L1.

[75] M. E. de Souza, 2013, " The Higgs-like Bosons and Quark Compositeness", Frontiers in Science, 3(3): 81.
[76] M. E. de Souza, 2014, "The Higgs boson and quark compositeness", Rencontres de Moriond 2014 Proceedings, http://moriond.in2p3.fr/QCD/2014/proceedings/de_Souza.pdf.
[77] R. Hofstadter, 1956, "Electron Scattering and Nuclear Structure", Rev. Mod. Phys. 28, 214.
[78] R. Hofstadter, F. Bumiller and M. R. Yearian, 1958, "Electromagnetic Structure of the Proton and Neutron", Rev. Modern Phys. 30(2), 482.
[79] R. R. Wilson, Electric Structure of Nucleons, http://inspirehep.net/record/1377841/files/Pages_from_C61-09-14_21.pdf
[80] M. M. Islam, R. J. Luddy, and A. V. Prokudin, 2006. "Near forward pp elastic scattering at LHC and nucleon structure", Int. J. Mod. Phys. A, 21, 1.
[81] G. Antchev et al. (TOTEM Collaboration), 2011, "Proton-proton elastic scattering at the LHC energy of $\sqrt{s}$ = 7 TeV", Eur. Phys. Lett. , 95, 41001.
[82] G. Antchev et al. (TOTEM Collaboration), 2011, "First measurement of the total proton-proton cross-section at the LHC energy of $\sqrt{s}$ = 7 TeV", Eur. Phys. Lett. , 96, 21002.
[83] G. Antchev et al. (TOTEM Collaboration), 2013, "Luminosity-Independent Measurement of the Proton-Proton Total Cross Section at $\sqrt{s}$ = 8 TeV", Phys. Rev. Lett. Vol. 111, 012001.
[84] C. J. Conselice, A. Wilkinson, K. Duncan, and A. Mortlock, 2016, "The Evolution of Galaxy Number Density at z < 8 and its Implications", ApJ 830, 83.
[85] J. S. B. Wyithe, H. Yan, R. A. Windhorst, and S. Mao, 2011, "A distortion of very-high-redshift galaxy number counts by gravitational lensing", Nature 469, 181.
[86] H. J. H. Clercx, A. H. Nielsen, D. J. Torres, and E. A. Coutsias, 2001, "Two-dimensional turbulence in square and circular domains with no-slip walls", Eur. J. Mech. B - Fluids 20, 557.
[87] J. Kuckei, 2002, "Superfluidity in neutron star matter", Prog. Part. Nucl Phys. 48(1), 41.
[88] T. Takatsuka, S. Nishizaki,Y. Yamamoto, and R. Tamagaki, 2002, "Superfluidity of Hyperon-Mixed Neutron Stars", Prog. Theor. Phys. Suppl. No. 146, 279.
[89] K. Adcox et al. [PHENIX Collaboration], 2005, "Formation of dense partonic matter in relativistic nucleus-nucleus collisions at RHIC: Experimental evaluation by the PHENIX collaboration", Nucl. Phys. A 757, 184.
[90] K. Aamodt et al. (ALICE Collaboration), 2011, "Higher harmonic anisotropic flow measurements of charged particles in Pb-Pb collisions at 2.76 TeV", Phys. Rev. Lett. 107, 032301.
[91] R. D. Pisarski, 2006, "Chasing the Unicorn: RHIC and the QGP", Brazilian Journal of Physics, 36, no. 1B.
[92] Statement in RHIC's web page on Tuesday, June 26, 2012, https://www.bnl.gov/rhic/news2/news.asp?a=3161&t=today
[93] Carl H. Gibson, 2010, "Turbulence and turbulent mixing in natural fluids", Phys. Scr. T142, 014030, 2010.
[94] A. R. Conn, G. F. Lewis, R. A. Ibata, Q. A. Parker, D. B. Zucker, A. W. McConnachie, N. F. Martin, D. Valls-Gabaud, N. Tanvir, M. J. Irwin, A. M. N. Ferguson, and S. C. Chapman, 2013, "The Three-Dimensional Structure of the M31 Satellite System; Strong Evidence for an inhomogeneous Distribution of Satellites" Ap J 766,120.
[95] R. A. Ibata, 2013, "A vast, thin plane of corotating dwarf galaxies orbiting the Andromeda galaxy", Nature 493, 62
[96] R. B. Tully, 2013, "Astronomy: Andromeda's extended disk of dwarfs", Nature 493, 31.
[97] E. J. Shaya and R. B. Tully, 2013, "The formation of Local Group planes of galaxies", MNRAS 436, 2096.
[98] R. B. Tully, N. I. Libeskind, I. D. Karachentsev, V. E. Karachentseva, L. Rizzi, and E. J. Shaya, 2015, "Two Planes of Satellites in the Centurus A Group", ApJ Lett 802, L25.
[99] K. Chiboucas, B. A. Jacobs, R. B. Tully, and I. D. Karachentsev, 2013, "Confirmation of Faint Dwarf Galaxies in the M 81 Group", Ap J, 146, 126.

[100] M. Bellazzini, T. Oosterloo, F. Fraternali, and G. Beccari, 2013, “Dwarfs walking in a row; The filamentary nature of the NGC 3109 association”, A&A 559, L1.
[101] W. E. Kunkel and S. Demers, 1976, in Royal Greenwich Observatory Bulletin, Vol. 182, The Galaxy and the Local Group, ed. R. J. Dickens, J. E. Perry, F. G. Smith, & I. R. King, p 241.
[102] D. Lynden-Bell, 1976, “Dwarf Galaxies and Globular Clusters in High Velocity Hydrogen Streams”, Mon. Not. R. Astr. Soc. 174, 695.
[103] D. Lynden-Bell, 1982, “The Fornax-Leo-Sculptor Stream”, The Observatory, 102, 202.
[104] N. I. Libeskind, Y. Homan, R. B. Tully, H. M Courtois, D. Pomarède, S. Gottlöber, M. Steinmetz, 2015, “Planes of satellite galaxies and the cosmic web”, Mon. Not. R. Astron. 452 (1), 1052.
[105] A. van der Wel1 et al., 2014, “3D-HST+CANDELS: The Evolution of the Galaxy Size-Mass Distribution since z = 3”, ApJ, 788, 28.
[106] M. Mosleh, R. J Williams, M. Franx, M. Kriek, 2010, “The Evolution of the Mass-Size Relation to z= 3.5 for UV-bright Galaxies and Submillimeter Galaxies in the GOODS-North Field”, ApJ 727(1).
[107] M.-J. Huang, 2005, “The physical mechanism of symmetric vortex merger: A new viewpoint”, Physics of Fluids, 17, 074105.
[108] Animation of two equal corotating vortices, https://www.youtube.com/watch?v=JwJTsJdWeek
[109] R. R. Trieling, O. U. V. Fuentes, and G. J. F. van Heijst, 2005, “Interaction of two unequal corotating vortices”, Physics of Fluids, 17, 087103.
[110] P. Bonfini, A. Zezas, M. Birkinshaw, D. M. Worrall, G. Fabbiano, E. O’Sullivan, G. Trinchieri and A. Wolter, 2012, “Studying the asymmetry of the GC population of NGC 4261”, Mon. Not. R. Astron. Soc., 421(4), 2872.
[111] J. L. Gomes et al., 2016, “Spiral-like star-forming patterns in CALIFA early-type galaxies”, A&A 585, A92.
[112] M. Cappellari1 et. al., 2011, “The ATLAS3D project – VII. A new look at the morphology of nearby galaxies: the kinematic morphology-density relation”, Mon. Not. R. Astron. Soc. 000, 1.
[113] M.-J. Huang, 2006, “A comparison between asymmetric and symmetric vortex mergers”, Proceedings of the 4th WSEAS International Conference on Fluid Mechanics and Aerodynamics, Elounda, Greece.
[114] M. Amoretti, D. Durkin, J. Fajans, R. Pozzoli and M. Romé, 2001, “Asymmetric vortex merger: Experiments and simulations”, Physics of Plasmas, 8(9), 3865.
[115] DTU 8e Lecture PPT Chap 16 Galaxies – Chabot College, slide 58.
[116] Lundgren’s spiral vortex, https://www.youtube.com/watch?v=v92ae5y9xRw.
[117] W. J. Kaufmann, III, in Galaxies and Quasars, W. H. Freeman and Co., San Francisco, 1979,
[118] E. J. M. Colbert, A. S. Wilson and J. Bland-Hawthorn, 1994, “The Radio Emission from the Ultra-Luminous Far-Infrared Galaxy NGC 6240”, ApJ 435, 89.
[119] S. C. Chapman, G. A. H. Walker and S. L. Morris, 1998, “The core structure of AGN: perils of adaptive optics artifacts”, http://astro-ph/9810250.
[120] H. Falcke and P. L. Biermann, 1999, “The jet/disk symbiosis III. What the radio cores in GRS 1915+105, NGC 4258, M 81, and Sgr A tell us about accreting black holes”, A&A 342, 49.
[121] E. Sturm et al., 2011, “Massive molecular outflows and negative feedback in ULIRGS observed by Herschel-PACS”, ApJ. 733, L16.
[122] E. Middleberg, A. L. Roy, N. M. Nagar, T. P. Krichbaum, R. P. Norris, A. S. Wilson, H. Falcke, E. J. M. Colbert, A. Witzel and K. J. Fricke, 2004, “Motion and Properties of Nuclear Radio Components in Seyfert Galaxies Seen with VLBI”, A&A 417, 925.
[123] C. Muñoz-Tuñon and J. E. Beckman, 1988, “Mass outflows and its consequences in the circumnuclear zones of galaxies”, Astrophysics and Space Science, 147(1), 173.
[124] K. Alatalo et al., 2011, “Discovery of an AGN-Driven Molecular Outflow in the Local Early-Type Galaxy NGC 1266”, ApJ 735(2), 88, 2011.

[125] M. S. Yun, N. A. Reddy, N. Z. Scoville, D. T. Frayer, E. I. Robson and R. P. J. Tilanus, 2004, “Multiwavelength Observations of the Gas-rich Host Galaxy of PDS 456: A New Challenge for the ULIRG-to-QSO Transition Scenar-io”, ApJ 601, 723.

[126] O. Almaini, “The Links Between AGN and Galaxy For-mation”, in Physics of Active Galactic Nuclei at all Scales, Eds. D. Alloin, R. Johnson and P. Lira, p. 222, Springer, Berlin, 2006.

[127] J. Reeves, E. Nardini, J. Gofford, V. Braito, G. Risaliti, D. Walton, F. Harrison, G. Matzeu, M. Costa, and G. Matt, “The Powerful Black Hole Wind in the Luminous Quasar PDS 456”, Proceedings of the conference The Ex-tremes of Black Hole Accretion, 8-10 June, 2015 in Madrid, Spain.

[128] Large Quasar Astrometric Catalog (LQAC), 3rd re-lease, https://heasarc.gsfc.nasa.gov/W3Browse/all/lqac.html

[129] F. Bertola and M. Capaccioli, 1975, “Dynamics of early type galaxies. I. The rotation curve of the elliptical galaxy NGC 4697”, Ap. J. 200, 439.

[130] DTU 8e Lecture PPT Chap 16 Galaxies – Chabot College, slide 58.

[131] A. Dressler, Galaxies, properties in relation to envi-ronment, https://ned.ipac.caltech.edu/level5/ESSAYS/Dressler/dressler.html

[132] J. H. Conway and N. J. A. Sloane, in Sphere Pack-ings, Lattices, and Groups, 2nd ed. New York: Spring-er-Verlag, 1993.

[133] A. Bezdek and W. Kuperberg, In Applied Geometry and Discrete Mathematics: The Victor Klee Festschrift (Ed. P. Gritzmann and B. Sturmfels). Providence, RI: Amer. Math. Soc., pp. 71-80, 1991.

[134] Sloan Digital Sky Survey web page, http://skyserver.sdss.org/dr1/en/proj/advanced/galaxies/separator.asp.

[135] C. Song and P. Wang, and H. A. Makse, 2008. "A phase diagram for jammed matter". Nature. 453 , 7195, 629.

[136] T. Wang et al., 2016, “Discovery of a galaxy cluster with a violently starbursting core at z=2.506”, ApJ 828, 56.

[137] S. Ortolani, A. Renzini, R. Gilmozzi, G. Marconi, B. Barbuy, E. Bica, and R. Rich, 1995, “Near-coeval formation of the Galactic bulge and halo inferred from globular cluster ages”, Nature 377, 701.