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# Cosmic Bubbles

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## Abstract

The present paper is inspired by the article "Ho'oleilana: An Individual Baryon Acoustic Oscillation?" published by R. B. Tully, C. Howlett, and D. Pomarède on Sep. 2023 [1]. They claim: *Evidence is presented here for the discovery of a remarkably strong individual contribution to the baryon acoustic oscillation (BAO) signal at z = 0.068, an entity that is given the name Ho'oleilana.* K. Dawson, co-spokesperson for Dark Energy Spectroscopic Instrument *is more inclined to believe that this latest finding is something of a coincidence, a chance alignment that simply looks like a sphere with a radius around what you'd expect for a BAO* [2]. In this paper, we provide a short summary of experimental observations of Boötes Void and Superclusters; discuss the main features of the developed Hypersphere World-Universe Model; introduce notions "Cosmic Voids" and "Cosmic Bubbles"; elaborate a mathematical framework for different types of Cosmic Bubbles (Hubble Spherical Bubble for the World, Disk Bubbles for Galaxies; Spherical Bubbles for Extrasolar Systems, Dark Matter (DM) Spherical Bubbles for Galaxies and Superclusters); make a conclusion that the Boötes is a DM Cosmic Bubble and suggest experiments, which confirm our conclusion.

## Keywords

World-Universe Model, Boötes Void, Boötes Superclusters, Macroobjects Bubbles, Dark Matter Bubbles, Fermi Bubbles, Boötes Bubbles

## 1. Introduction

In the article "Ho'oleilana: An Individual Baryon Acoustic Oscillation?" [1], R. B. Tully, C. Howlett, and D. Pomarède claim: *Evidence is presented here for the discovery of a remarkably strong individual contribution to the baryon acoustic oscillation (BAO) signal at z = 0.068, an entity that is given the name Ho'oleilana. The radius of the 3D structure is* $155h_{75}^{-1}$ *Mpc. At its core is the Boötes supercluster. The Sloan Great Wall, CfA Great Wall, and Hercules complex all lie within the BAO shell. The interpretation of Ho'oleilana as BAO structure with* *our preferred analysis implies a value of the Hubble constant of* $76.9^{+8.2}_{-4.8}$ km·s$^{-1}$·Mpc$^{-1}$.

The authors summarize their results: *Significance of the detection of Ho'oleilana, its shape, its relation to other previously known structures in the local Universe, and the prominence of the feature compared to the expectations of both a random field of galaxies and simulations with large-scale structure but suppressed BAO, strongly suggest that Ho'oleilana is itself a part of the BAO feature rather than a chance alignment* (see **Figure 1**). BAO stands for "baryon acoustic oscillation," a sort of frozen sound wave created by processes near the dawn of time.

A. Mann in the article "Ho'oleilana, a Billion-Light-Year-Wide Bubble of Galaxies, Astounds Astronomers" [2] wrote: *According to theoretical predictions, that formation is not quite the right size to be a BAO. This discrepancy could either imply that conditions in the early universe weren't quite what astronomers have expected or that the structure is a chance alignment of galaxies masquerading as a BAO. Tully and Pomarède think their discovery could be used to probe fundamental properties of the cosmos. But in order to do so, they need to convince the rest of the community that the result is what they believe it to be.*

*The size of any individual BAO is set by the speed of sound in the early universe's primordial plasma, which was roughly half the speed of light. This created pressure waves with particular amplitudes, which were stretched out by later cosmic expansion to a bit less than half a billion light-years. But Ho'oleilana's radius is actually about 10 percent greater than would be expected with such processes. To Tully and his colleagues, this could indicate something important about the nascent universe.*

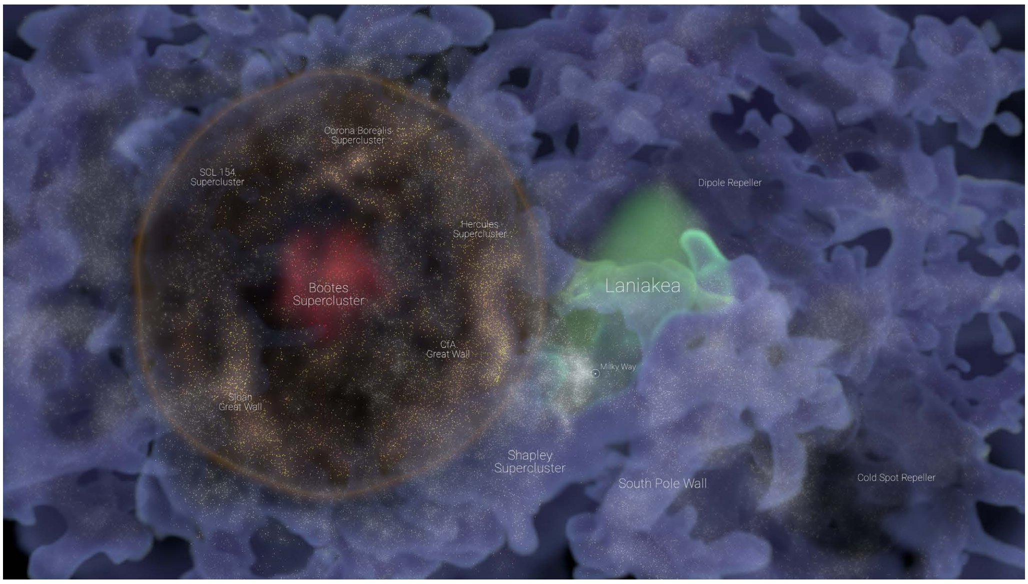


**Figure 1.** Ho'oleilana. D. Pomarède. Credits: Frédéric Durillon, Animea Studio; Daniel Pomarède, IRFU, CEA University Paris-Saclay; government funding provided by France 2030 (P2I Graduate School of Physics) ref ANR-11-IDEX-0003. https://twitter.com/DanielPomarede/status/1699049162174533919. Adapted from [2].

*Of course, the aberrant size of the team's BAO could also lead to other conclusions. The outlines of the billionish-light-year bubbles are extremely faint and only become apparent when one examines an enormous number of objects over great distances, says K. Dawson. He's more inclined to believe that this latest finding is something of a coincidence, a chance alignment that simply looks like a sphere with a radius around what you'd expect for a BAO.*

## 2. Boötes Void and Superclusters

Cosmic voids are vast spaces between filaments (the largest-scale structures in the universe), which contain very few or no galaxies. The cosmological evolution of the void regions differs drastically from the evolution of the Universe as a whole: there is a long stage when the curvature term dominates, which prevents the formation of galaxy clusters and massive galaxies. Hence, although even the emptiest regions of voids contain more than ~15% of the average matter density of the Universe, the voids look almost empty to an observer. Voids typically have a diameter of 30 to 300 Mly; particularly large voids called supervoids. They were first discovered in 1978 in a pioneering study by S. Gregory and L. A. Thompson.

Voids are believed to have been formed by baryon acoustic oscillations in the Big Bang, collapses of mass followed by implosions of the compressed baryonic matter. Starting from initially small anisotropies from quantum fluctuations in the early universe, the anisotropies grew larger in scale over time. Regions of higher density collapsed more rapidly under gravity, eventually resulting in the large-scale, foam-like structure or "cosmic web" of voids and galaxy filaments seen today. Voids located in high-density environments are smaller than voids situated in low-density spaces of the universe [3].

Boötes Void is one of the largest known voids in the Universe and is referred to as a supervoid. Its discovery was reported by R. Kirshner, *et al.* (1981). The centre of the Boötes Void is approximately 700 Mly from Earth. Other astronomers soon discovered that the void contains a few galaxies. In 1987, J. Moody, R. P. Kirshner, *et al.* published their findings of eight galaxies in the void. M. Strauss and J. Huchra announced the discovery of three more galaxies in 1988, and G. Aldering, G. Bothun, R. P. Kirshner, and R. Marzke announced the discovery of fifteen galaxies in 1989. By 1997, the Boötes Void was known to contain 60 galaxies. A normal region of the universe of this size would usually contain many thousands of bright galaxies. Most of the galaxies discovered are usually located near the edges of the void [4].

There are two superclusters in Boötes within 1 Bly. The nearest one is about 830 Mly away, the second one lies directly behind it at a distance of about 1 Bly. The Boötes superclusters are famous mainly because they lie next to (and slightly behind) the Boötes void. This void is one of the most famous voids in the universe mainly because it was one of the first major voids discovered. The void contains very few galaxies, although there are a lot of foreground galaxies between us and the void. There has been no scientific study of the superclusters in Boötes. Although these superclusters are much bigger than the Virgo supercluster, there are many closer superclusters which are considered to be more interesting [5].

## 3. Medium of the World

The existence of the Medium is a principal point of the Hypersphere World-Universe Model (WUM). It follows from the observations of Intergalactic Plasma; Cosmic Microwave Background Radiation (CMBR); Far-Infrared Background Radiation. Intergalactic voids discussed by astronomers are, in fact, examples of the Medium in its purest. CMBR is part of the Medium; it then follows that the Medium is an absolute frame of reference. Relative to CMBR rest frame, the Milky Way (MW) galaxy and the Sun are moving with the speed of 552 and 370 km·s$^{-1}$, respectively. The Medium of the World is Homogeneous and Isotropic. Distribution of Macroobjects (MOs) is spatially Inhomogeneous and Anisotropic and temporally Non-simultaneous. In WUM, Physical Laws are determined by the Medium of the World.

The Medium of the World, consisting of protons, electrons, photons, neutrinos, and Dark Matter Particles (DMPs), is an active agent in all physical phenomena in the World. Time, Space and Gravitation are closely connected with the Impedance, Gravitomagnetic parameter, and Energy density of the Medium, respectively. It follows that neither Time, Space nor Gravitation could be discussed in absence of the Medium. WUM confirms the Supremacy of Matter postulated by A. Einstein: *When forced to summarize the theory of relativity in one sentence: time and space and gravitation have no separate existence from matter*.

### 3.1. Energy Density of the World

Imagine that the World is a Hubble Bubble with a radius $R = c\tau$ (where $c$ is a gravitodynamic constant that is identical to the electrodynamic constant $c$ in Maxwell's equations and $\tau$ is a cosmological time) and an energy density of a spherical surface $\sigma_0$ that is a temperature invariant surface enthalpy [6]:

$$\sigma_0 = \frac{hc}{a^3}$$

where $h$ is Planck constant and $a$ is a basic size unit: $a = 1.7705641 \times 10^{-14}\ \text{m}$.

With Nikola Tesla's principle at heart, *there is no energy in matter other than that received from the environment*, we calculate an energy of the World $E_W$:

$$E_w = 4\pi R^2 \sigma_0$$

and an average energy density $\rho_W$:

$$\rho_W = \frac{3\sigma_0}{R} = \frac{3hc}{a^3 R} = \frac{3hc}{a^4}\frac{a}{R} = 3\rho_0 \times Q^{-1}$$

that is inversely proportional to $R$. An energy density unit $\rho_0$ equals to: $\rho_0 = hc/a^4$ and a dimensionless time-varying quantity $Q_{av}$ equals:

$$Q_{av} = \frac{a^2 c^4}{8\pi hc} \times G_{av}^{-1} = 0.7599440 \times 10^{40}$$

where $G_{av}$ is the average value of the experimentally measured gravitational parameter $G_{av}$ [7]:

$$G_{av} = \frac{G(1) + G(2)}{2} = 6.674334 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

The quantity $Q$ that is a measure of a size $R$ and age $A_\tau$ of the world and is, in fact, the Dirac Large Number ($t_0$ is a basic time unit: $t_0 = a/c = 5.9059662 \times 10^{-23}$ s ):

$$Q = \frac{R}{a} = \frac{A_\tau}{t_0}$$

WUM is based on two parameters only: dimensionless Rydberg constant α (later named fine-structure constant) and time-varying Quantity $Q$.

### 3.2. Critical Energy Density

The principal idea of WUM is that $\rho_W$ equals to the critical energy density $\rho_{cr}$: $\rho_W = \rho_{cr}$, which can be found by considering a sphere of radius $R_M$ and enclosed mass $M$ that can be calculated by multiplication of critical mass density by the volume of the sphere. When the World has the critical density, the Hubble velocity $H \times R_M$ ($H = c/R$ is the Hubble parameter) equals to the escape velocity $v_{esc}$ [8]:

$$v_{esc}^2 = \frac{2GM}{R_M} = \frac{2G}{R_M} \times \frac{4\pi}{3} R_M^3 \times \frac{\rho_{cr}}{c^2} = (H \times R_M)^2$$

which gives an equation for $\rho_{cr}$:

$$\rho_{cr} = 3H^2c^2/8\pi G$$

This equation can be rewritten as:

$$\frac{4\pi G}{c^2} \times \frac{2}{3}\rho_{cr} = \mu_g \times \rho_M = H^2 = \frac{c^2}{R^2}$$

where $\mu_g = \frac{4\pi G}{c^2}$ is a gravitomagnetic parameter and $\rho_M = \frac{2}{3}\rho_{cr}$ is an energy density of the Medium. Considering that $H \propto R^{-1}$, it is easy to see that the gravitational parameter $G \propto R^{-1}$. We emphasize that the values of the main cosmological parameters $G$ and $H$ depend on the value of $\rho_M$ which is the characteristic of the Medium that is Homogeneous and Isotropic. The critical energy density of the World in the present Epoch equals to [6]:

$$\rho_{cr} = 3\rho_0 \times Q^{-1} = 4.980161 \,\text{GeV/m}^3$$

### 3.3. Dark Matter Particles [9]

WUM proposes multicomponent DM system consisting of two couples of co-annihilating DMPs: a heavy Dark Matter Fermion (DMF), DMF1 (1.3 TeV) and a light spin-0 boson, DIRAC (70 MeV) that is a dipole of Dirac's monopoles with charge $\mu = e/2\alpha$ ($e$ is an elementary charge and $\alpha$ is a dimensionless Rydberg constant); a heavy fermion, DMF2 (9.6 GeV) and a light spin-0 boson, ELOP (340 keV) that is a dipole of preons with electrical charge e/3; self-annihilating fermions DMF3 (3.7 keV) and DMF4 (0.2 eV), and boson XION (5.3 eV) that is an analog of Axion discussed in literature. In WUM, XIONs are responsible for the Le Sage's mechanism of gravitation.

The reason for this multicomponent DM system was to explain the diversity of DM Cores of MOs of the World (superclusters, galaxies, and extrasolar systems), which are Fermion Compact Objects in our Model.

WUM postulates that rest energies of DMFs and bosons are proportional to a basic energy unit $E_0 = hc/a$ multiplied by different exponents of $\alpha$ and can be expressed with following formulae:

DMF1 (fermion): $E_{DMF1} = \alpha^{-2} E_0 = 1.3149948\ \text{TeV}$.

DMF2 (fermion): $E_{DMF2} = \alpha^{-1} E_0 = 9.5959804\ \text{GeV}$.

DIRAC (boson): $E_{DIRAC} = \alpha^{0} E_0 = 70.025252\ \text{MeV}$.

ELOP (boson): $E_{ELOP} = 2/3\,\alpha^{1} E_0 = 340.66596\ \text{keV}$.

DMF3 (fermion): $E_{DMF3} = \alpha^{2} E_0 = 3.7289394\ \text{keV}$.

DMF4 (fermion): $E_{DMF4} = \alpha^{4} E_0 = 0.19857107\ \text{eV}$.

XION (boson) $E_{XION} = 1/2\,\alpha^{6} E_0 = 5.2870895\ \mu\text{eV}$.

It is worth noting that the rest energy of electron $E_e$ equals to: $E_e = \alpha E_0$ and the Rydberg unit of energy is: $Ry = hcR_\infty = 0.5\alpha^3 E_0 = 13.605693\ \text{eV}$.

### 3.4. Content of the World [9]

One of the principal ideas of WUM holds that relative energy densities of the World's particles in terms of the critical energy density $\rho_{cr}$ are constants in all times and proportional to the proton energy density in the World's Medium $\rho_p$ that in the present Epoch equals to [6]:

$$\rho_p = \frac{2\pi^2\alpha}{3}\rho_{cr} = 0.048014655\rho_{cr} = 239.1207\ \text{MeV/m}^3$$

Our Model holds that the energy density of all types of self-annihilating DMPs is proportional to $\rho_p$. In all, there are 6 different types of self-annihilating DMPs: DMF1, DMF2, DIRAC, ELOP, DMF3, and DMF4. Then a total energy density of DMPs $\rho_{DM}$ is:

$$\rho_{DM} = 6\rho_p = 0.28808793\rho_{cr}$$

that is in good agreement with the results in [10]. The total XION energy density $\rho_{XION}$ is:

$$\rho_{XION} = 1.35\pi^2\rho_p = 0.63974563\rho_{cr}$$

The total baryonic energy density $\rho_B$ is:

$$\rho_B = 1.5\rho_p$$

The sum of electron and CMBR energy densities $\rho_{eCMBR}$ equals to:

$$\rho_{eCMBR} = 1.5\frac{m_e}{m_p}\rho_p + 2\frac{m_e}{m_p}\rho_p = 3.5\frac{m_e}{m_p}\rho_p$$

We take energy density of neutrinos $\rho_\nu$ to equal:

$$\rho_\nu = \rho_{CMBR}$$

For Far-Infrared Background Radiation energy density $\rho_{FIRB}$ we take

$$\rho_{FIRB} = \frac{1}{40}\frac{m_e}{m_p}\rho_p$$

Then the energy density of the World $\rho_W$ equals to the theoretical critical energy density:

$$\rho_W = \left[1.35\pi^2 + 7.5 + \left(5.5 + \frac{1}{40}\right)\frac{m_e}{m_p}\right]\rho_p = \rho_{cr}$$

From this equation we can calculate the value of $1/\alpha$ using electron-to-proton mass ratio $m_e/m_p$:

$$\frac{1}{\alpha} = \frac{\pi^2}{60}\left[54\pi^2 + 300 + (220 + 1)\frac{m_e}{m_p}\right] = 137.03600$$

which is in excellent agreement with the commonly adopted value of 137.035999. It follows that there is a direct correlation between constants $\alpha$ and $m_e/m_p$ expressed by the obtained equation. As shown, $m_e/m_p$ is not an independent constant but is instead derived from $\alpha$.

As a conclusion:

- The World's energy density is inversely proportional to a dimensionless time-varying parameter $Q \propto \tau$ in all cosmological times;
- The particles relative energy densities are proportional to constant $\alpha$.

### 3.5. Weak Interaction [11]

According to WUM, strength of gravity is characterized by gravitational parameter $G$:

$$G = G_0 \times Q^{-1}$$

where $G_0 = \frac{a^2c^4}{8\pi hc}$ is an extrapolated value of $G$ at the Beginning of the World ($Q = 1$). $Q$ in the present Epoch equals to: $Q = 0.759972 \times 10^{40}$. The range of gravity equals to the size of the World $R$:

$$R = a \times Q = 1.34558 \times 10^{26}\ \text{m}$$

Weak interaction is characterized by the parameter $G_W = G_0 \times Q^{-1/4}$, which is about 30 orders of magnitude greater than $G$. The range of the weak interaction $R_W$ in the present epoch equals to:

$$R_W = a \times Q^{1/4} = 1.65314 \times 10^{-4}\ \text{m}$$

that is much greater than the range of the weak nuclear force ($10^{-16} \Leftrightarrow 10^{-17}$ m). A volume of Weak interaction $V_W$ is

$$V_W = 1.89242 \times 10^{-11}\ \text{m}^3$$

and a critical concentration $n_W^{cr}$ equals to:

$$n_W^{cr} = 5.28424 \times 10^{10}\ \text{m}^{-3}$$

The introduced principally new Weak Interaction between DMPs provides integrity of all Macroobjects' Cores (see Section 4), In our view, Weak interaction between particles DMF3 provides integrity of DM Fermi Bubbles (see Section 6).

## 4. Macroobject Shell Model [11]

In WUM, Macrostructures of the World (Superclusters, Galaxies, Extrasolar systems) have Nuclei made up of DMFs, which are surrounded by Shells composed of DM and Baryonic Matter. The shells envelope one another, like a Russian doll. The lighter a particle, the greater the radius and the mass of its shell. Innermost shells are the smallest and are made up of heaviest particles; outer shells are larger and consist of lighter particles. A proposed Weak Interaction of DMPs provides integrity of all shells. Table 1 describes parameters of MOs' Cores, which are 3D fluid balls with a very high viscosity and function as solid-state objects.

The calculated parameters of the shells show that:

- Nuclei made up of DMF1 and/or DMF2 compose Cores of dark stars in Galaxies and normal stars in Extrasolar Systems;
- Shells of DMF3 and/or Electron-Positron plasma around Nuclei made up of DMF1 and/or DMF2 make up Cores of Galaxies;
- Nuclei made up of DMF1 and/or DMF2 surrounded by shells of DMF3 and DMF4 compose Cores of Superclusters.

## 5. Macroobject Bubbles

In our opinion, **Cosmic Voids** are vast spaces between filaments, which have no galaxies and contain the Medium of the World only with the energy density equals to $2/3\rho_{cr}$ but not ≳15% of the average matter density of the Universe, as it is supposed in [3]. **Cosmic Bubbles** have boundaries between an internal parts of them and surrounding media with the surface energy density $\sigma_0$.

**Table 1.** Parameters of MOs' cores made up of different Fermions in present Epoch.

| Fermion | Rest Energy $E_{fs}$, MeV | Macroobject Mass $M_{max}$, kg | Macroobject Radius $R_{min}$, m | Macroobject Density $\rho_{max}$, kg·m$^{-3}$ |
|---|---|---|---|---|
| DMF1 | $1.3 \times 10^{6}$ | $1.9 \times 10^{30}$ | $8.6 \times 10^{3}$ | $7.2 \times 10^{17}$ |
| DMF2 | $9.6 \times 10^{3}$ | $1.9 \times 10^{30}$ | $8.6 \times 10^{3}$ | $7.2 \times 10^{17}$ |
| Electron-Positron | 0.51 | $6.6 \times 10^{36}$ | $2.9 \times 10^{10}$ | $6.3 \times 10^{4}$ |
| DMF3 | $3.7 \times 10^{-3}$ | $1.2 \times 10^{41}$ | $5.4 \times 10^{14}$ | $1.8 \times 10^{-4}$ |
| DMF4 | $2 \times 10^{-7}$ | $4.2 \times 10^{49}$ | $1.9 \times 10^{23}$ | $1.5 \times 10^{-21}$ |

### 5.1. Extrasolar Systems

Extrasolar Systems (ESS) are Bubbles with a boundary between ESS and Interstellar Medium that has a surface energy density $\sigma_0$. This vast, bubble-like region of space, which surrounds the Sun, is continuously inflated by solar jets. The outside radius of the Solar Bubble $R_{SB}$ equals to:

$$R_{SB} = \left(\frac{3M_{\odot}c^2}{4\pi\sigma_0}\right)^{1/2} \cong 1.1\times10^{15}\ \mathrm{m} \cong 0.12\ \mathrm{ly}$$

where $M_{\odot}$ is the mass of the Sun. The value of 3 above follows from the ratio for all MOs of the World: 1/3 of the total mass is in the central MO and 2/3 of the total mass is in the structure around it.

### 5.2. Galaxies

**Milky Way** (MW) galaxy is the second-largest spiral galaxy in the Local Group (after Andromeda Galaxy), with its estimated visible stellar disk diameter $D_{MW} = 185 \pm 15\ \mathrm{kly}$, thickness of thin stellar disk about 2 kly and mass $M_{MW} = (1.6 - 3.2)\times10^{42}\ \mathrm{kg}$ [12]. In our view, MW is a Disk Bubble whose boundary with the Intergalactic Medium has a surface energy density $\sigma_0$. The Disk Bubble contains Interstellar Medium (ISM) and (100 - 400) billion ESS. According to WUM, mass of MW equals to:

$$M_{MW} = \frac{\pi D_{MW}^2 \sigma_0}{2c^2}$$

We calculate $D_{MW}$ by the following equation:

$$D_{MW} = \left(\frac{2M_{MW}c^2}{\pi\sigma_0}\right)^{1/2} = (170 - 240)\ \mathrm{kly}$$

The calculated value of the visible stellar disk diameter is in good agreement with its estimated value obtained by astronomers. Considering the average stellar disk diameter $D_{MW} = 185\ \mathrm{kly}$ we can calculate:

- Mass of MW: $M_{MW} = 1.92\times10^{42}\ \mathrm{kg}$.
- Average density: $\rho_{MW} = 4.20\times10^{-20}\ \mathrm{kg\cdot m^{-3}}$.
- Average concentration of DMF3 in ISM: $n_{DMF3}^{ISM} = 3.04\times10^{11}\ \mathrm{m^{-3}}$.

That is significantly larger than the critical concentration $n_W^{cr}$ (see Section 3.5). It means that weak interaction between DMF3 provides integrity of MW's disk bubble.

**Andromeda Galaxy** (AG) is a barred spiral galaxy approximately 2.5 Mly from Earth and the nearest large galaxy to MW with about $10^{12}$ stars. It has an estimated visible stellar disk diameter ~220 kly and mass (3 ± 1) × $10^{42}$ kg [13]. Parameters of AG are close enough to the parameters of MW. It seems reasonable that the calculations of the galaxy parameters made above for MW are valid for AG also.

The experimental observations of galaxies in the universe show that most of them are disk galaxies [14]. Considering the fact that the calculated concentrations of DMF3 are significantly larger than the critical concentration, we can suppose that our conclusions for MW are fair for all galaxies in the World.

It is worth noting that in frames of WUM, Galaxies emerged due to the Explosive Volcanic Rotational Fission of Overspinning DM Superclusters' Cores composed of DM particles DMF1, DMF2, DMF3, and DMF4. As the result of this mechanism, Galaxy Bubbles created, which have look like "Chicken egg" at that time:

- "Yolk", spinning liquid DM Core of galaxy with high viscosity composed of DMPs (DMF1, DMF2, and DMF3). "Yolk" contains 1/3 of the total galaxy Matter;
- "Albumen", liquid ISM with low viscosity made of DMF3 with dissolved other DMPs. "Albumen" adds up to 2/3 of the total galaxy Matter;
- "Membrane", boundary between ISM and Intergalactic Medium with surface energy density $\sigma_0$.

ESS emerges due to the Explosive Volcanic Rotational Fission of Overspinning DM galaxy Core and enter ISM. As a result, galaxy Bubble expands in the plane of the spinning galaxy's DM Core and becomes a Disk Bubble.

## 5.3. Superclusters

It is worth noting that the Laniakea Supercluster (LSC), a collection of around $10^5$ nearby galaxies [15], including MW stretches over 0.52 Bly that corresponds to the calculated diameter of single Bubble made up of DMF4 (see Section 6.2). We emphasize that ~$10^5$ nearby galaxies are moving around Centre of LSC. All these galaxies did not start their movement from the "Initial Singularity". The neighboring superclusters have the same structures [16].

13.77 Byr ago, when LSC emerged, the estimated number of DM Supercluster Cores in the World was around $\gtrsim 10^3$. It is unlikely that all of them gave birth to Luminous Superclusters at the same cosmological time being far away from each other. In our view, the World presents a Patchwork Quilt of different Luminous Superclusters, which emerged in various places of the World at different Cosmological times [16].

## 5.4. Parallel Worlds

In WUM, the World is a **Hubble Bubble** with the radius *R*, a volume $V_W = 4/3\pi R^3$, and the energy density of a spherical surface $\sigma_0$ [6]. The World is a part of the 3D Finite Boundless Hypersphere of 4D Nucleus of the World, which is expanding in Its fourth spatial dimension. As a result, the Hypersphere with the 3-dimensional surface volume of $V_H = 2\pi^2 R^3$ is evenly stretched. The ratio of $V_H$ to $V_W$ is:

$$V_H / V_W = 1.5\pi = 4.71\,.$$

It means that in the Hypersphere could exist four "Parallel Worlds" with the same laws of physics because all points of the Hypersphere are equivalent and there are no preferred centers or boundaries of it.

**CMBR Cold Spot** is a region of the sky seen in microwaves that has been found to be unusually large and cold relative to the expected properties of CMBR. The "Cold Spot" is ≅70 μK colder than the average CMBR temperature (approximately 2.7 K), whereas the root mean square of typical temperature variations is only 18 μK.

Various alternative explanations exist, including so-called Eridanus Supervoid that is an extremely large region of the universe, roughly 0.5 to 1 Bly across and 6 to 10 Bly away, at redshift $z \approx 1$, containing a density of matter much smaller than the average density at that redshift.

A controversial claim by Laura Mersini-Houghton is that it could be the imprint of another universe beyond our own. She said, "*Standard cosmology cannot explain such a giant cosmic hole*" and made the hypothesis that the WMAP cold spot is "… *the unmistakable imprint of another universe beyond the edge of our own*". If true, this provides the first empirical evidence for a parallel universe (though theoretical models of parallel universes existed previously) [17].

## 6. Dark Matter Bubbles

### 6.1. Fermi Bubbles [11]

In 2010, gamma-ray observations by Fermi revealed previously unknown features in our galaxy that now called the Fermi Bubbles. These mysterious structures emerge above and below the center of MW, spanning a total length of about 50 kly. They emit higher-energy gamma rays than the rest of the galaxy's disk. A completely unexpected discovery like the Fermi Bubbles is a special treat. However, scientists know that there are many more surprises waiting to be uncovered by Fermi. In the most recent catalog of sources from Fermi's Large Area Telescope, fully a **third of detected source positions are not known to have a gamma-ray emitting object at that location**. What could be producing these gamma rays?

The outlines of the bubbles are quite sharp, and the bubbles themselves glow in nearly uniform gamma rays over their colossal surfaces. Gamma-ray spectrum at Galactic latitude ≤ 10˚, without showing any sign of cutoff up to around 1 TeV, remains unconstrained. Years after the discovery of FBs, their origin and the nature of the gamma-ray emission remain unresolved.

M. Su, *et al.* identify a gamma-ray cocoon feature in the southern and north Fermi bubble, a jet-like feature along the cocoon's axis of symmetry. Both the cocoon and jet-like feature have a hard spectrum from 1 to 100 GeV. If confirmed, these jets are the first resolved gamma-ray jets ever seen.

G. Ponti, *et al.* report prominent X-ray structures on intermediate scales (hundreds of parsecs) above and below the plane, which appear to connect the Galactic Centre region to the FBs. These structures, which they term the Galactic Centre "chimneys", constitute exhaust channels through which energy and mass, injected by a quasi-continuous train of episodic events at the Galactic Centre, are transported from the central few parsecs to the base of the FBs.

D. Hooper and T. R. Slatyer discuss two emission mechanisms in the FBs: inverse Compton scattering and annihilating DM. In their opinion, the second emission mechanism must be responsible for the bulk of the low-energy, low-latitude emission. The spectrum and angular distribution of the signal is consistent with that predicted from ~10 GeV DMPs annihilating to leptons**.** This component is similar to the excess GeV emission previously reported by D. Hooper from the Galactic Center.

It is worth noting that a similar excess of gamma-rays was observed in the central region of the Andromeda galaxy (M31). A. McDaniel, *et al.* calculated the expected emission across the electromagnetic spectrum and found that the best fitting models are with the DMP mass 11 GeV [18].

In the article "Evidence of Fermi bubbles around M31", M. S. Pshirkov, *et al.* performed search for an extended gamma-ray halo in the energy range 0.3 - 100 GeV around M31 and found that the best-fit halo template corresponds to two 6 - 7.5 kpc bubbles symmetrically located perpendicular to the M31 galactic disc, similar to the Fermi bubbles found around the Milky Way centre [19].

WUM explains FBs the following way [11]:

- Core of MW is made up of DMPs: DMF1 (1.3 TeV), DMF2 (9.6 GeV), and DMF3 (3.7 keV). The second component (DMF2) explains the excess GeV emission reported by D. Hooper from the Galactic Center. Core rotates with surface speed at equator close to the escape velocity between Gravitational Bursts (GBs), and over the escape velocity at the moments of GBs;
- Bipolar astrophysical jets (which are astronomical phenomena where outflows of matter are emitted as an extended beams along the axis of rotation) of DMPs are ejected from the rotating Core into the Galactic halo along the rotation axis of the Galaxy;
- Due to self-annihilation of DMF1 and DMF2, these beams are gamma-ray jets. The prominent X-ray structures on intermediate scales (hundreds of parsecs) above and below the plane (named the Galactic Centre "chimneys") are the result of the self-annihilation of DMF3;
- FBs are bubbles whose boundary with the Intergalactic Medium has a surface energy density $\sigma_0$. These bubbles are filled with DM particles: DMF1, DMF2, and DMF3. In our Model, FBs are MOs with a mass $M_{FB}$ and diameter $D_{FB}$, which are proportional to: $M_{FB} \propto Q^{3/2}$ and $D_{FB} \propto Q^{3/4}$ respectively. According to WUM, diameter of FBs equals to:

$$D_{FB} = L_{DMF3} \times Q^{3/4} = \frac{a}{\alpha^2} \times Q^{3/4} = 28.6 \text{ kly}$$

where $L_{DMF3}$ is Compton length of particles DMF3. The calculated diameter is in good agreement with the measured size of the FBs 25 kly and 32.6 kly. Mass and average density $\rho_{FB}$ are:

$$M_{FB} = \frac{\pi D_{FB}^2 \sigma_0}{c^2} = \frac{\pi m_0}{\alpha^4} \times Q^{3/2} \cong 9.16 \times 10^{40} \text{ kg}$$

$$\rho_{FB} = \frac{6\sigma_0}{D_{FB}c^2} = 6\alpha^2 \rho_0 \times Q^{-3/4} \cong 8.83 \times 10^{-21} \text{ kg/m}^3$$

Recall that the mass of MW is about: $M_{MW} = (1.6\text{ - }3.2) \times 10^{42}$ kg.

In WUM, FBs are DMPs Bubbles containing uniformly distributed DM Objects, in which DMPs self-annihilate and radiate X-rays and gamma rays. FBs made up of DMF3 particles resemble a honeycomb filled with DMF1 and DMF2. Weak interaction between DMF3 particles provides integrity of FBs. Gamma rays up to 1 TeV are the result of the self-annihilation of DMF1 (1.3 TeV) and DMF2 (9.6 GeV) in DM Objects, which are MOs whose density is sufficient for the self-annihilation of DMPs to occur. On the other hand, they are much smaller than stars in the World, and have a high concentration in FBs to provide nearly uniform gamma ray glow over their colossal surfaces. The Core of MW supplies FBs with new DMPs through the galactic wind, explaining the brightness of FBs remaining constant during the time of observations. In our opinion, FBs are built continuously throughout the lifetime of MW (13.77 By).

## 6.2. Boötes Bubbles

By analogy with FBs, we can calculate characteristics of DM Bubbles in conjunction with Superclusters. The main difference between Galaxies and Superclusters is in their outer shells, which composed of particles DMF3 for Galaxies and of DMF4 for Superclusters. Considering that a Compton length of particles DMF4, $L_{DMF4}$, is considerably larger than the Compton length of particles DMF3, $L_{DMF3}$:

$$L_{DMF4} = \frac{1}{\alpha^2} L_{DMF3}$$

we can calculate a diameter of Boötes Bubble (BB) $D_{BB}$, mass $M_{BB}$, average density $\rho_{BB}$, and concentration of DMF4 $n_{DMF4}^{BB}$:

$$D_{BB} = L_{DMF4} \times Q^{3/4} = \frac{a}{\alpha^4} \times Q^{3/4} = 0.537 \text{ Bly}$$

$$M_{BB} = \frac{\pi D_{BB}^2 \sigma_0}{c^2} = \frac{\pi m_0}{\alpha^8} \times Q^{3/2} \cong 3.23 \times 10^{49} \text{ kg}$$

$$\rho_{BB} = \frac{6\sigma_0}{D_{BB}c^2} = 6\alpha^4 \rho_0 \times Q^{-3/4} = 2\alpha^4 \rho_{cr} \times Q^{1/4} \cong 53\rho_{cr} \cong 4.70 \times 10^{-25} \text{ kg/m}^3$$

$$n_{DMF4}^{BB} \cong 1.33 \times 10^{12} \text{ m}^{-3} > n_W^{cr} = 5.28424 \times 10^{10} \text{ m}^{-3}$$

It means that Weak interaction between DMF4 provides integrity of BBs.

It is worth noting that the energy density of the Medium $\rho_M = 2/3\,\rho_{cr}$. Hence, the energy density of Superclusters' Bubbles $\rho_{SB}$ is 79.5 times larger than an energy density of Supervoids $\rho_{SV}$, which have a concentration of DMF4 $n_{DMF4}^{SV}$ smaller than $n_W^{cr}$:

$$n_{DMF4}^{SV} \cong 1.67 \times 10^{10} \text{ m}^{-3} < n_W^{cr} = 5.28424 \times 10^{10} \text{ m}^{-3}$$

In our view, Boötes Bubbles emerge above and below the center of Boötes Supercluster, spanning a total length of about 1 Bly. We emphasize that the centre of the Boötes Bubbles (BBs) is approximately 700 Mly from the Earth, and there are two superclusters in Boötes within one billion light years: the nearest one is about 830 Mly away, the second one lies directly behind it at a distance of about 1 Bly. The centre of BBs does not coincide with the centers of the Boötes superclusters. Most probably, these structures emerge above and below the center of the first Boötes Supercluster.

By analogy with FBs, we suppose that BBs are DMPs clouds containing uniformly distributed clumps of DM Objects, in which DMPs self-annihilate and radiate X-rays and gamma rays. There are no galaxies inside of BBs. In favor of the existence of **Boötes Bubbles** speaks the fact that the **Boötes Void** is known to contain 60 galaxies only, which are located near the edges of the void (see Section 2).

To confirm the existence of BBs we should make measurements of high-energy X-rays and gamma rays from the Boötes. Considering the high concentration of particles DMF4 in BBs (that is higher than $n_W^{cr}$), it is possible to observe "Unidentified Infrared Emission Bands" (UIB), which occur around peaks at 3.3, 6.2, 7.7, 8.6, 11.2, and 12.7 μm. In literature, these emissions are observed from circumstellar regions, interstellar media, star-forming regions, and extragalactic objects for which the identity of the emitting materials is unknown. In WUM, we give an explanation of UIB emission based on the self-annihilation of DM particles DMF4 (0.19 eV) and bi-DMF4 (DMF4 pairs) with a rest energy about 0.38 eV. To the best of our knowledge, WUM is the only cosmological model in existence that is consistent with UIB emission phenomenon [20].

## 7. Conclusions

According to R. B. Tully, C. Howlett, and D. Pomarède, *The interpretation of Hoʻoleilana as BAO structure with our preferred analysis implies a value of the Hubble constant of* $76.9^{+8.2}_{-4.8}$ km·s$^{-1}$·Mpc$^{-1}$. *This value of Hubble constant is more consistent with what is found from other direct local Universe probes*, $H_0$ = 69.8 ± 0.6 (*stat*) ± 1.6 (*sys*) km·s$^{-1}$·Mpc$^{-1}$ (*Freedman*, *et al. 2020*); $H_0$ = 73.1 ± 1.0 km·s$^{-1}$·Mpc$^{-1}$ (*Riess*, *et al. 2022*); 74.6 ± 3.0 km·s$^{-1}$·Mpc$^{-1}$ (*Tully*, *et al. 2023*), *rather than the value of* $H_0$ = 67.4 ± 0.5 km·s$^{-1}$·Mpc$^{-1}$ *inferred from propagating the early Universe constraints* (*Planck Collaboration*, *et al. 2020*). *By implication, if Hoʻoleilana is representative of the statistical population of BAO*, ***additional late-time physics may be required to increase the expansion rate of the Universe towards the present day.***

It is worth noting that in frames of WUM the calculated value of Hubble constant in 2013 [6]:

$$H_0 = 68.733\,\mathrm{km}\cdot\mathrm{s}^{-1}\cdot\mathrm{Mpc}^{-1}$$

is in excellent agreement with the most recent measured value in 2021:

$$H_0 = 68.7 \pm 1.3\,\mathrm{km}\cdot\mathrm{s}^{-1}\cdot\mathrm{Mpc}^{-1}$$

using the Cosmic Microwave Background data only [21].

We emphasize that the values of the main cosmological parameters $G$ and $H$ depend on the value of the energy density $\rho_M$ which is the characteristic of the **Medium** that is Homogeneous and Isotropic (see Section 3.2). In frames of WUM, **there is no need to invent new Physical Laws** for describing early stages of the World observed by JWST and by R. B. Tully, *et al.* We can use the well-known equations considering time-varying physical parameters $G$ and $H$.

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## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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