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IMAGE: OBSERVATORY WITH STAR TRAILS ON MOUNTAINS FOR CLEAR SKY

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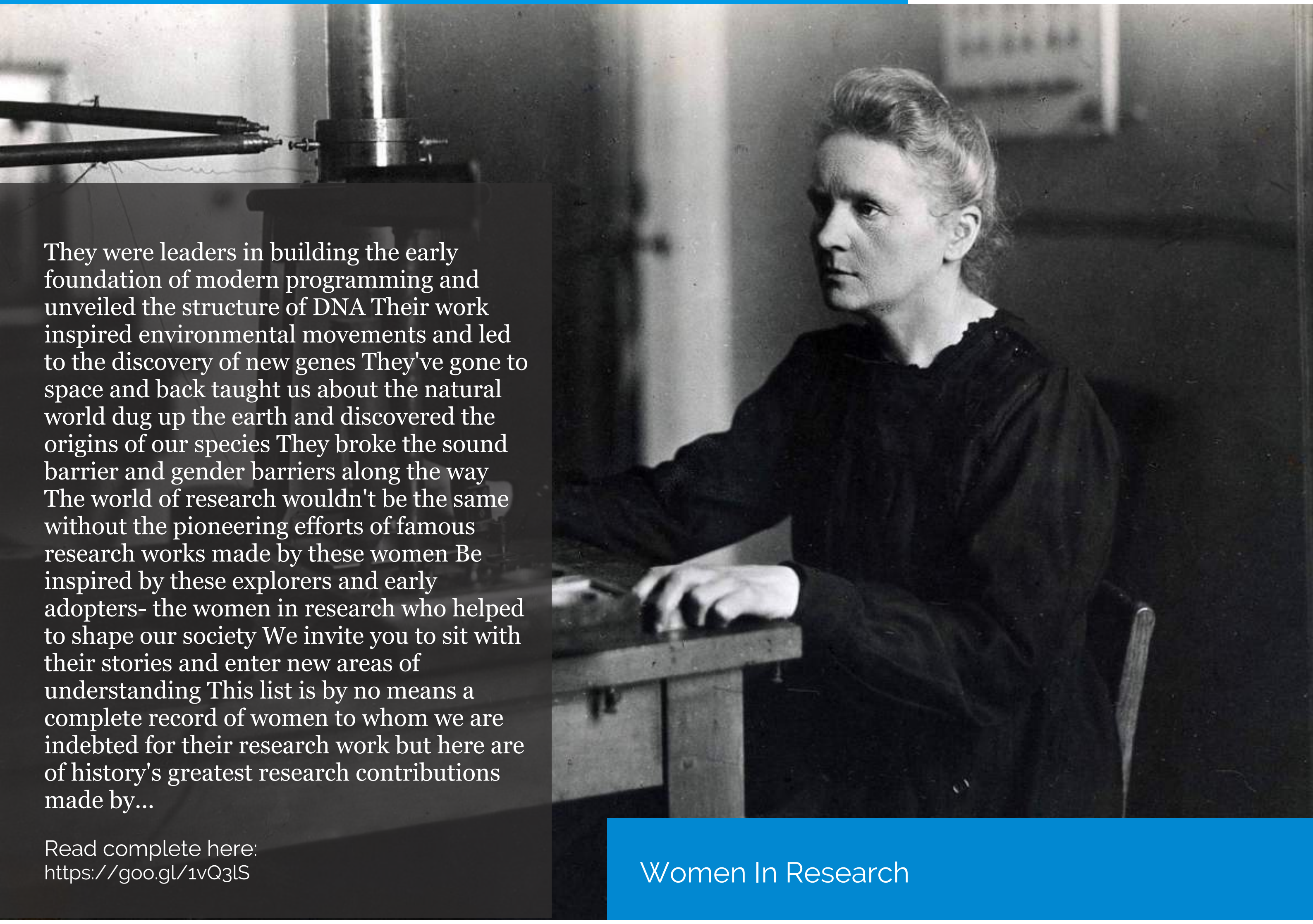

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They were leaders in building the early foundation of modern programming and unveiled the structure of DNA Their work inspired environmental movements and led to the discovery of new genes They've gone to space and back taught us about the natural world dug up the earth and discovered the origins of our species They broke the sound barrier and gender barriers along the way The world of research wouldn't be the same without the pioneering efforts of famous research works made by these women Be inspired by these explorers and early adopters- the women in research who helped to shape our society We invite you to sit with their stories and enter new areas of understanding This list is by no means a complete record of women to whom we are indebted for their research work but here are of history's greatest research contributions made by...

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In Vitro Multiplication of Hemp (Cannabis sp.) in Cotopaxi-Ecuador

Pacheco, E. & Morales, J

Universidad Técnica de Cotopaxi

ABSTRACT

In this research an in vitro multiplication protocol for Cannabis sp. was developed for growing and obtention of new varieties. In stage 1 germination percentage of different landraces was evaluated in vitro and using peat. In stage 2 germinated achenes were subcultured in peat plus 6-benzyl amino purine (6-BAP), macro and micronutrients; and in stage 3 the process for in vitro multiplication of shoots was optimized. Landraces CRNTIO, M.B., and V.P., as well as culture medium GENNBIO were used. Treatments were evaluated using percentages, and quantitative characters were analysed among landraces through analysis of variance (ANOVA). The percentage of in vitro germination for M.B. = 32%, followed by CNRTIO = 16%, and using peat P.V. = 8%, and M.B. = 93.75%. In stage 2 the number of leaves (mean) was statistically different between P.V. = 14 and M.B. = 10.67; the explant length (cm), and the number of shoots were similar between P.V. and M.B. In stage 3 significant differences were obtained for number of shoots or leaves (mean ± S.E.) between P.V. = 1.70 ± 0.51 and M.B. = 0.00 ± 0.51, also for explant length (mm) between P.V. = 2.00 ± 0.57 and M.B. = 0.00 ± 0.57; and in CRNTIO2 was observed callogenesis response in presence of kinetin in the selected medium. The impact of this approach is the development of an efficient protocol for shoot multiplication, and regeneration of hemp plantlets to be genetically transformed, and conserved in germplasm banks for industrial uses in Cotopaxi-Ecuador.

Keywords: landrace; plant growth regulators; achene; mother plant; micropropagation.

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Pacheco, E.[α] & Morales, J.[σ]

ABSTRACT

In this research an in vitro multiplication protocol for Cannabis sp. was developed for growing and obtention of new varieties. In stage 1 germination percentage of different landraces was evaluated in vitro and using peat. In stage 2 germinated achenes were subcultured in peat plus 6-benzyl amino purine (6-BAP), macro and micronutrients; and in stage 3 the process for in vitro multiplication of shoots was optimized. Landraces CRNTIO, M.B., and V.P., as well as culture medium GENNBIO were used. Treatments were evaluated using percentages, and quantitative characters were analysed among landraces through analysis of variance (ANOVA). The percentage of in vitro germination for M.B. = 32%, followed by CNRTIO = 16%, and using peat P.V. = 8%, and M.B. = 93.75%. In stage 2 the number of leaves (mean) was statistically different between P.V. = 14 and M.B. = 10.67; the explant length (cm), and the number of shoots were similar between P.V. and M.B. In stage 3 significant differences were obtained for number of shoots or leaves (mean ± S.E.) between P.V. = 1.70 ± 0.51 and M.B. = 0.00 ± 0.51, also for explant length (mm) between P.V. = 2.00 ± 0.57 and M.B. = 0.00 ± 0.57; and in CRNTIO2 was observed callogenesis response in presence of kinetin in the selected medium. The impact of this approach is the development of an efficient protocol for shoot multiplication, and regeneration of hemp plantlets to be genetically transformed, and conserved in germplasm banks for industrial uses in Cotopaxi-Ecuador.

Keywords: landrace; plant growth regulators; achene; mother plant; micropropagation.

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I. INTRODUCTION

In the industry of *Cannabis spp*. There are many hundreds of psychoactive and non- psychoactive varieties whose uses are mainly destinated to the medicinal, cultural, and recreational field; the cannabis industry has high potential of growing due to the increase in number of countries focused in its medicinal use. The production of *Cannabis* in the world has increased since 2011 to 2017 to 406.1 tons (t), and it is expected that licit global market change from 7% in 2018 to 44% in 2025, moving 214 billion of dollars (166 licit and 48 illicit) (Ramírez, Naranjo and Torres 2018).

Among the advantages found to make cultivation of these species viable in countries close to the equator, it is mentioned an adequate legal framework, lower production costs (lighting, labor, inputs), good productive infrastructure, availability, and a favorable productive fabric (pharmacy and floriculture). It is important to promote *Cannabis* industry due to its potential for creation of job, and export (Ramírez, Naranjo and Torres 2018).

The *Cannabis* plant has existed for about 10000 years since the discovery of agriculture in the Old World; it is one of the oldest crops of man, it is a source of hemp fiber, oil, achenes (food seeds), narcotic properties used in medicine and pharmacology in the treatment of diseases, and accepted in many world religions (Schultes et al. 2000). Botanically, the *Cannabis* is part of the Cannabaceae family, which contains two genres, *Cannabis* and *Humulus*; and three species for the current crop, *C. indica*, *C. sativa*, and *C. ruderalis*, different by their form of growth, achenes, and mainly by their fiber (Schultes et al. 2000; Thomas 2012). In recent years, the active principle cannabidiol (CBD), an indirect antagonist of tetrahydrocannabinol (THC), has received more importance due to its pharmacological and non-addictive effects.

In Ecuador, given the event of legalization of *Cannabis* on September 17 in 2019, approved by the national assembly, there is a legal regulation for medicinal or therapeutic and industrial purposes. The content must be less than 1% THC and between 10-15% CBD. In addition, there are seven licenses: 1) Import and commercialization of seeds; 2) Sowing and production of seeds; 3) Cultivation of *Cannabis*; 4) Cultivation of hemp for industrial use; 5) Processing and production of derivatives; 6) Plant breeding and/or germplasm banks and research; 7) Acquisition of derivatives and/or biomass or *Cannabis* flower (Ministry of Agriculture and Livestock 2020; Changoluisa and Peñafiel 2021).

In this country there are approximately 7.3 million hectares for agricultural production (ESPAC 2019); approximate extension for permanent and transitory crops and cultivated pastures is 4872049.88 ha, 19% of the national territory (INEC 2016; Morales and Andrade 2023). Therefore, 10000 ha of hemp cultivation would not affect another productive sector, consolidating the power of cutting-edge technologies such as *in vitro* micropropagation of hemp. In Ecuador about 700 companies are associated with hemp and the use of its derivatives in various products (Salgado 2020); being an industrial crop, an efficient regeneration protocol is necessary for genetic transformation, micropropagation and germplasm conservation (Cheng et al. 2016). Therefore, it is described an *in vitro* shoot multiplication method using achenes as initial explant.

II. MATERIALS AND METHODS

The achenes of *Cannabis sp.*, landraces CRNTIO, M.B. and P.V., were acquired by the company GENNBIO (Breeding_Genetics_Biotechnology) through REDES DE LIBERTAD. The experimental work covered the following stages: introduction and germination (Stage 1), germinated achenes (Stage 2), and *in vitro* shoot multiplication (Stage 3). In Stage 1, GENNBIO culture medium (Morales and Andrade 2023; Morales and Chiluisa-Utreras 2022) was used, with 2.5% (p/v) sucrose and 0.05% (p/v) activated charcoal, pH adjusted to 5.8 and previously autoclaved at 121 °C for 20 minutes; in Stage 2 peat was used plus the addition of 6-benzyl amino purine (6-BAP) (Galán-Ávila et al. 2020; Villezcas 2020), macro and micronutrients; and in Stage 3, *in vitro* shoot multiplication process was optimized by adding kinetin (KIN) to the treatments (Wang et al. 2009). In all stages, cultures remained in growth chamber at temperature of 24 ± 2 °C, and photoperiod of 16 hours of light and 8 hours of darkness.

2.1 Introduction and germination (Stage 1)

A disinfection treatment was applied prior to *in vitro* introduction by soaking the achenes in running water for 20 minutes (Chaohua et al. 2016), and superficially sterilizing with alcohol 75% (v/v) for 2 minutes and 30 seconds, followed by immersion in sodium hypochlorite (NaClO) 3% (v/v) with a surfactant agent for 25 minutes (Galán-Ávila et al. 2020), and several washes with sterile distilled water after each disinfectant agent. The disinfection treatment combined investigations with achenes as initial explant. The variables were germination percentage, and contamination.

2.2 Germinated achenes (Stage 2)

Germinated achenes CRNTIO (*in vitro*), M.B. (*in vitro*), and P.V. (peat), were subcultured in previously autoclaved peat, containing 2.0 mg·L^{-1} of 6-BAP (Galán-Ávila et al. 2020; Villezcas 2020), macro and micronutrients in sealed plastic vessels to avoid explant dehydration. The variables were number of leaves, explant length (cm), and number of nodes.

2.3 In vitro shoot multiplication (Stage 3)

Nodal segments of germinated achenes were subcultured in GENNBIO medium with different concentrations of plant growth regulators (Table 2). The data were arranged in 2 x 2 factorial design, two varieties, two hormonal treatments, and n replicates; and through analysis of variance (ANOVA) means were compared using Tukey's test. Additionally, exploratory cultures were carried out with explants from a mother plant. The variables were number of shoots or leaves, and explant length (mm). Statistical packages InfoStat 2016, and Minitab 16 were used.

Table 2: Growth regulators applied to nodal segments of germinated achenes

Explant	Growth regulators	References
Stage 2 explant (M.B. and P.V.)	0.25 mg·L^{-1} AIA and 1.0 mg·L^{-1} BAP	(Galán-Ávila et al. 2020; Villezcas 2020)
Stage 2 explant (M.B. and P.V.)	2.0 mg·L^{-1} KIN	(Wang et al. 2009)
Mother plant (CRNTIO)	0.25 mg·L^{-1} AIA and 1.0 mg·L^{-1} BAP; 2.0 mg·L^{-1} KIN	(Galán-Ávila et al. 2020; Villezcas 2020; Wang et al. 2009)

III. RESULTS AND DISCUSSION

The material consisted of achenes product of mass selection process, adapted to the equatorial line. The method was developed for cultivars of *Cannabis sativa* L.; landraces are heterozygous populations due to cross-pollination; and represent an important gene pool in plant breeding programs.

3.1 Introduction and germination (Stage 1)

In this research, an achene is considered germinated (Figure 1), when the radicle exceeds 1 mm in length outside its cover (Prohens, Soler and Nuez 1999). The use of antibiotics is recommended after disinfection with alcohol or chlorine (Smith 2000), to avoid contamination once the achenes have germinated.

3.1.1 Percentage of germination

The highest percentage of *in vitro* germination (n = 50) was obtained with M.B. = 32%, followed by CNRTIO = 16%, and in peat with P.V. = 8%. Previous studies with *Cannabis* mention an *in vitro* germination percentage (5%) similar to that obtained with P.V., however, the concentration of agar-agar and landraces are key factors to increase these percentages and reduce germination time and emergence of cotyledons (< 7 days), due to the fact that by traditional methods germination and emergence of cotyledons occurs after the fourth day with imported varieties of hemp (Simbaña 2005). Previously, higher germination percentage was obtained in peat (n = 16) with M.B. = 93.75% (Figure 2). By using these methods, *in vitro* and in peat, controlled nutritive microenvironments are generated (Ioannidis, Tomprou, and Mitsis 2022), space is reduced, and times are optimized.

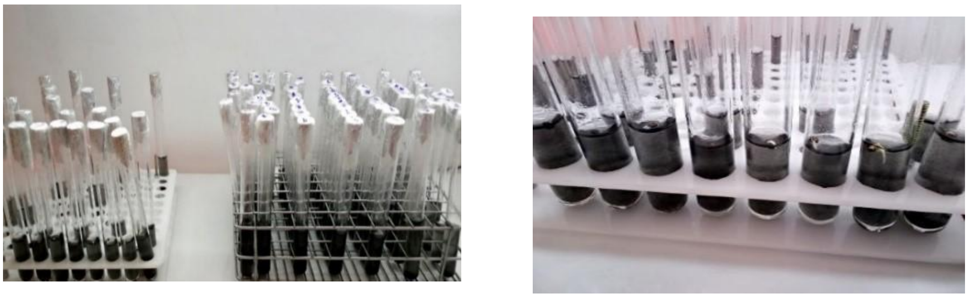

Figure 1: Introduction and *in vitro* germination of achenes. Source: GENNBIO.

Figure 2: Introduction and germination in peat and *in vitro* physiology of achenes. Source: GENNBIO.

3.2 Germinated achenes (Stage 2)

As the explants developed, those called off type were discarded.

3.2.1 Number of leaves

The number of leaves (mean) was higher in P.V. = 14 (n = 2) compared to M.B. = 10.67 (n = 3); assuming that the variances are the same, and applying T test for independent samples, these means are significantly different, with p-value = 0.0099.

3.2.2 Length of explant

While, the explant length (mean) did not present significant differences between P.V. = 11.7 cm and M.B. = 9.0 cm, with p-value = 0.3067.

3.2.3 Number of nodes

On the other hand, the number of nodes was statistically similar between P.V. = 6.5 and M.B. = 5.0, with p-value = 0.2048 (Figure 3).

Figure 3: Germinated and subcultured achenes in peat inside growth capsule. Source: GENNBIO.

3.3 In vitro multiplication of shoots (Stage 3)

In vitro shoot multiplication in *Cannabis sp.* was executed by adding antibiotic solutions to the protocol, mainly fungicides and bactericides in standardized concentrations during the process.

3.3.1 Number of shoots or leaves

In a completely randomized design (DCA), the landrace*regulator interaction did not present significant differences, since p-value = 0.2213; therefore, the analysis was continued with the main effects landrace and regulator, sending the landrace*regulator effect to the error; thus, the number of shoots or leaves (mean ± S.E.) was statistically different between P.V. = 1.70 ± 0.51 and M.B. = 0.00 ± 0.51, with p-value = 0.0304 (Table 3; Figure 4). In previous studies with *Cannabis* variety Changtu, it is mentioned the obtention of 1.83, 2.00, and 1.74 auxiliary shoots using KT in proliferation stage, fourteen days after subculture (Wang 2009), similar to the number of shoots or leaves obtained in this research with P.V. using young explants, since they response better to *in vitro* conditions compared to differentiated tissues, due to the high rate of mitosis (Zwenger 2014).

Table 3: Number of shoots or leaves in landraces of *Cannabis* at multiplication stage.

Landrace	Mean ± S.E.	n	Group
P.V.	1.70 ± 0.51	10	B
M.B.	0.00 ± 0.51	10	A

Figure 4: Multiplication of shoots using nodal segments of germinated achenes. Source: GENNBIO.

3.3.2 Explant length

In a completely randomized design (CRD), the landrace*regulator interaction did not present significant differences, since p-value = 0.2213; however, applying Tukey's test, different groups were observed, being the experimental point P.V.:Cit = 3.20 mm ± 0.77 the largest explant (Figure 5), which means that the best result was obtained with application of KIN in P.V.

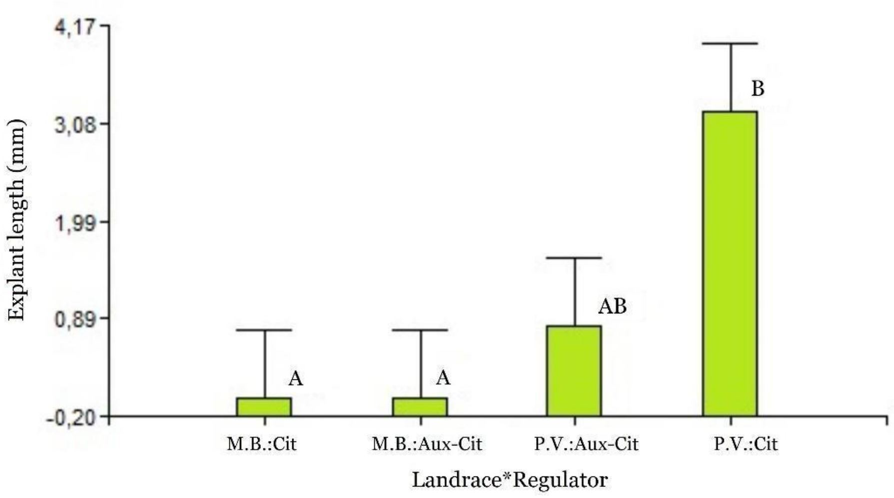

Figure 5: Explant length (mm) in *Cannabis* landraces with different growth regulators. Distinct letters form groups with differences in their means according to Tukey's test.

The analysis was continued with the main effects landrace and regulator, sending the landrace*regulator effect to the error; thus, explant length (mean ± S.E.) was statistically different between P.V. = 2.00 mm ± 0.57 and M.B. = 0.00 mm ± 0.57, with p-value = 0.0234 (Table 4; Figure 6). Normality of errors was checked using Ryan-Joiner's test (similar to Shapiro-Wilk), with p-value = 0.061.

Table 4: Explant length (mm) in landraces of *Cannabis* at multiplication stage.

Landrace	Mean ± S.E.	N	Group
P.V.	2.00 ± 0.57	10	B
M.B.	0.00 ± 0.57	10	A

Figure 6: Explant length (mm) in P.V. landrace at multiplication stage in presence of kinetin. Source: GENNBIO.

IV. CONCLUSIONS

In stage 1, the cannabis landrace with the highest *in vitro* germination and using peat was M.B. = 32% and 93.75%, respectively; followed by *in vitro* germination in CNRTIO = 16%, and P.V = 8%.

In stage 2, the number of leaves (mean) was statistically different between P.V. = 14 and M.B. = 10.67. The explant length (cm) and the number of nodes were similar between P.V. and M.B.; however, the latter are essential for shoot multiplication process at industrial scale.

In stage 3, it was significantly demonstrated the highest number of shoots or leaves (mean ± S.E.) in P.V. = 1.70 ± 0.51, also the largest explant length in P.V. = 2.00 mm ± 0.57 in presence of cytokinin fourteen days after subculture, respectively. Finally, in CRNTIO2 was observed callogenesis response in presence of kinetin in the selected culture medium.

The impact of this project is the development of an efficient protocol for shoot multiplication, and regeneration of hemp plantlets to be genetically transformed, and conserved in germplasm banks for industrial uses in Cotopaxi-Ecuador.

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I. INTRODUCTION

Model selection is a challenging step in statistical modelling. Modelling any data requires characterization of the associated data generating process (DGP). The DGP is unknown and therefore we face several admissible competing models. Model selection consists on selecting a model, which mimics such unknown DGP, from a set of admissible models according to a criterion. One retains the model which makes such criterion optimal, Tibshirani et al. (2015), Ferraty and Hall (2015) and Li et al. (2017). There exist various model selection criteria in the literature when admissible models have fully parametric specification, such as the Wald test, the likelihood ratio test, the Lagrange multiplier test, the information criteria and so on, see Hamilton (1994), Greene (2003) and Hooten and Hobbs (2015). The other case, when admissible models contain simultaneously parametric and nonparametric specifications, seems underdeveloped, Hendry et al. (2008). Encompassing tests appear to be helpful for the latter situation where an encompassing model is intended to account the salient feature of the encompassed model. Therefore, encompassing test can detect redundant models among the admissible models.

Encompassing tests are based on two points, that the encompassing model ought to be able to explain the predictions and to predict some mis-specifications of the encompassed model, Hendry et al. (2008). We know that there are various considerations and developments of encompassing tests, we refer readers to Mizon (1984), Hendry and Richard (1989), Gouriéroux and Monfort (1995) and Florens *et al.* (1996). For an overview on the concept of encompassing tests, see Bontemps and Mizon (2008) and Mizon (2008). Applications of encompassing tests can be found inside the model selection procedure of general to specific (GETS) modelling developed by Hendry and Doornik (1994), Hoover and Perez (1999). For application in real data, see Nazir (2017).

Recently, Bontemps et al. (2008) have developed encompassing tests which cover large set of methods such as parametric and nonparametric methods. Among their results, encompassing tests for kernel nonparametric regression method are established. They provide asymptotic normality of the associated encompassing statistics under the independent and identically distributed hypothesis (i.i.d). We extend their results by relaxing the independent hypothesis. We then focus on processes with some dependence structures. This extension lies on the generalization of encompassing test to dependent processes.

The paper is organized as follows. In section 2, we provide an overview of encompassing test. In section 3, we study the asymptotic behaviors of the encompassing test associated to the linear parametric modelling and the kernel nonparametric method. In last section, we conclude.

II. ENCOMPASSING TEST

This section introduces the encompassing test and then builds the corresponding encompassing hypothesis. So, given two regression models $\mathcal{M}_1$ and $\mathcal{M}_2$, we are interested in knowing if the model $\mathcal{M}_1$ can account the result of model $\mathcal{M}_2$. In other words, we want to know if $\mathcal{M}_1$ encompasses $\mathcal{M}_2$ or in a short notation $\mathcal{M}_1\mathcal{E}\mathcal{M}_2$. Testing such a hypothesis will be done using the notion of encompassing test.

Generally speaking, model $\mathcal{M}_1$ encompasses model $\mathcal{M}_2$, if the parameter $\theta_{\mathcal{M}_2}$ of the latter model can be expressed in function of the parameter $\theta_{\mathcal{M}_1}$ of the former model. In other words, let $\Delta(\theta_{\mathcal{M}_1})$ be the pseudo true value of $\theta_{\mathcal{M}_2}$ on $\mathcal{M}_1$. In general, the pseudo-true value is defined as the plim of $\hat{\theta}_{\mathcal{M}_2}$ on $\mathcal{M}_1$, Bontemps et al. (2008). For more discussion on pseudo-true value associated with the KLIC[1], we refer to Sawa (1978) and Govaerts et al. (1994) among others. The encompassing statistic is given by the difference between $\hat{\theta}_{\mathcal{M}_2}$ and $\Delta(\hat{\theta}_{\mathcal{M}_1})$ scaled by a coefficient a_n. Specification of the encompassing test will depend on the estimation of the regression method: parametric or nonparametric methods.

Let $S=(Y,X,Z)$ be a zero mean random process with valued in $\mathbb{R}x\mathbb{R}^dx\mathbb{R}^q$ where $d,q\in\mathbb{N}^*$. For $x\in\mathbb{R}^d$ and $z\in\mathbb{R}^q$, consider the two models $\mathcal{M}_1$ and $\mathcal{M}_2$ as the conditional expectations $m(x)$ and $g(z)$, respectively. These can be defined as follows:

$$\mathcal{M}_1: \quad m(x)=E[Y|X=x] \quad and \quad \mathcal{M}_2: \quad g(z)=E[Y|Z=z] \tag{2.1}$$

Moreover, the general unrestricted model is given by $r(x,z)=E[Y|X=x,Z=z]$.
Following the encompassing test in Bontemps *et al.* (2008), we are interested in testing the hypothesis that $\mathcal{M}_1$ encompasses $\mathcal{M}_2$, and then introducing the null hypothesis:

$$\mathcal{H}: E[Y|X=x,Z=z]=E[Y|X=x]. \tag{2.2}$$

This null states that $\mathcal{M}_1$ is the owner model, and $\mathcal{M}_2$ will be served on validating this statement and is called the rival model. We test this hypothesis $\mathcal{H}$ through the following implicit encompassing hypothesis:

$$\mathcal{H}^*: E[E[Y|X=x]/Z=z]=E[Y|Z=z]. \tag{2.3}$$

The following homoskedasticity condition will be assumed all along this work:

$$Var[Y|X=x,Z=z]=\sigma^2. \tag{2.4}$$

Moreover, a necessary condition for the encompassing test relies on the errors of both models where the intended encompassing model $\mathcal{M}_1$ should have smaller standard error than the encompassed model $\mathcal{M}_2$.

In general, $\mathcal{M}_1$ or $\mathcal{M}_1$ can be estimated using nonparametric or parametric regression method. We will consider these different situations when the processes $(S_n)_n$ are dependent. We begin by constructing the encompassing statistic associated to each of these four situations and then discuss their asymptotic behaviors.

III. ASYMPTOTIC BEHAVIOR OF THE ENCOMPASSING STATISTIC

We are interested on the asymptotic behavior of the encompassing statistic associated to the null hypothesis $\mathcal{M}_1\mathcal{E}\mathcal{M}_2$. We can encounter the following four situations: $\mathcal{M}_1$ and $\mathcal{M}_2$ are both estimated parametrically, $\mathcal{M}_1$ and $\mathcal{M}_2$ are both estimated nonparametrically, $\mathcal{M}_1$ is estimated nonparametrically and $\mathcal{M}_2$ parametrically and $\mathcal{M}_1$ is estimated parametrically and $\mathcal{M}_2$ nonparametrically. We will consider the kernel regression estimate for nonparametric methods and the linear regression for parametric methods. For both dependent processes, we will study and establish the asymptotic normality of the corresponding four encompassing tests.

---

[1] Kullback-Leiber Information Criterion

Consider a sample $S_i = (Y_i, X_i, Z_i)$, $i = 1, ..., n$, which can be viewed as realization of the random process $S = (Y, X, Z)$ with valued in $\mathbb{R}\text{x}\mathbb{R}^d\text{x}\mathbb{R}^q$ where $d, q \in \mathbb{N}^*$. We suppose that S_i, $i = 1, ..., n$ has a joint density f. Moreover, $\varphi(.,.)$, $\varphi(. \mid .)$ and $\varphi(.)$ will denote the joint, the conditional and the marginal densities of the process (Y, Z), respectively. That is, for $y \in \mathbb{R}$ and $z \in \mathbb{R}^q$, $\varphi(y, z)$, $\varphi(y \mid z)$ and $\varphi(z)$ correspond to the density of the following processes (Y, Z) at point (y, z), $(Y \mid Z = z)$ at point y and Z at point z, respectively. Similarly, h will denote the joint, the conditional and the marginal densities of the process (Y, X), according to the argument that it takes.

To get the asymptotic normality of the associated encompassing statistic, we need the following assumptions from Bosq (1998). The first assumption characterizes the dependence structure.

Assumption 3.1. *(S_t) is α-mixing with $\alpha(n) = O(n^{-\rho})$ where $\rho > \frac{\nu^2+4}{2\nu}$ for some positive ν.*

The next assumption collects regularity conditions on the continuity and on the differentiability of the density functions.

Assumption 3.2. *φ and $g * \varphi$ are $C_{2,d}(b)$ for some real b where $C_{2,d}(b)$ the space of twice continuously differentiable real valued functions f, defined on $\mathbb{R}^d$, such that $||\varphi||_\infty \leq b$ and $||\varphi^{(2)}||_\infty \leq b$ with $\varphi^{(2)}$ denotes any partial derivative of order 2 for φ. Next, $Sup_{t\geq k}||\varphi(Z_1, Z_t)||_\infty < \infty$ and last, $\varphi(.)E[Y_1^2|Z_1 = .]$ is continuous at z.*

The last assumption concerns finiteness of the moments of $(Y_n, Z_n)_n$.

Assumption 3.3. *$||E[|Y_1|^{4+\nu}|Z_1 = .]||_\infty < \infty$; $E[|Z_1|^{4+\nu}] < \infty$ for some positive ν; $Sup_{t\in\mathbb{N}}||E[Y_1^i Y_t^j|Z_t = ., Z_1 = .]||_\infty < \infty$ where $i \geq 0$, $j \geq 0$, $i + j = 2$.*

Throughout this section, we assume the existence of continuous version of the various joint and marginal density functions and of the three conditional means m, g and r. In addition, the square integrability will be assumed.

For more precision, $N(\mu, v)$ will denote the Gaussian distribution with mean μ and variance v. We now consider the first case that is the encompassing test when the two models $\mathcal{M}_1$ and $\mathcal{M}_2$ have parametric specification.

3.1 Parametric modelling for M1 and M2

Encompassing test for parametric modelling has been developed a lot in the literature. We discuss briefly one parametric encompassing test where models $\mathcal{M}_1$ and $\mathcal{M}_2$ have linear parametric specification. In that case, the two models $\mathcal{M}_1$ and $\mathcal{M}_2$ are given in relation (3.1) with the nesting model r:

$$\begin{aligned} &m(x) = \beta' x \;\; with \;\; \beta = (E[XX'])^{-1}E[XY] \\ &g(z) = \gamma' z \;\; with \;\; \gamma = (E[ZZ'])^{-1}E[ZY] \\ &r(x,z) = \alpha' w \;\; with \;\; \alpha = E[WW']^{-1}E[WY] \;\; and \;\; W = (X,Z). \end{aligned} \tag{3.1}$$

We can get the estimates $\hat{\beta}$, $\hat{\gamma}$ and $\hat{\alpha}$ of the paramaters β, γ and α, respectively, using the sample $S_i = (Y_i, X_i, Z_i)$, $i = 1, ..., n$. Now, testing $\mathcal{M}_1\mathcal{E}\mathcal{M}_2$ corresponds to the test of the null hypothesis $\mathcal{H}$ where the conditional mean is just the linear projection. Therefore, the encompassing statistic of the null $\mathcal{M}_1\mathcal{E}\mathcal{M}_2$ can be written as follows.

$$\hat{\delta}_{\beta,\gamma} = \hat{\gamma} - \hat{\gamma_L}(\hat{\beta}), \tag{3.2}$$

where $\hat{\gamma_L}(\hat{\beta})$ is an estimate of the pseudo-true value $\gamma_L(\beta)$ associated with $\hat{\gamma}$ on $\mathcal{H}_1$. Remarking that the pseudo-true value is defined by $\gamma_L(\beta) = (E[ZZ'])^{-1}E[ZX']\beta$, we state in the following theorem the asymptotic behavior of the encompassing statistic in relation (3.2).

Theorem 3.1. *Assume that the relation 2.4 is satisfied. When the sample* $S_i = (Y_i, X_i, Z_i)$, $i = 1, ..., n$ *are i.i.d., then under* $\mathcal{H}$, *we get:*

$$\sqrt{n}\hat{\delta}_{\beta,\gamma} \to N(0, \sigma^2\Omega) \quad in \quad distribution \quad as \quad n \to \infty. \tag{3.3}$$

where $\Omega = Var(Z)^{-1}E[Var(Z \mid X)]Var(Z)^{-1}$.

For development on this asymptotic behavior of the encompassing statistic, we refer to Gouriéroux et al. (1983) and Mizon and Richard (1986). For recent discussion on this encompassing test for fully parametric case, Bontemps et al. (2008) is a good reference.

Development of the parametric encompassing test goes beyond independent processes in the literature. As encompassing test for dynamic stationary models and time series regressions have been discussed in Govaerts et al. (1994), Hendry and Nielsen (2006), among others.
Next, we will study the completely nonparametric case.

3.2 Nonparametric modelling for M1 and M2

We now consider the case where the two models $\mathcal{M}_1$ and $\mathcal{M}_2$ defined in (2.1) are estimated using nonparametric techniques. To test the hypothesis " $\mathcal{M}_1$ encompasses $\mathcal{M}_2$ ", we build the corresponding encompassing statistic and establish asymptotic property of such statistic. Considering the functional estimates m_n and g_n of the unknown functions m and g in relation (2.1) respectively, we define the encompassing statistic as follows:

$$\hat{\delta}_{m,g}(z) = g_n(z) - \hat{G}(m_n)(z), \tag{3.4}$$

where $\hat{G}(m_n)$ is an estimate of the pseudo true value $G(m)$ associated with g_n on $\mathcal{H}$, which is defined by $G(m) = E[m \mid Z = z]$.

Using the sample $S_i = (Y_i, X_i, Z_i)$, $i = 1, ..., n$, the kernel regression estimates m_n of the function m, and g_n of the function g have the following expressions:

$$m_n(x) = \frac{\frac{1}{nh_{1n}^d} \sum_{i=1}^n K_1(\frac{x-X_i}{h_{1n}})Y_i}{\frac{1}{nh_{1n}^d} \sum_{i=1}^n K_1(\frac{x-X_i}{h_{1n}})} \quad g_n(z) = \frac{\frac{1}{nh_{2n}^q} \sum_{i=1}^n K_2(\frac{z-Z_i}{h_{2n}})Y_i}{\frac{1}{nh_{2n}^q} \sum_{i=1}^n K_2(\frac{z-Z_i}{h_{2n}})} \tag{3.5}$$

where h_{jn} and K_j, $j = 1, 2$ are window widths and kernel densities, respectively. The kernel densities satisfy

$$K_j(u) \geq 0 \ \ and \ \int K_j(u)du = 1 \ \ j = 1, 2. \tag{3.6}$$

We provide in the following, a theorem establishing the asymptotic convergence of the encompassing statistic.

Theorem 3.2. *Suppose that assumptions 3.1-3.3 hold. Moreover, suppose that relation (3.6) is satisfied. Then, under $\mathcal{H}$, we get:*

$$\sqrt{nh_{2n}^q}\hat{\delta}_{m,g}(z) \rightarrow N(0, \frac{\sigma^2 \int K_2^2(u)du}{\varphi(z)}) \quad in \quad distribution \quad as \quad n \rightarrow \infty. \tag{3.7}$$

$\varphi(z)$ is the marginal density of the Z at z and $\sigma^2 = Var[Y|X = x, Z = z]$.

Proof of theorem 3.2 The proof of this theorem will be based on the decomposition of the expression of the encompassing statistic into two parts as follows:

$$
\begin{aligned}
\sqrt{nh_{2n}^q}\hat{\delta}_{m,g}(z) &= \sqrt{nh_{2n}^q}(g_n(z)-\hat{G}(m_n)(z)) \\
&= \sqrt{nh_{2n}^q}(\sum_{t=1}^n \frac{K_2(\frac{z-Z_t}{h_{2n}})}{\sum_{t=1}^n K_2(\frac{z-Z_t}{h_{2n}})}Y_t - \sum_{t=1}^n \frac{K(\frac{z-Z_t}{h_n})}{\sum_{t=1}^n K(\frac{z-Z_t}{h_n})}m_n(x_t)) \\
&= \sqrt{nh_{2n}^q}\sum_{t=1}^n \frac{K_2(\frac{z-Z_t}{h_{2n}})}{\sum_{t=1}^n K_2(\frac{z-Z_t}{h_{2n}})}(Y_t-m(x_t)) \qquad (3.8) \\
&+ \sqrt{nh_{2n}^q}\sum_{t=1}^n \frac{K(\frac{z-Z_t}{h_n})}{\sum_{t=1}^n K(\frac{z-Z_t}{h_n})}(m(x_t)-m_n(x_t)) \\
&= C_1 + C_2.
\end{aligned}
$$

The first part C_1 coincides to the kernel regression of the residuals $\epsilon_t = Y_t - m(x_t)$ onto Z_t. When assumptions 3.1-3.3 hold, then under $\mathcal{H}$, we achieved the convergence in distribution of the first part to a normal distribution using Rhomari's result in Bosq (1998). The second part C_2 reflects the limit in probability of the supremum of the difference $m_n(x_t) - m(x_t)$ at $x_t \in \mathbb{R}^d$ scaled by $\sqrt{nh_n^q}$ and its convergence can be derived from the rate of covergence of the uniform convergence of the estimate $m_n(x_t)$ which has been provided by Bosq (1998).

3.3 Parametric modelling M1 vs nonparametric modelling M2

We consider the case that model $\mathcal{M}_1$ is a linear parametric model and $\mathcal{M}_2$ is estimated by kernel nonparametric technique. Therefore, the hypothesis $\mathcal{H}$ will have linear parametric specification. The encompassing statistic associated to the null $\mathcal{M}_1\mathcal{E}\mathcal{M}_2$ can be written as follows:

$$\hat{\delta}_{\beta,g}(z) = g_n(z) - \hat{G}_L(\hat{\beta})(z), \qquad (3.9)$$

where $\hat{G}_L(\hat{\beta})$ is an estimate of the pseudo-true value $G_L(\beta)(z)$ associated with g_n on $\mathcal{H}$, which is defined by $G_L(\beta)(z) = \beta' E[X \mid Z = z]$.

For the nonparametric specification of $\mathcal{M}_2$, we consider the estimate g_n as the kernel regression estimate of g given in (2.1). Since the rival model g is estimated using kernel method, the various assumptions on kernel density and window width will be maintained.

Even the process exhibits some dependences, we can still establish the asymptotic normality of the encompassing statistic defined in relation (3.9).

Theorem 3.3. *Assume that relation 2.4 and assumptions 3.1-3.3 are satisfied. Then, under* $\mathcal{H}$ *with linear specification and when the bandwidth* h_{2n} *satisfy kernel regularity condition, we get:*

$$\sqrt{nh_{2n}^q}\hat{\delta}_{\beta,g}(z) \to N(0, \frac{\sigma^2 \int K_2^2(u)du}{\varphi(z)}) \quad in \quad distribution \quad as \quad n \to \infty. \tag{3.10}$$

$\varphi(z)$ *is the marginal density of the* Z *at* z.

Proof of theorem 3.3 Using similar techniques as previously, we can write the encompassing statistic as follows:

$$\begin{aligned}
\sqrt{nh_{2n}^q}\hat{\delta}_{\beta,g}(z) &= \sqrt{nh_{2n}^q}(g_n(z) - \hat{G}_L(\hat{\beta})(z)) \\
&= \sqrt{nh_{2n}^q}(\sum_{t=1}^{n} \frac{K_2(\frac{z-Z_t}{h_n})}{\sum_{t=1}^n K_2(\frac{z-Z_t}{h_{2n}})} Y_t - \sum_{t=1}^{n} \frac{K(\frac{z-Z_t}{h_n})}{\sum_{t=1}^n K(\frac{z-Z_t}{h_n})} \hat{\beta}' X_t) \\
&= \sqrt{nh_{2n}^q}\sum_{t=1}^{n} \frac{K_2(\frac{z-Z_t}{h_n})}{\sum_{t=1}^n K_2(\frac{z-Z_t}{h_{2n}})}(Y_t - \beta' X_t) \qquad (3.11) \\
&+ \sqrt{nh_{2n}^q}\sum_{t=1}^{n} \frac{K(\frac{z-Z_t}{h_n})}{\sum_{t=1}^n K(\frac{z-Z_t}{h_n})} X_t'(\beta - \hat{\beta}) \\
&= D_1 + D_2.
\end{aligned}$$

When assumptions 3.1-3.3 hold, then under $\mathcal{H}$, D_1 converges in distribution to a normal law with mean zero and variance $\frac{\sigma^2}{\varphi(z)} \int K_2^2(u)du$, see Bosq (1998). Concerning D_2, using central limit theorem for linear processes in Peligrad and Utev (1997), the normality asymptotic of the linear process has been established. Therefore, this implies the normality asymptotic of $\sqrt{n}(\beta - \hat{\beta})$. The remaining expression in D_2 vanishes to zero as n tends to infinity. Thus, D_2 converges in distribution to zero. This completes the proof.

3.4 Nonparametric modelling M1 vs parametric modelling M2

We consider the owner model $\mathcal{M}_1$ to be estimated using a nonparametric method and the rival model $\mathcal{M}_2$ to be a linear parametric method. Therefore, the encompassing statistic associated to the null $\mathcal{M}_1\mathcal{E}\mathcal{M}_2$ is given by:

$$\hat{\delta}_{m,\gamma} = \hat{\gamma} - \hat{\gamma}(m_n), \tag{3.12}$$

where $\hat{\gamma}(m_n)$ is an estimate of the pseudo-true value $\gamma(m)$ associated with $\hat{\gamma}$ on $\mathcal{H}$, which is defined by $\gamma(m) = (E[ZZ'])^{-1}E[Zm]$.

When the estimate of model $\mathcal{M}_1$ is obtained from the kernel regression and the model $\mathcal{M}_2$ is from linear parametric modelling, we summarize the asymptotic results in the following theorem.

Theorem 3.4. *Assume that relation (2.4) is satisfied. When the kernel* K_1 *and the bandwidth* h_{1n} *satisfy the usual regularity condition and when we have one of the following points:*

Assumption 3.1 holds and the kernel regression estimate m_n *and the process* $(Y_n, X_n)_n$ *satisfy assumptions 3.2 and 3.3.*
Then, under $\mathcal{H}$*, we get:*

$$\sqrt{n}\hat{\delta}_{m,\gamma} \to N(0,\Sigma) \quad in \quad distribution \quad as \quad n \to \infty. \tag{3.13}$$

where $\Sigma = plim_{n\to\infty} Var(\sqrt{n}\hat{\delta}_{m,\gamma})$.

Proof of theorem 3.4 We split the encompassing statistic $\sqrt{n}\hat{\delta}_{m,\gamma}$ into two parts. The first part yields $F_1 = \sqrt{n}(\frac{1}{n}\sum_{i=1}^n Z_i Z_i)^{-1}(\frac{1}{n}\sum_{i=1}^n Z_i(Y_i - m(x_i)))$ which gives the asymptotic normality of the theorem, Peligrad and Utev (1997).

The second part is $F_2 = \sqrt{n}(\frac{1}{n}\sum_{i=1}^n Z_i Z_i)^{-1}(\frac{1}{n}\sum_{i=1}^n Z_i(m(x_i) - m_n(x_i)))$. Again, we bound this by taking the supremum with respect to x_i. Thus, F_2 vanishes to zero from the uniform convergence of $m_n(x_i)$, Bosq (1998). This completes the proof of theorem 3.4.

We remark that we should be careful about mutual encompassing of both models which concerns the bijection of the pseudo true value function $G(.)$.

IV. CONCLUSION

We have considered encompassing test for functional parameters. As stated in Hendry et al. (2008) that the work of Bontemps *et al.* (2008) is the starting treatment of such type of encompassing test based on nonparametric methods. We have extended that work to dependent process.

When using kernel method and linear regression as estimator of conditional expectations, we have established asymptotic normality of the encompassing test for dependent processes. These results would be helpfull for analysing non-nested non-parametric and parametric models.

Development of encompassing test to nonparametric methods opens new research direction in theory as well as in practice. Application of the various results on real data would accelerate such development.

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Age, Size, Dynamics of Energy, Matter, and Masses of Black Holes in the Model of Accelerated Expansion of the Universe, based on the Idea of a Hypothetical 4-dimensional Inverted Substance

Evgeny P. ORLOV

ABSTRACT

The consequences of the previously proposed model of accelerated expansion of the Universe based on the idea of a hypothetical 4-dimensional substance with an inverse population of energy levels are considered. Based on the data on the time and redshift of the beginning of recombination and the last scattering, taking into account the dependence of the redshift on time obtained in this model, the age of the Universe was found, which turned out to be ≈230 billion years. The dimensions of the Universe, which is a 4-dimensional spherical layer with a radius of 2400 Gpc, are determined. The dynamics of black hole mass growth is found to coincide with the observed data on the growth of black hole masses in elliptical galaxies, where there is no gas, the accretion of which could explain the growth of their masses. The dynamics of the masses of black holes in the considered model is compared with the dynamics of the masses in the model based on the standard model. It is shown that the dynamics of the growth of the energy of baryonic and dark matter coincides in form with the dynamics of the growth of the masses of black holes.

Keywords: 4D substance, 4D spherical layer, redshift, Type Ia supernovae, quasars, gamma-ray bursts, black holes, elliptical galaxies, baryonic and dark matter.

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АННОТАЦИЯ

Рассмотрены следствия из предложенной ранее модели ускоренного расширения Вселенной, основанной на представления о гипотетической 4-мерной субстанции с инверсной заселенностью энергетических уровней. На основе данных о времени и красном смещении начала рекомбинации и последнего рассеяния с учетом полученной в данной модели зависимости красного смещения от времени найден возраст Вселенной, который оказался ≈230 млрд лет. Определены размеры Вселенной, представляющей собой 4-мерный сферический слой с радиусом 2400 Гпк. Найдена динамика роста масс черных дыр, совпадающая с наблюдаемыми данными роста масс черных дыр в эллиптических галактиках, где отсутствует газ, аккреция которого могла бы объяснить рост их масс. Проведено сравнение динамики масс черных дыр в рассматриваемой модели с динамикой масс в модели, основанной на стандартной модели. Показано, что динамика роста энергии барионной и темной материи по форме совпадает с динамикой роста масс черных дыр. Проведено сравнение скорости формирования материи со скоростью звездообразования. Сделан вывод, что в настоящее время темная материя практически не образуется, а наиболее быстрыми темпами она образовывалась при красном смещении больше двух.

Ключевые слова: 4-мерная субстанция, 4-мерный сферический слой, красное смещение, сверхновые типа Ia, квазары, гамма-всплески, черные дыры, эллиптические галактики, барионная и темная материя.

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I. ВВЕДЕНИЕ

В работе [1] на основе представления о гипотетической 4-мерной субстанции с инверсной заселенностью энергетических уровней была предложена модель ускоренного расширения Вселенной, которая с большой точностью описывает диаграммы Хаббла для сверхновых типа Ia [2], квазаров [3] и источников гамма-всплесков [4]. Она также позволяет объяснить почему параметр Хаббла, определенный по реликтовому излучению, отличается от параметра Хаббла, найденного на основе лестницы расстояний [5, 6].

Как и в [7-10] в рассматриваемой модели, наша Вселенная заключена в 4-мерном сферическом слое, образованном перед расширяющимся 4-мерным шаром, внутри которого находится источник расширения. Однако, в отличие от работ [7-10], источник расширения имеет иную природу и геометрию. В [1] источник обусловлен вынужденными переходами с верхнего на нижний уровни энергии 4-мерной гипотетической субстанции, а 4-мерный сферический слой возникает на определенном этапе расширения ее шаровой области в результате фазового перехода в твердое состояние (механизм фазового перехода не рассматривается, поскольку не влияет на результаты работы). Как показано в [1] твердый 4-мерный сферический слой оказывает сильное влияние на динамику расширения Вселенной в силу своей гигантской по сравнению с обычными твердыми телами упругостью, обеспечивающей распространение в нем волн деформаций со скоростью света.

Такой слой удерживает волны деформаций вещества этого слоя возбуждаемые в нем в процессе «бомбардировки» внутренней поверхности слоя квантами излучения, образующимися при вынужденных переходах с верхнего на нижний уровни энергии 4-мерной гипотетической субстанции. Собственные волновые функции, описывающие деформации вещества слоя или, другими словами, моды слоя сопоставляются в зависимости от числа полуволн, укладывающихся в направлении нормали к слою, тем или иным элементарным частицам. Твёрдый сферический слой для этих частиц-волн и образуемых ими макрообъектов выступает как вакуум, который практически не оказывает сопротивления их движению. Мода, отвечающая минимальной энергии, сопоставляется с электроном, поэтому толщина сферического слоя равна половине комптоновской длины волны электрона и несоизмерима мала по сравнению с его радиусом и доступными нам для наблюдения космическими расстояниями. В силу этого 4-мерный сферический слой в этих же масштабах может рассматриваться как неограниченный плоскопараллельный слой [11, 12], образованный упомянутой твёрдой субстанцией, а пространство внутри него может рассматриваться как 3-мерное плоское пространство. Подчеркнём, что даже такая грубая модель потенциала, удерживающего волны в слое, как бесконечно глубокая потенциальная яма, способна как показано в [13-15] точно описывать как кинематику, так и динамику релятивистских эффектов.

Отметим, что данная модель не противоречит модели Большого взрыва. Отличие лишь в том, что электроны, протоны и нейтроны возникают в процессе образования 4-мерного сферического слоя как моды этого слоя и с момента их возникновения начинается первичный нуклеосинтез [16, 17]. Момент образования 4-мерного сферического слоя можно рассматривать как момент образования нашей Вселенной как пространства, заполненного различными видами материи.

В [1] было показано, что в данной модели величина 13.8 млрд лет характеризует не возраст Вселенной, а время распространения света от тех галактик, ускорение удаления которых имеет минимальное значение. На основе недавно обнаруженной кривизны Вселенной [18] были даны оценки радиуса 4-мерного сферического слоя и возраста Вселенной. Эти оценки носят весьма приблизительный характер. Как показано ниже найти эти характеристики Вселенной с бóльшей точностью можно, используя полученные в [1] формулы для зависимости красного смещения и радиуса 4-мерного сферического слоя от времени, прошедшего с момента образования Вселенной, которое определяется по моменту времени и красному смещению начала первичной рекомбинации и моменту времени и красному смещению последнего рассеяния.

II. ВОЗРАСТ ВСЕЛЕННОЙ И РАДИУС СФЕРЫ ПОСЛЕДНЕГО РАССЕЯНИЯ

Зависимость красного смещения от времени распространения излучения от источника в рассматриваемой модели описывается формулой

$$z(x) = H_0 t_0 \frac{x}{1+x} \exp\left\{ \frac{H_0 t_0}{2\pi} \frac{T_0}{R_0} \left[x - \ln(1+x) \right] \right\} \tag{1}$$

где $x = (t - t_e)/t_0$; H_0 – параметр Хаббла; t – настоящий момент времени; t_e – момент времени, в который происходит излучение источника; t_0 – момент времени, когда возник 4-мерный сферический слой, то есть наша Вселенная; R_0 – радиус 4-мерного сферического слоя в момент его возникновения t_0; $T_0 = ct_0$. Все параметры, входящие в формулу определены в [1] из сравнения полученных зависимостей с диаграммами Хаббла для суперновых Ia, квазаров и гамма-всплесков: H_0 = 67.7 км/с/Мпк; t_0 = 27.7 млрд лет; $H_0 t_0 = 1.92$; R_0 = 2.24 Гпк; T_0 = 8.5 Гпк; $H_0 t_0 T_0/(2\pi R_0) = \beta/4$, где $\beta = 4.64$ [1]. Момент времени t_e это момент, который наблюдается в прошлом из настоящего времени. Разность настоящего и наблюдаемого моментов времени будем обозначать буквой τ.

Как известно, в модели Большого взрыва [16] приблизительно через двадцать минут после возникновения 4-мерного сферического слоя первичный нуклеосинтез завершается и вещество во Вселенной представляет собой ионизированную электрон-фотон-протонную плазму, очень плотную и горячую. Энергия теплового движения столь велика, что любые нейтральные атомы, едва образовавшись, почти сразу распадаются в соударениях на протоны и электроны. Фотоны взаимодействуют с первичной плазмой, излучаясь при ускоренном движении заряженных частиц и рассеиваясь на них.

По мере расширения Вселенной плазма остывает. В какой-то момент фотоны рассеявшись в последний раз, становятся свободными и равномерно устремляются во все стороны, сформировав то, что называется реликтовым излучением [19]. Таким образом, наблюдаемое сегодня реликтовое излучение образовалось во время перехода первоначальной высокотемпературной плазмы в состояние газа нейтральных частиц – атомов водорода и гелия.

Область космоса, в которой образовалось реликтовое излучение, называют поверхностью последнего рассеяния [16]. Она окружает нас со всех сторон и может быть представлена в виде сферы радиуса R_f. Внутри поверхности последнего рассеяния Вселенная является прозрачной. Поверхность последнего рассеяния образовалась при температуре плазмы около 3000 К и примерном возрасте Вселенной 380000 лет [20]. Красное смещение для поверхности последнего рассеяния составляет $z_f \approx 1090$ [21]. Но до момента последнего рассеяния была эпоха остывания первоначальной плазмы и следующая за ней эпоха рекомбинации. Начало эпохи рекомбинации соответствует 200000 лет от t_0 и $z_r = 1400$ [22]. Указанные выше значения времен определены в стандартной космологической модели. В рассматриваемой модели зависимость разности настоящего и наблюдаемого моментов времени τ от красного смещения, отличается от зависимости в стандартной модели и описывается формулой (1), рис. 1. Видно, что при рассматривании процессов, протекавших в прошлом, производная

$$\frac{\mathrm{d}t}{\mathrm{d}z} = \frac{t_0}{z(x)}\frac{x(1+x)}{1+bx^2/4},$$

где $x = \tau/t_0$, уменьшается, то есть время замедляется. Красному смещению $z = z_f$ соответствует момент времени T_f = 214.4 млрд лет, а $z = z_r$ соответствует момент времени T_r = 221 млрд лет. Считая, что промежуток времени $T_r - T_f$ = 6.65 млрд лет пропорционален промежутку времени в стандартной модели $(3.8 - 2.0)\cdot 10^5 = 1.8\cdot 10^5$ лет, а $T - T_r$, где T – возраст Вселенной, пропорционален промежутку времени $2.0\cdot 10^5$ лет, получаем, что $T - T_r$ = 7.4 млрд лет. Отсюда находим возраст Вселенной T = 221 + 7.4 = 228.4 ≈ 230 млрд лет. Этому значению, как следует из формулы

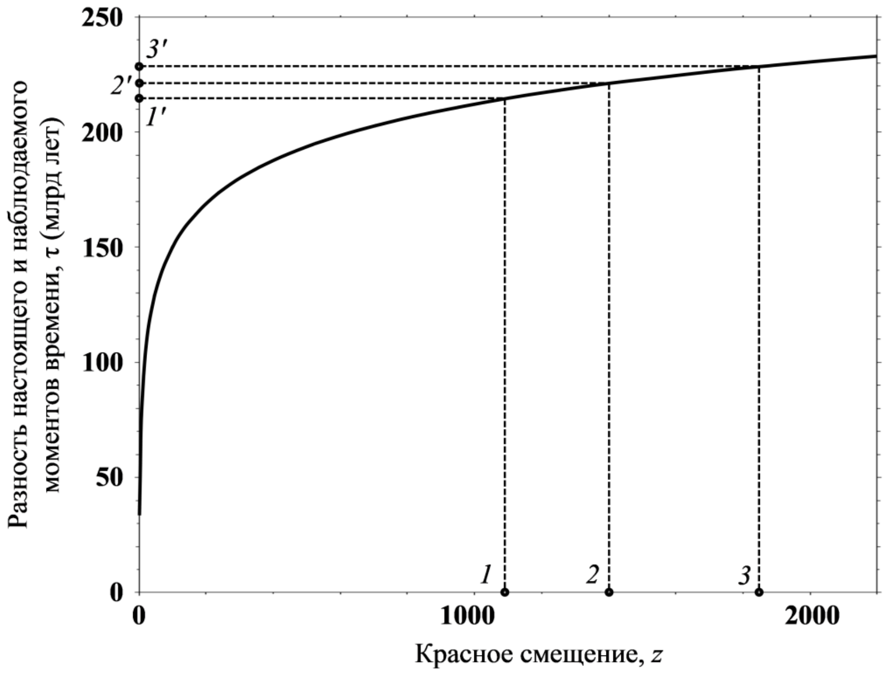

Рис. 1: Зависимость разности настоящего и наблюдаемого моментов времени τ от красного смещения. Точка *1* (z = 1090) отвечает моменту времени последнего рассеяния 214.4 млрд лет (точка *1′*); точка *2* (z = 1400) отвечает началу эпохи рекомбинации 221 млрд лет (точка *2′*); точка *3* (z = 1850) отвечает моменту возникновения 4-мерного сферического слоя, то есть Возрасту Вселенной 228.4 млрд лет (точка *3′*).

$$Z = H_0 t_0 \frac{T/t_0}{(1+T/t_0)^{1+\beta/4}} \exp\left(\frac{\beta T}{4t_0}\right),$$

полученной из (1) при замене $t_e = t_0$, $t - t_0 = T$ и $z = Z$, соответствует красное смещение Z ≈ 1850, что проиллюстрировано графиком на рис. 1.

Найденный здесь возраст Вселенной 230 млрд лет на 15% меньше полученной ранее в [1] оценки по кривизне пространства Вселенной. Если отсчитывать возраст от момента зарождения 4-мерного шара, то $T^* = T + t_0$ ≈ 258 млрд лет.

В [1] получена формула для расстояния, которое фотоны проходят от источника излучения до точки наблюдения в зависимости от времени распространения фотонов

$$D(x) = ct_0 \int_0^x \exp\left\{ \frac{H_0 t_0}{2\pi} \frac{ct_0}{R_0} \left[x' - \ln(1 + x') \right] \right\} \sqrt{1 + \left(\frac{H_0 t_0}{2\pi} \frac{x'}{1 + x'} \right)^2} \, dx'.$$

Это позволяет найти радиус сферы последнего рассеяния. В данной модели этот радиус искривлен, так как соответствующее ему расстояние лежит на гиперповерхности 3-мерной сферы. Используя приведенную формулу, в которой полагаем $x = T_f/t_0$, получаем величину радиуса сферы последнего рассеяния

$$\mathscr{R}_f = D\left(\mathscr{T}_f/t_0\right) = T_0 \int_0^{\mathscr{T}_f/t_0} \exp\left\{ \frac{\beta}{4} \left[x' - \ln\left(1 + x'\right) \right] \right\} \sqrt{1 + \left(\frac{H_0 t_0}{2\pi} \frac{x'}{1 + x'} \right)^2} \, dx' \approx 5.6 \times 10^3 \text{ Гпк.}$$

III. РАЗМЕРЫ ВСЕЛЕННОЙ

Зная возраст Вселенной, можно получить сведения о ее размерах. Полагая в формуле для радиуса 4-мерного сферического слоя

$$R(t) = R_0 \exp\left\{ \frac{\beta}{4} \left[\frac{t - t_0}{t_0} - \ln\left(1 + \frac{t - t_0}{t_0} \right) \right] \right\},$$

полученной в [1], $t - t_0 = T$, находим радиус Вселенной $R = R(t_0 + T) \approx 2.4 \cdot 10^3$ Гпк, что примерно в раза меньше сделанной в [1] оценки

Полученный результат позволяет объяснить, почему даже на таких огромных расстояниях как до самых далеких галактик UDFj-39546284 и GN-z11 мы видим плоскую Вселенную. Как показано в [1] расстояние до этих галактик составляет примерно $D_g \approx 80$ Гпк. Для объяснения найдем отклонение касательной к 3-мерной сфере в точке расположения нашей Галактики от сферической поверхности в точке расположения наблюдаемой галактики, которая удалена на расстояние D_g. Угол между направлениями из центра 3-мерной сферы в нашу Галактику и в далекую галактику $\alpha = D_g/R$. Отклонение касательной в точке наблюдения от источника излучения $\delta = R(1/\cos\alpha - 1) \approx R\alpha^2/2$. Подставляя сюда α, получаем $\delta/R \approx (D_g/R)^2/2 \approx 0{,}55 \cdot 10^{-3} << \Omega_k$, где $\Omega_k = 0.04$ –кривизна Вселенной, найденная в [18]. Таким образом, отклонение от 3-мерной сферы на расстоянии до самых далеких галактик примерно в 73 раза меньше кривизны Вселенной, что вряд ли можно заметить на современном этапе развития астрономической измерительной техники. Чтобы можно было заметить кривизну Вселенной по наблюдениям галактик необходимо обнаружить галактики удаленные от нашей Галактики на $D_g > R(2\Omega_k)^{1/2} \approx 680$ Гпк.

В рассматриваемой модели можно ввести понятие длины экватора Вселенной, то есть длины экватора 3-мерной сферы $L_e = 2\pi R$, которая составляет $\approx 1.5 \cdot 10^4$ Гпк. Вычисляя отношение $R_f/(L_e/2) \approx 0.74$ видим, что реликтовое излучение приходит из области, которая больше полушария 4-мерного шара. Таким образом, можно сделать вывод, что в рассматриваемой модели большая часть Вселенной прозрачна для реликтового излучения.

Также можно говорить об объеме Вселенной, V как площади гиперповерхности 3-мерной сферы S_3: $V = S_3 = (4/3)\pi^2 R^3 \approx 1.7 \cdot 10^{11}$ Гпк^3. В совокупности с найденной в [1] динамикой плотности энергии в 4-мерном шаре и во Вселенной это позволяет проанализировать динамику полной энергии Вселенной.

IV. ДИНАМИКА ПОЛНОЙ ЭНЕРГИИ ВСЕЛЕННОЙ

Зная возраст Вселенной можно теперь определить во сколько раз возросла плотность энергии внутри 4-мерного шара, к которому прилегает 4-мерный сферический слой и, соответственно, во сколько раз уменьшилась плотность энергии материи от момента образования 4-мерного сферического слоя. Подставляя в полученное в [1] выражение $\rho_\Xi(t) = \rho_\Xi(t_0)(t/t_0)^\beta$ значение $t = \mathrm{T} + t_0$, получаем $\rho_\Xi(\mathrm{T})/\rho_\Xi(t_0) = (1 + \mathrm{T}/t_0)^\beta \approx 3\cdot10^4$. Во столько же раз уменьшилась плотность энергии материи во Вселенной $\rho_\mathrm{E}(t)$, так как в данной модели $\rho_\mathrm{E}(t) = \mathrm{const}/\rho_\Xi(t)$ [1]. Поскольку плотность энергии материи во Вселенной в настоящий момент предполагается равной критической плотности и составляет $5.2\cdot10^{-6}$ ГэВ/см^3 [23], то в момент образования Вселенной $\rho_\mathrm{E}(t_0) = \rho_\mathrm{E}(\mathrm{T})(1 + \mathrm{T}/t_0)^\beta \approx 0.16$ ГэВ/см^3.

Полная энергия излучения внутри 4-мерного шара

$$\Xi(t) = \rho_\Xi(t)V_4(t) = \frac{\rho_\Xi(t)}{\rho_\Xi(t_0)}\left[\frac{R(t)}{R_0}\right]^4 \rho_\Xi(t_0)R_0^4 .$$

С учетом того, что $\rho_\Xi(t_0)(R_0)^4 = \Xi(t_0)$, $\rho_\Xi(t) = \rho_\Xi(t_0)(t/t_0)^\beta$, а отношение $R(t)/R_0$ может быть представлено в виде

$$\frac{R(t)}{R_0} = \exp\left(\frac{\beta}{4}\frac{t-t_0}{t_0}\right)\Bigg/\left(1+\frac{t-t_0}{t_0}\right)^{\beta/4} \qquad (2)$$

полная энергия внутри 4-мерного шара возрастает как $\Xi(t) = \Xi(t_0)\exp[\kappa(t - t_0)$ в полном соответствии с исходным в [1] уравнением $d\Xi/dt = \kappa\Xi$, где $\kappa = 5.31\times10^{-18}$ с$^{-1}$ – определенная в [1] вероятность перехода в фотонное состояние с верхних энергетических уровней 4-мерной гипотетической субстанции на нижележащие.

Полная энергия материи во Вселенной меняется в соответствии с формулой

$$E(t) = \rho_\mathrm{E}(t)V(t) = E(t_0)\frac{\rho_\mathrm{E}(t)}{\rho_\mathrm{E}(t_0)}\left[\frac{R(t)}{R_0}\right]^3$$

где $E(t_0) = \rho_\mathrm{E}(t_0)\mathrm{V}(t_0) = (4/3)\pi^2(R_0)^3\rho_\mathrm{E}(t_0)$ – полная энергия Вселенной в момент ее образования. С учетом (2), и того, что $\rho_\mathrm{E}(t) = \rho_\mathrm{E}(t_0)(t/t_0)^{-\beta}$, получаем

$$\frac{E(t)}{E(t_0)} = \exp\left(\frac{3\beta}{4}\frac{t-t_0}{t_0}\right)\Bigg/\left(1+\frac{t-t_0}{t_0}\right)^{7\beta/4} \qquad (3)$$

График зависимости $E(t)/E(t_0)$ представлен на рис. 2. Видно, что сначала полная энергия Вселенной падает примерно в 9 раз, а затем начинает расти и через промежуток времени, равный возрасту Вселенной, увеличивается в $4\cdot10^4$ раз по сравнению с энергией Вселенной в момент ее образования. Таким образом, приходим к выводу, что имеют место как потери, так и приток энергии материи во Вселенную. Чтобы выяснить соотношение между притоком энергии и ее потерями воспользуемся выражением для скорости изменения энергии во Вселенной, которое получается дифференцированием (3) по времени:

$$\frac{dE}{dt}=\frac{\beta E}{4t_0}\left[3-\frac{7}{1+\left(t-t_0\right)/t_0}\right]. \qquad (4)$$

Правая часть (4) состоит из положительной части $3\beta E/(4t_o)$ и отрицательной части $dE/dt = -(7\beta E/4t_o)[1+(t-t_o)/t_o]^{-1}$. Из поведения графика на рис. 2 и из формулы (4) видно, что при $t = t_o$ производная отрицательна. Спустя промежуток времени, отсчитываемый от момента времени образования Вселенной $t - t_o = 4t_o/3 \approx 37$ млрд лет производная обращается в нуль, а затем монотонно возрастает и при $t - t_o \to \infty$ стремится к значению $3\beta/4t_o$. Начиная с момента ≈ 37 млрд лет приток начинает превышать потери.

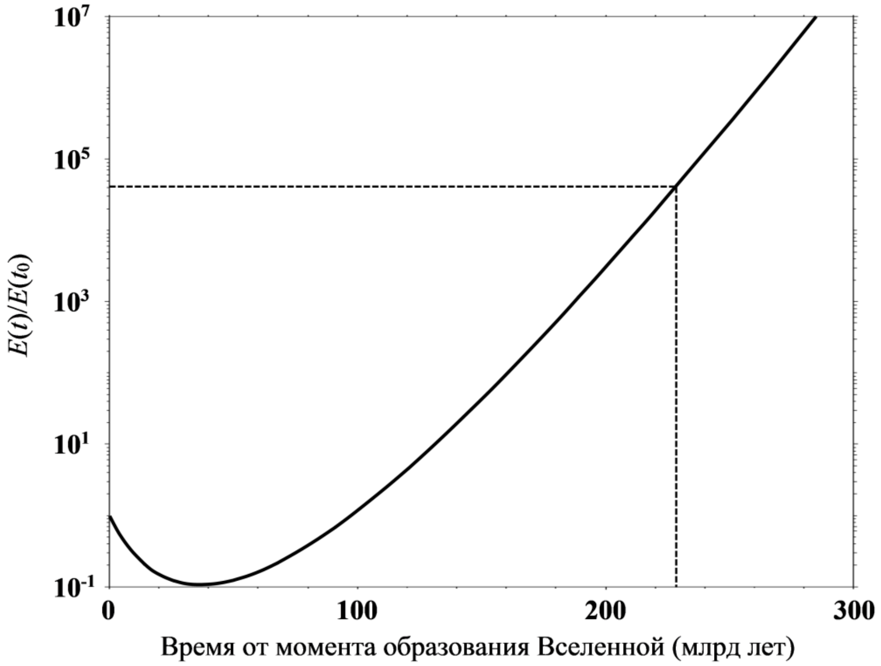

Рис. 2: Поведение полной энергии Вселенной во времени с момента ее образования. Вертикальная штриховая прямая соответствует возрасту Вселенной 228 млрд лет, рассчитанному по рассматриваемой модели.

V. ДИНАМИКА МАСС ЧЕРНЫХ ДЫР

Возможное объяснение потерь энергии основывается на том, что часть энергии, поступающей во Вселенную из 4-мерного шара, поглощается черными дырами (ЧД) [24]. Число квантов излучения в 4-мерном шаре растет экспоненциально [1]. Так как «бомбардировка» внутренней границы 4-мерного сферического слоя вначале слабая из-за малого количества квантов излучения в 4-мерном шаре, то процесс поглощения энергии ЧД превалирует над процессом возбуждения мод в 4-мерном сферическом слое, обусловленном «бомбардировкой» внутренней границы 4-мерного сферического слоя квантами излучения гипотетической 4-мерной субстанции. По мере экспоненциального роста числа квантов излучения в 4-мерном шаре частота «бомбардировки» увеличивается и процессы рождения элементарных частиц начинают превалировать над потерями энергии в ЧД.

Как говорилось выше, правая часть (4) состоит из положительной и отрицательной частей. Полагая, что отрицательная часть обусловлена поглощением энергии ЧД, и подставляя в нее E из (3) получаем формулу для скорости изменения энергии в ЧД

$$\frac{\mathrm{d}E_{\text{ВН}}}{\mathrm{d}t} = \frac{7bE(t_0)}{4t_0}\exp\left(-\frac{3b}{4}\right)\exp\left(\frac{3b}{4}\frac{t}{t_0}\right)\Big/\left(\frac{t}{t_0}\right)^{1+7b/4}$$

Интегрируя это выражение по времени и выделяя в нем два слагаемых, одно из которых описывает энергию, которая поглощается ЧД от момента возникновения Вселенной к моменту начала ее наблюдения t_e, а другое – за промежуток времени $\tau = t - t_e$ между t_e и настоящим моментом времени t, равным $t_0 + \mathrm{T}$ ($\tau = t_0 + \mathrm{T} - t_e$), получаем

$$E_{\text{ВН}}(t_0+\mathrm{T}) = E_{\text{ВН}}(t_0) + E_{\text{ВН}}\Big|_{t_0}^{t_e} + E_{\text{ВН}}\Big|_{t_e}^{\mathrm{T}+t_0},$$

где t_e представлено в виде $t_e = t_0 + \mathrm{T} - \tau$:

$$E_{\text{ВН}}\Big|_{t_e}^{\mathrm{T}+t_0} = (7b/4)E(t_0)e^{-3b/4}\int_{1+(\mathrm{T}-\tau)/t_0}^{1+\mathrm{T}/t_0} f_{\text{ВН}}(x)\,dx,$$

$$E_{\text{ВН}}\Big|_{t_0}^{t_e} = (7b/4)E(t_0)e^{-3b/4}\int_{1}^{1+(\mathrm{T}-\tau)/t_0} f_{\text{ВН}}(x)\,dx,$$

$$f_{\text{ВН}}(x) = \frac{e^{(3b/4)x}}{x^{1+7b/4}}.$$

Поскольку соотношение энергии ЧД и полной энергии наблюдаемой Вселенной в момент ее возникновения неизвестно, то положим, что доля энергии $E_{\text{ВН}}$ в момент образования Вселенной в полной энергии E равна μ: $E_{\text{ВН}}(t_0) = \mu E(t_0)$, $0 \le \mu \le 1$. Если считать, что число ЧД во Вселенной за промежуток времени τ не меняется, то для ЧД, удаленных по времени на τ от настоящего момента времени, масса каждой ЧД $M_{\text{ВН}}$ с момента наблюдения t_e возрастет в

$$E_{\text{ВН}}\Big|_{t_e}^{\mathrm{T}+t_0}\Big/\left[\mu E(t_0) + E_{\text{ВН}}\Big|_{t_0}^{t_e}\right] \text{ раз.}$$

$$F = \frac{M_{\text{ВН}}(t)}{M_{\text{ВН}}(t_e)} = \frac{E_{\text{ВН}}\Big|_{t_e}^{\mathrm{T}+t_0}}{\mu E(t_0) + E_{\text{ВН}}\Big|_{t_0}^{t_e}} = \frac{(7b/4)e^{-3b/4}\int_{1+(\mathrm{T}-\tau)/t_0}^{1+\mathrm{T}/t_0} f_{\text{ВН}}(x)\,dx}{\mu + (7b/4)e^{-3b/4}\int_{1}^{1+(\mathrm{T}-\tau)/t_0} f_{\text{ВН}}(x)\,dx}. \qquad (5)$$

Совместно с формулой (1), в которой $x = \tau/t_0$, получаем параметрическую зависимость фактора роста F массы ЧД от красного смещения излучения звезд родительской галактики, в которой находится данная ЧД. Отметим, что формула (5) справедлива тогда, когда нет аккреции газа на ЧД и слияния ЧД.

График зависимости F от красного смещения в диапазоне значений $0 \le z < \mathrm{Z}$ при разных значениях μ, изображен на рис. 3а. Видно, что в современную эпоху ($z << 0.1$) рост масс ЧД незначительный. Напротив, при $0.1 < z < 2$ происходит интенсивный рост масс ЧД практически одинаковый для всех рассмотренных значений μ. Затем рост замедляется и в диапазоне значений $z > 10$ становится заметно различие роста при разных μ. При $z > 1000$ масса ЧД может претерпевать огромные изменения, например, для $\mu = 1/100$ в 10^6 раз. Видно, что в диапазоне $0 \leq z \approx 1.2$ возрастание масс ЧД происходит в 7 раз, а в диапазоне $0 \leq z \approx 2$ – в 20 раз, что хорошо совпадает с представленными в [25, 26] данными наблюдений роста масс ЧД в эллиптических галактиках.

VI. ДИНАМИКА ПРИТОКА ЭНЕРГИИ И СКОРОСТЬ ФОРМИРОВАНИЯ БАРИОННОЙ И ТЕМНОЙ МАТЕРИИ

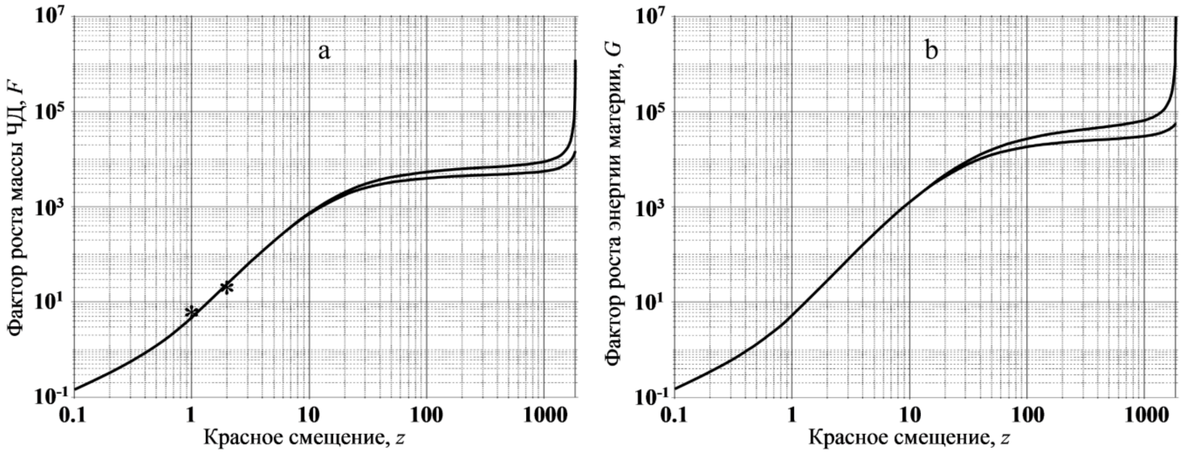

Рис. 3: Зависимость фактора роста F масс черных дыр от красного смещения излучения звезд галактик, в которых расположены ЧД (a); энергии материи (b). Кривые,идущие снизу вверх, построены для начальных долей энергии ЧД и материи 1 и 1/100. Звездочки – данные работ [25, 26].

Рассмотрим теперь динамику притока энергии. Обозначим приток энергии как $E^{(+)}$. Подставляя в положительный член правой части формулы (4) выражение (3) для $E(t)$, получаем выражение для производной $\mathrm{d}E^{(+)}/\mathrm{d}t$:

$$\frac{\mathrm{d}E^{(+)}}{\mathrm{d}t} = \frac{3bE(t_0)}{4t_0}\exp\left(\frac{3b}{4}\frac{t-t_0}{t_0}\right)\Bigg/\left(1+\frac{t-t_0}{t_0}\right)^{7b/4}.$$

Также как и в случае рассмотрения динамики энергии ЧД представим отношение притока энергии за период времени от момента возникновения Вселенной к моменту начала ее наблюдения t_e, а другое – за промежуток времени $\tau = t - t_e$ между t_e и настоящим моментом времени t, равным $t_o + \mathrm{T}$ ($\tau = t_o + \mathrm{T} - t_e$),

$$G = \frac{E^{(+)}(\tau)}{E^{(+)}(t_e)} = \frac{E^{(+)}\Big|_{t_e}^{\mathrm{T}+t_0}}{nE(t_0) + E^{(+)}\Big|_{t_0}^{t_e}} = \frac{(3b/4)e^{-3b/4}\int_{1+(\mathrm{T}-\tau)/t_0}^{1+\mathrm{T}/t_0} f^{(+)}(x)\,dx}{n + (3b/4)e^{-3b/4}\int_{1}^{1+(\mathrm{T}-\tau)/t_0} f^{(+)}(x)\,dx},$$

где $f^{(+)}(\xi) = \exp(3\beta\xi/4)/\xi^{7\beta/4}$; ν – доля энергии $E^{(+)}$ в момент образования Вселенной в полной энергии E: $E^{(+)}(t_o) = \nu E(t_o)$; $0 \le \nu \le 1$, $\nu + \mu = 1$. Совместно с формулой (1), в которой $x = \tau/t_o$, получаем параметрическую зависимость фактора роста G притока энергии от красного

смещения, график которой представлен на рис. 3b. Видно, что история роста приточной составляющей энергии и поглощаемой ЧД схожи по форме. Это говорит о коэволюции этих составляющих энергии, что соответствует выводам [27].

Минимум $\mathrm{d}E^{(+)}/\mathrm{d}t$ также как и функции $E(t)$ реализуется при $t - t_o = 4t_o/3 \approx 37$ млрд лет от образования Вселенной. Используя формулу (1), находим, что этому моменту времени соответствует $z = (4/3)H_o t_o \exp(\beta/3)/(7/3)^{(1+\beta/4)} \approx 1.93$. Как известно [28], при таком значении z достигается максимум скорости звездообразования. В связи с этим рассмотрим функцию пропорциональную функции $[\mathrm{d}E^{(+)}/\mathrm{d}t]^{-1}$, в которой разность $t - t_o$ заменена на τ:

$$M_{FR} = \left(1 + \frac{\tau}{t_0}\right)^{7\beta/4} \exp\left(-\frac{3\beta}{4}\frac{\tau}{t_0}\right). \qquad (6)$$

В совокупности с формулой (1) получаем параметрическую зависимость M_{FR} от z. График этой зависимости изображен на рис. 4 сплошной кривой. Максимум функции (6) приходится на минимум функции $\mathrm{d}E^{(+)}/\mathrm{d}t$, то есть на значение $z = 1.93$, а отношение максимального значения к значению при $z = 0$ составляет $(7/3)^{7\beta/4}\exp(-\beta) \approx 9.4$, что совпадает с характеристиками пика скорости звездообразования [28].

По данным работы [29] темп образования звезд при $z = 1.125$ по меньшей мере в 4 раза превышает аналогичную величину при $z = 0.375$. По данным работ [28, 30] скорость звездообразования при $z = 2.75$ в три раза превышает современное значение, но в четыре раза ниже, чем при $z = 1$. Еще в три раза наблюдаемая скорость звездообразования снижается к $z = 4$. Построенный по этим данным график зависимости скорости звездообразования от красного смещения изображен на рис. 4 штриховой линией. Слева от максимума скорость звездообразования практически совпадает со скоростью формирования материи, а справа – проходит значительно ниже ее. Интеграл от $z = 1.3$ до $z = Z$ составляет ≈ 90% от всего интеграла по z от $z = 0$ до $z = Z$, что значительно больше 50%, чем при звездообразовании [28].

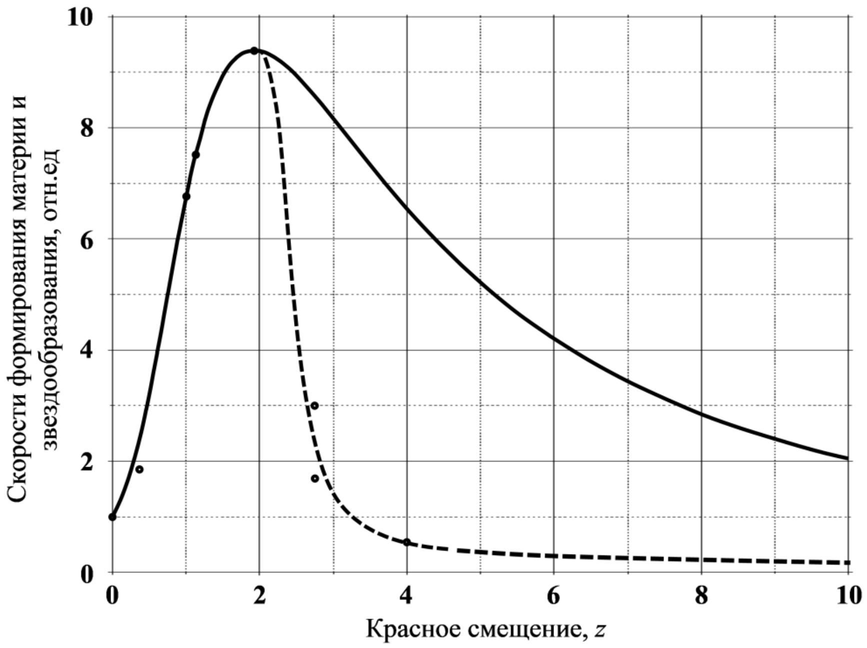

Рис. 4: Зависимость скорости формирования материи от красного смещения (сплошная кривая) и скорости звездообразования (штриховая кривая). Точки проставлены в соответствии с данными работ [28-30].

Если допустить, что именно функция (6) описывает скорость формирования материи, то можно предположить, что рассматриваемая функция характеризует скорость формирования не только барионной материи, из 10% части которой состоят звезды, но и скорость формирования холодной темной материи. Это предположение требует доказательства, которое выходит за рамки данной работы.

VII. ОБСУЖДЕНИЕ РЕЗУЛЬТАТОВ

Как отмечалось в [1] оцененный в ней возраст Вселенной в 270 млрд лет и определенный в данной работе и равный 230 млрд лет согласуется с данными наблюдений, в которых обнаружено, что рождение малометалличных звёзд и даже целых галактик происходит во Вселенной во всё время её жизни, см., например, [31]. В [32] говорится, что на основании этих данных возникло мнение, что на данном этапе утверждать что-либо о возрасте Вселенной нет никаких оснований. Более того высказывалась мысль о том, что наблюдения последних лет, свидетельствующие о продолжающемся зарождении звёзд и галактик, дают основание для утверждения о вечном существовании Вселенной. Рассматриваемая модель не дает повода соглашаться с таким предположением. Полученный в ней возраст Вселенной ≈230 млрд лет хотя более чем в 16 раз больше принятой в стандартной космологии оценки ≈ 14 млрд лет, но конечен.

Оценка в [1] радиуса Вселенной, исходящая из условия $\delta/D_g = D_g/(2R) \le 0.1\Omega_k$, дала для R значение $\approx 10^4$ Гпк, а для возраста Вселенной 270 млрд лет. Если исходить из условия $\delta/R \approx (D_g/R)^2/2 \le 0.1\Omega_k$, то получаем R ≈ 900 Гпк, а возраст Вселенной при таком значении R составляет ≈ 200 млрд лет. Таким образом, полученная на основе данных о реликтовом излучении и данных о первичной рекомбинации радиус Вселенной $R \approx 2{,}4 \cdot 10^3$ Гпк заключен между значениями 900 и 10^4 Гпк, полученными на основе данных о кривизне пространства Вселенной, а возраст Вселенной T = 230 млрд лет – между значениями 200 и 270 млрд лет, что увеличивает достоверность найденных в данной работе значений R и T. Отношение $R/R_o \approx 1000$, то есть по сравнению с современной Вселенной первоначальная Вселенная в момент возникновения представляется точкой, что согласуется с представлениями теории Большого взрыва.

Из результатов анализа динамики полной энергии Вселенной и роста масс ЧД можно заключить, что утверждение об образовании части ЧД сразу при рождении Вселенной не противоречит рассматриваемой модели и энергия заключенная в них составляет некоторую долю μ от полной начальной энергии Вселенной. Однако из графиков на рис. 3a видно, что для определения μ потребуются наблюдения ЧД при $z > 10$.

Исследования динамики масс ЧД, обсуждаемые в обзоре [33], а также исследования, проведенные, например, в [27], показывают, что в общем случае, изменение массы ЧД во времени зависит от модели ЧД. Исследование, проведенное в данной работе, приводит к заключению, что динамика масс ЧД не зависит от модели ЧД, а зависит в пренебрежении их слиянием и аккрецией газа на них только от динамики энергии излучения в 4-мерном шаре и динамики расширения Вселенной. В диапазоне значений $0 \le z \le 10$ динамика масс ЧД практически не зависит от доли энергии, заключенной в них при рождении Вселенной.

Сравнение динамики ЧД, рассмотренной в данной работе, с результатами исследований динамики ЧД, полученных в других работах, показывает, что в некоторых диапазонах значений z имеется достаточно удовлетворительной совпадение. Так, в [34] предлагается однопараметрический рост масс ЧД в терминах масштабного коэффициента стандартной космологической модели a, $M(a) = M(a_i)(a/a_i)^k$, где a_i - масштабный коэффициент, при котором объект становится космологически связанным, $a \ge a_i$. Так как $a/a_i = (1 + z)^k$, где k - сила космологической связи, то фактор роста массы ЧД $F_c = (1 + z)^k$. В [25] на основании наблюдений ЧД в эллиптических галактиках найдено, что $k = 3{,}11^{+1{,}19}_{-1{,}33}$ ($k_{min} = 1.78$; $k_{max} = 4.3$). Если бы космологическая связь отсутствовала, то $k = 0$.

На рис. 5 представлены графики фактора роста масс ЧД рассчитанные как по рассматриваемой модели для $\mu = 1$ (кривая *1*) и $\mu = 1/100$ (кривая *2*) так и факторов роста масс ЧД в модели [34], рассчитанные при разных значениях k. Видно, что фактор F, рассчитанный по рассматриваемой модели практически совпадает в области значений $1 \le z \le 4.5$ с кривой, рассчитанной для F_c при $k = 2.96$ (кривая *3*). При $k = 3.11$ (кривая *4*) имеются существенные отличия. Показаны также кривые для F_c при k_{max} (кривая *5*) и при k_{min} (кривая *6*). Видно, что кривые *1* и *2*, иллюстрирующие поведение фактора F по рассматриваемой модели в диапазоне значений $1 \le z \le 8$ лежат между этими предельными кривыми, но при z, выходящем за пределы диапазона $1 \le z \le 4.5$, значительно отличаются от кривой *3*, рассчитанной для $k = 2.96$. При $z > 8$ отличие еще больше. Вывод о том какие зависимости адекватны истинному росту масс ЧД может быть сделан на основе новых наблюдений галактик, удаленных от нас на $z \ge 4.5$.

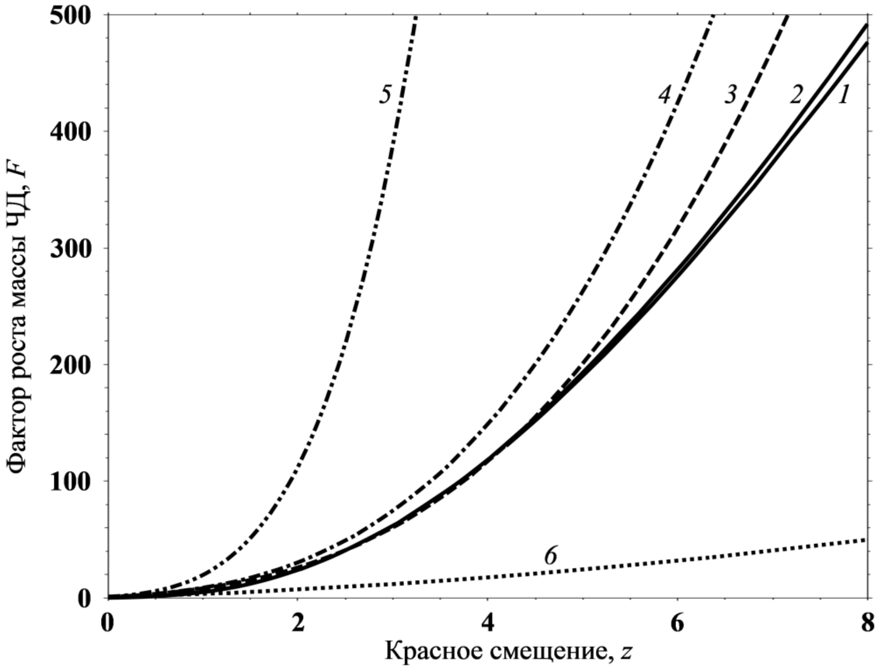

Рис. 5. Факторы роста масс ЧД F от момента излучения звезд родительской галактики, рассчитанные по рассматриваемой модели для $\mu = 1$ (*1*); 1/100 (2);F_c при $k = 2{,}96$ (*3*); 3,11 (*4*); при $k_{\max} = 4{,}3$ (*5*); при $k_{\min} = 1{,}78$ (*6*).

Сравнение формулы (6) со скоростью звездообразования приводит к предположению, что скорость звездообразования и скорость формирования материи обратно пропорциональна скорости притока энергии во Вселенную за вычетом энергии, поглощаемой ЧД. Таким образом, можно предположить, что рассматриваемая функция (6) характеризует скорость формирования не только барионной материи, из 10% которой состоят звезды, но и холодной темной материи. То, что при $z \approx 1.9$ характеристики функции (6) совпадают с характеристиками скорости звездообразования, а интеграл от нее в диапазоне значений $1.3 \leq z \leq Z$ существенно превышает соответствующий интеграл от скорости звездообразования говорит о том, что в более раннюю эпоху формирование барионной и холодной темной материи шло более интенсивно по сравнению со звездообразованием и эпохой, лежащей в диапазоне $0 < z < 1.9$. Разделение скорости формирования холодной темной материи и скорости формирования барионной материи выходит за рамки данной работы и требует отдельного рассмотрения.

VIII. ЗАКЛЮЧЕНИЕ

В данной работе рассматриваются следствия из предложенной ранее в [1] модели ускоренного расширения Вселенной, основанной на представления о гипотетической 4-мерной субстанции с инверсной заселенностью энергетических уровней. На основе данных о времени и красном смещении начала рекомбинации и последнего рассеяния и полученной в [1] зависимости красного смещения от разности настоящего момента времени и момента времени, в который наблюдаются объекты Вселенной, найден возраст Вселенной, который оказался равным ≈230 млрд лет. Это согласуется с выводами из исследований процесса рождения малометалличных звёзд [31] и с оценками возраста Вселенной, полученными в [1] на основе кривизны Вселенной.

Рассчитан радиус 4-мерного шара, к которому прилегает наша Вселенная, то есть радиус Вселенной, $R \approx 2.4 \cdot 10^3$ Гпк, а также длина экватора этого шара $L_e = 2\pi R$, которая составляет $\approx 1.5 \cdot 10^4$ Гпк. Показано, что найденное значение R согласуется с оценками на основе кривизны

Вселенной. Найден также объем Вселенной V как площадь гиперповерхности 3-мерной сферы: $V \approx 1{,}9 \cdot 10^{10}$ Гпк^3.

Рассчитан радиус сферы последнего рассеяния R_f, который оказался равным $\approx 5{,}6 \cdot 10^3$ Гпк. Из сравнения R_f с L_e сделан вывод, что в рассматриваемой модели большая часть Вселенной прозрачна для реликтового излучения.

В предположении, что в настоящее время плотность энергии во Вселенной равна критической оценена плотность энергии при возникновении Вселенной, которая составляла 0.16 ГэВ/см^3. Проанализирована динамика полной энергии Вселенной. Показано, что в данной модели полная энергия Вселенной меняется во времени. В течение первых 37 млрд лет после возникновения Вселенной ее полная энергия падает примерно в 10 раз, а затем начинает расти и к настоящему моменту времени увеличилась примерно в 10^4 раз по сравнению с энергией Вселенной в момент ее образования. Таким образом, сделан вывод, что имеют место как потери, так и приток энергии во Вселенную. На основе анализа скорости изменения энергии во Вселенной и сравнения с данными наблюдений за ростом масс черных дыр в эллиптических галактиках сделан вывод, что потери энергии во Вселенной обусловлены ее поглощением черными дырами, а приток обусловлен возбуждением мод в твердом 4-мерном слое под действием «бомбардировки» внутренней границы этого слоя квантами излучения в 4-мерном шаре, возникающими в процессе стимулированных переходов с верхних энергетических уровней гипотетической 4-мерной субстанции на нижележащие. Показано, что динамика роста масс черных дыр, описываемая полученными в настоящей работе формулами, не зависит от модели черной дыры. Результаты расчетов показывают, что масса черных дыр в диапазоне $0 \le z \approx 1.2$ возрастает почти в 7 раз, а в диапазоне $0 \le z \approx 2$ – в 20 раз. Это хорошо совпадает с результатами наблюдений черных дыр в эллиптических галактиках [25, 26], где к моменту наблюдения черных дыр не осталось вещества для увеличения их масс.

Сравнение динамики ЧД, рассмотренной в данной работе, с результатами исследований динамики ЧД, полученных в других работах, показывает, что в некоторых диапазонах значений z имеется достаточно удовлетворительной совпадение. Так в однопараметрической модели [34], опирающейся на стандартную космологическую модель, при силе космологической связи, равной 2,96 имеется удовлетворительное совпадение в диапазоне значений $1 \le z \le 4.5$. При выходе за пределы указанного диапазона результаты расчетов по модели [34] сильно отличаются от результатов расчетов по формулам настоящей работы. Для выяснения того какие зависимости адекватны истинному росту масс ЧД необходимы наблюдения подходящих галактик, удаленных от нас на $z \ge 4.5$.

Показано, что динамика роста энергии барионной и темной материи по форме совпадает с динамикой роста масс черных дыр. Проведено сравнение скорости формирования материи со скоростью звездообразования. Сделан вывод, что в настоящее время темная материя практически не образуется, а наиболее быстрыми темпами она образовывалась при красном смещении больше двух.

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The Story of Human Evolution is based on Fictional Fossil Evidence

Allan G. Krill

ABSTRACT

In a new version of the aquatic-ape theory, Homo sapiens evolved directly from isolated chimpanzees on Galapagos-like volcanic islands in western Africa. The theory explains human features such as the lack of fur, the ability to accumulate subcutaneous blubber, the large brain, and bipedal locomotion. It fits well with principles of evolution, and with anatomy, physiology, genetics, geography and geology. But it does not fit with hominin fossils. This calls for an alternative hypothesis: humans evolved without fossils being formed, and supposed hominin fossils are all misunderstandings. I have studied the published literature, and am convinced that some of the most famous fossil evidence is false: Bones of the Lucy skeleton are probably modern, taken from a burial vault near the discovery site. The Laetoli footprints are probably from Homo sapiens of Pleistocene age. The footprint layer has been covered up to protect it, so geological misinterpretations have not been noticed by visitors. The Turkana Boy Homo erectus skeleton is probably not a fossil, but is a mutilated child of the Congo atrocities of 1885-1908, whose bones were planted at Nariokotome to be discovered by scientists. The Little-Foot skeleton of Sterkfontein Cave is a composite, including probable human foot bones from a medical school. The century-old story of human evolution on the savanna is like an historical fiction novel, in which details need to be invented to make the story educational, interesting, and convincing to readers. Fossils have been required, to quell the unscientific belief in creationism.

Keywords: human evolution, lucy, laetoli, turkana, nariokotome, little-foot.

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The Story of Human Evolution is based on Fictional Fossil Evidence

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ABSTRACT

In a new version of the aquatic-ape theory, Homo sapiens evolved directly from isolated chimpanzees on Galapagos-like volcanic islands in western Africa. The theory explains human features such as the lack of fur, the ability to accumulate subcutaneous blubber, the large brain, and bipedal locomotion. It fits well with principles of evolution, and with anatomy, physiology, genetics, geography and geology. But it does not fit with hominin fossils. This calls for an alternative hypothesis: humans evolved without fossils being formed, and supposed hominin fossils are all misunderstandings. I have studied the published literature, and am convinced that some of the most famous fossil evidence is false: Bones of the Lucy skeleton are probably modern, taken from a burial vault near the discovery site. The Laetoli footprints are probably from Homo sapiens of Pleistocene age. The footprint layer has been covered up to protect it, so geological misinterpretations have not been noticed by visitors. The Turkana Boy Homo erectus skeleton is probably not a fossil, but is a mutilated child of the Congo atrocities of 1885-1908, whose bones were planted at Nariokotome to be discovered by scientists. The Little-Foot skeleton of Sterkfontein Cave is a composite, including probable human foot bones from a medical school. The century-old story of human evolution on the savanna is like an historical fiction novel, in which details need to be invented to make the story educational, interesting, and convincing to readers. Fossils have been required, to quell the unscientific belief in creationism.

Keywords: human evolution, lucy, laetoli, turkana, nariokotome, little-foot.

I. INTRODUCTION

Paleoanthropologists study fossils, which they use to write the story of human evolution. The fossils they need are found in dry parts of Africa. Western Africa lacks mammal fossils, because the hot and humid climate there causes bones to decay before fossilization can occur.

We know from DNA that chimpanzees are our closest relatives, and gorillas are our next closest. Over the past 10 Ma, gorillas have evolved in four different locations (Fig. 1) into four different taxa (*Gorilla gorilla gorilla, Gorilla gorilla diehli, Gorilla beringei beringei, Gorilla beringei graueri*). Similarly, chimpanzees have evolved in five different locations into five different taxa (*Pan troglodytes verus, Pan troglodytes vellerosus, Pan troglodytes troglodytes, Pan troglodytes schweinfurthii, Pan paniscus)*. There are no fossils in any of these humid areas.

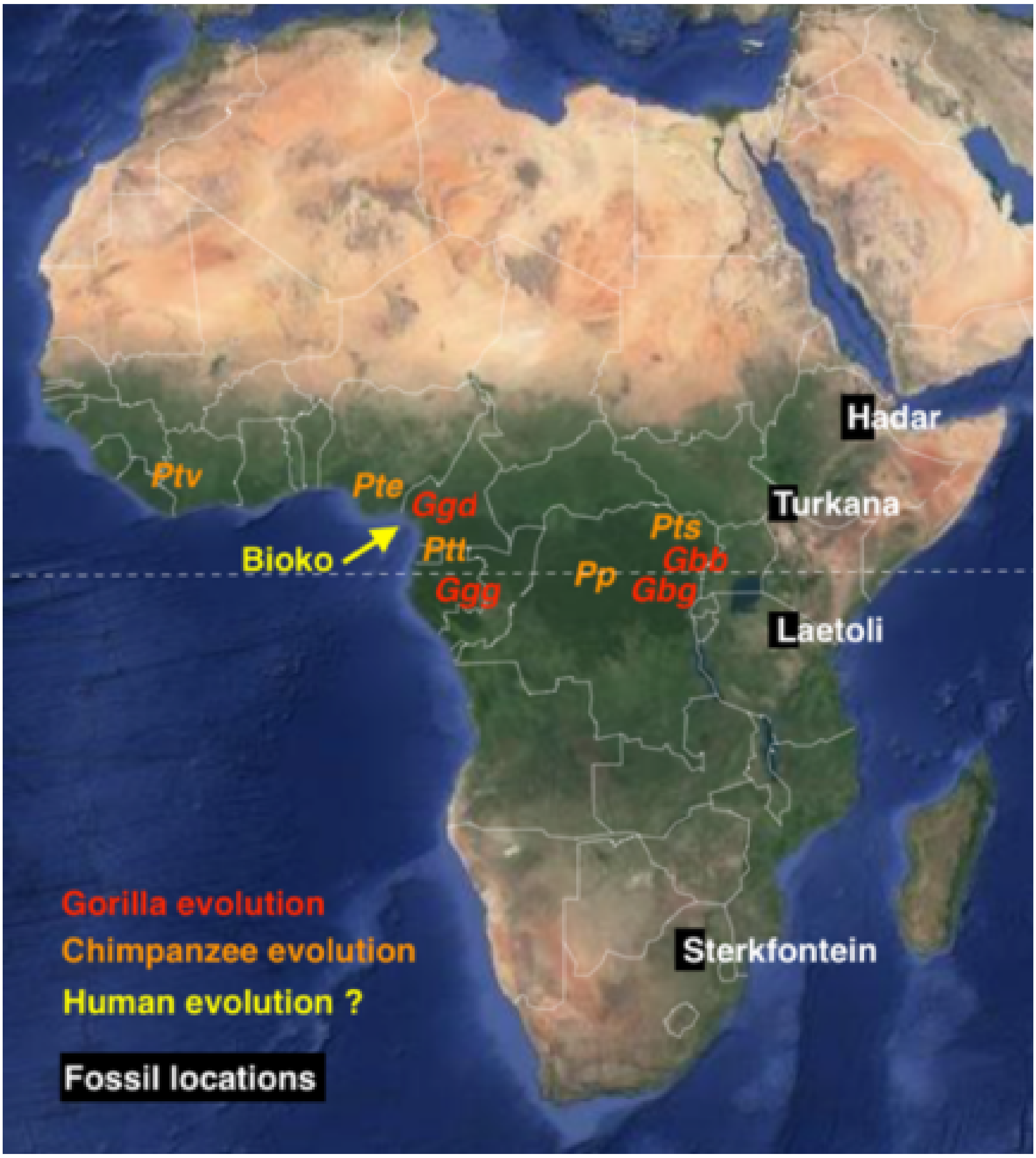


Figure 1: Locations where gorillas and chimpanzees evolved. Some of the best known hominin fossils are from **H**adar (Lucy), **L**aetoli, **T**urkana, and **S**terkfontein (Little-Foot). Base map from Google maps.

Where did humans evolve? Paleoanthropologists tell us that it was in arid eastern Africa, where fossils can be found. I think that is a cognitive bias, an example of The Streetlight Effect (Fig. 2).

Figure 2: The lack of interest in western Africa may be an example of The Streetlight Effect. Drawing by Alex Krill

Why did humans evolve? There is no clear answer. A survey (1) among life-scientists shows that there is no consensus as to the evolutionary cause of any of the remarkable human traits, such as naked skin, large brain, subcutaneous fat, external nose, and bipedal locomotion.

Human traits can all be explained by the unorthodox aquatic-ape theory, in which humans evolved from a chimpanzee-like ancestor during a period of semiaquatic habitat (2, 3). Now a new version of the aquatic-ape theory has been published (4), with humans evolving in western Africa, in a scenario similar to evolution of animals on the Galapagos Islands. In this theory, a few chimpanzees rafted to barren islands of newly formed proto Bioko. There was no forest where they stranded, and they were forced to live on a marine diet. They adopted a semiaquatic habitat, and become bipedal by wading in seawater to gather shellfish and seaweed. Like many marine mammals, they lost their fur, and evolved fat cells for producing subcutaneous blubber. They evolved large brains from the omega-3 fatty acids of the marine diet. All other human features can also be explained in this way. The theory fits well with principles of evolution, with geology, geography, and with human and chimpanzee anatomy, physiology, and genetics. But it does not fit well with hominin fossils—that paleoanthropologists tell us are human ancestors.

Since learning about the aquatic-ape theory, I have studied the primary literature on the most important hominin fossils. Fossils have been needed to argue against the non scientific belief in creationism. But I think the savanna story and the fossils that support it are incorrect. I see that key fossil evidence has been invented, like details in a historical fiction novel, needed to make an educational story convincing and interesting. Here I show why some of the best known hominin fossils should no longer be believed.

Non-scientific practices in paleoanthropology

Ape fossils are rare. There has never been reported a fossil bone of the gorilla or the chimpanzee. Three teeth of a chimpanzee were once found near Lake Turkana in Kenya (5), but I think they were planted there to fool scientists.

Because of the rarity of ape fossils, paleoanthropology has special practices to encourage more people to look for them and find them. Some of these practices go against good science, in which evidence should be reproducible by impartial scientists. Three of the practices that are especially problematic are: 1) the acceptance of surface-finds, 2) the prevention of hands-on study by outsiders, and 3) the lack of blinding in age-determination studies.

The acceptance of surface-finds

Most hominin fossils are surface-finds. A fossil is found lying loose on a layer of known geologic age, and nothing more is found by digging. A fossil can only lie exposed that way for a few years before it either found or is destroyed by weathering.

A surface-find is not good scientific evidence, because it is easily falsified, and cannot be verified or obtained again. Any type of irreproducible evidence should be subject to doubt. But in paleoanthropology, a finder's claims are not questioned. A scientist may suspect that a fossil find was not legitimate, but a public accusation could not be proven and would ruin the reputation of the accuser.

In contrast to hominins, dinosaur bones and complete skeletons are abundant. They are found by looking for a fragment lying loose on the ground. But this is not a surface-find. The searcher moves uphill to where the fragment is eroding out of the sedimentary layer, and then excavates complete bones. For dinosaurs, the claim that a fossil bone or partial skeleton was found loose on the ground would not be taken seriously.

The prevention of hands-on study by unbiased scientists

To encourage fossil hunting, the finder of a hominin fossil has exclusive rights to study it. The finder can prevent independent scientists from seeing the material until the finder's team is finished publishing (6, 7). The finder's study can go on for decades. Even afterwards, the material is too valuable and fragile to allow outsiders to handle it. They must work with photographs, replicas, and descriptions of the original materials.

The finder selects specialists to study the fossil material. These scientists are not impartial. If they cast doubt on the material's authenticity or suitability, it will spoil the team's chance

for important publications. Chemical and physical tests that might disprove a fossil's authenticity are not carried out.

Specialists glue fragments together in suitable positions. This involves decisions about how the fragments should fit, and how to fill in missing pieces. These decisions can determine such things as brain size and upright stance. Once glued, it is not possible for others to propose alternatives. Any objection to the exciting results would appear to be motivated by envy.

Lack of blinding in age-determination studies

When minerals or rocks are radiometrically dated, the result will not be publishable if it is not sufficiently precise, or if the date is outside the range of acceptable ages. Publishability trumps reliability. To make the results publishable, it is often necessary for scientists to ignore parts of the data that would spoil the final result. Deletion of some data is no secret to those who do the dating, but it is rarely mentioned.

I know from geological experience with isotopic dating, that radiometric dates are often incorrect because of observer expectation bias. I think that for a radiometric date to be trustworthy, it should be obtained by workers who do not know what age is preferred. Ideally, the material should be dated twice, in independent laboratories. This is never done.

A critical look at published reports of famous human fossils.

Java Man

Eugène Dubois was a Dutch anatomist who collected fossils. After reading about the concept of a missing link, he moved to Java in 1887 *"obsessed with finding it and winning scientific fame and fortune."* (7), p 29). He succeeded: in 1891 he announced Java Man. It consisted only of three items, which were not actually found together: a femur (thigh bone), a tooth, and a skullcap.

Discussions of Java Man greatly contributed to the awareness and status of paleoanthropology. Within 10 years, almost eighty books or articles had been published on this topic. Most scientists who saw Dubois' three items rejected his claims that these were human fossils. Therefore, he kept them hidden away for several decades.

Peking Man

Peking Man was a missing-link sensation in the 1930's. The fossils consisted of skull fragments from as many as 15 individuals, found together with stone tools. High-quality casts and scientific descriptions were made. But somehow, all the original material was lost in 1941, and has never been found (7). Paleoanthropologists currently assign both Java Man and Peking Man to *Homo erectus*.

Piltdown Man

Piltdown Man was a missing link found in England in 1912. It consisted of a skull with a large braincase and a protruding jaw, that confirmed the assumption that the large brain evolved before other human features. Despite some doubt, it was accepted for almost 40 years, and then proven to be a hoax. The pieces actually came from the cranium of a human, and the jaw of an orangutan. They had been broken so that they might fit together. They were stained to look old, and dirt was cemented into the cracks. A long canine tooth was filed down, to make it look human.

The trickster was Charles Dawson, an amateur archeologist and respected solicitor. He claimed to have gotten the main pieces from the Piltdown gravel pit. He planted additional bones and tools at the locality, and led experts to where they could be discovered. It was later shown that Dawson owned a collection of false artifacts (8).

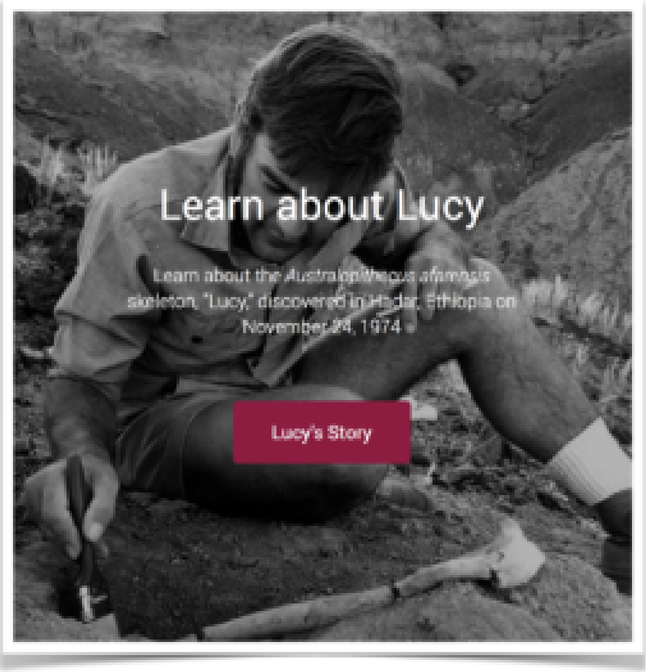
Three anatomy experts who studied the original material constructed the braincase to be 1070 cm^3, much smaller than it actually was. They saw human-like features in the jaw, and ape-like features in the cranium. No one today doubts that these were honest errors in judgment. They received British knighthood, largely as a result of their contribution to the scientific status of England. Some scientists were skeptical, but no one could suggest that the fossil was a hoax.

It was fluorine testing that finally debunked Piltdown Man. Bones absorb fluorine from the ground over time, so ancient bones should be rich in fluorine (9). Bones from the same individual buried in the same sediments will have absorbed about the same amount of fluorine. After the scandal of Piltdown Man, one might expect that fluorine testing would be required for all hominin fossils. But there is no incentive to carry out a fluorine test, or a carbon-14 analysis, or look for DNA, because such tests require destruction of a small amount of the fossil material.

Piltdown Man generated immense public interest that boosted the science of paleoanthropology. Several hundred scientific papers were published. It was often mentioned by the media in 1925 during the famous Scopes monkey-trial, where an American school teacher was accused of teaching evolution. Fossils were needed to argue against the unscientific belief in creationism.

Lucy (Hadar, Ethiopia)

The Lucy skeleton was found by Professor Donald C. Johanson on Sunday, November 24, 1974, in Hadar, Ethiopia. In Johanson's books (10, 11, 12) it is clear that the bones were a surface-find, with nothing found by digging. Yet on the web page of the Institute of Human Origins (IHO), which Johanson founded in 1981, he is shown excavating a bone (Fig. 3).



Learn about Lucy

Learn about the Australopithecus afarensis skeleton, "Lucy," discovered in Hadar, Ethiopia on November 24, 1974

Figure 3: Despite the implications of this photograph, all the Lucy bones were lying loose on the surface. Image from the Institute of Human Origins

Lucy's Story was written to imply that some of the bones were found by digging (13):

> *Within moments, he spotted a right proximal ulna (forearm bone) and quickly identified it as a hominid. Shortly thereafter, he saw an occipital (skull) bone, then a femur, some ribs, a pelvis, and the lower jaw. Two weeks later, after many hours of excavation, screening, and sorting, several hundred fragments of bone had been recovered, representing 40 percent of a single hominid skeleton.*

Much less than 40 percent of that skeleton was actually found, and nothing was found by excavation. But this misleading information is useful against creationism, and therefore benefits science. We might call it a noble lie. My complaint is that misinformation pervades paleoanthropology and is used against the aquatic-ape theory, which is also science.

I think the discovery of the Lucy bones was a Piltdown-type hoax. I contend that it is impossible for a partial skeleton to be lying loose on the surface in a badlands terrain like Hadar. Bones are buried and preserved in a horizontal layer of sediment. As that layer is eroded on a hillside, rain removes only a centimeter or so at a time. A few fragments of weathered bone loosen, and are washed downhill, while the remaining bone stays covered in the horizontal layer. In the next rainstorm, the first fragments are washed away and a few new ones are loosened. Sometimes a large part of a bone with rock matrix can tumble down the hill, but never a collection of bones with no rock matrix from a single individual.

Finding many bones at once, with nothing found by digging, verges on the miraculous. I think that the bones were planted by Johanson's student Tom Gray in order to fool him and to help him. Here you can read the first two pages of Johanson's book *Lucy's Legacy*. It is a long citation, but it is important. Since outsiders are not allowed access to original fossil material, this is the sort of evidence that we must use (12), p. 3-4).

Lucy's Legacy by Donald C. Johanson and Kate Wong

Never in my wildest fantasies did I imagine that I would discover a fossil as earthshaking as Lucy. When I was a teenager, I dreamed of traveling to Africa and finding a "missing link." Lucy is that and more: a 3.2-million-year-old skeleton who has become the spokeswoman for human evolution. She is perhaps the best known and most studied fossil hominid of the twentieth century, the benchmark by which other discoveries of human ancestors are judged.

Whenever I tell the story, I am instantly transported back to the thrilling moment when I first saw her thirty-four years ago on the sandy slopes of Hadar in Ethiopia's Afar region. I can feel the searing, noonday sun beating down on my shoulders, the beads of sweat on my forehead, the dryness of my mouth— and then the shock of seeing a small fragment of bone lying inconspicuously on the ground. Most dedicated fossil hunters spend the majority of their lives in the field without finding anything remarkable, and there I was, a thirty-one-year-old newly minted Ph.D., staring at my childhood dream at my feet.

Sunday, November 24, 1974, began, as it usually does for me in the field, at dawn. I had slept well in my tent, with the glittering stars visible through the small screen that kept out the mosquitoes, and as sunrise announced a brilliant new day, I got up and went to the dining tent for a cup of thick, black Ethiopian coffee. Listening to the morning sounds of camp life, I planned with some disinclination the day's activities: catching up on correspondence, fossil cataloging, and a million other tasks that had been set aside to accommodate a visit from anthropologists Richard and Mary Leakey. I looked up as Tom Gray, my grad student, appeared.

> *"I'm plotting the fossil localities on the Hadar map," he said. "Can you show me Afar Locality 162, where the pig skull was found last year?"*
>
> *"I have a ton of paperwork and am not sure I want to leave camp today." "Can you do the paperwork later?"*
> *"Even if I start it now I'll be doing it later," I grumbled. But something inside — a gut sense that I had learned to heed — said I should put the paperwork aside and head to the outcrops with Tom.*

The first sentence is clearly false. Johanson made it clear in the second sentence, and in the last sentence of the second paragraph, that he had always dreamed of finding an earthshaking missing link. Tom Gray drove him to the place where his dream came true. The Lucy bones were lying in such a way that (12, p. 7): "*a single desert thunderstorm could have washed them off the plateau, over a cliff and into oblivion, forever.*"

Johanson immediately decided that this was a female *Australopithecus*, and they named it Lucy. As he wrote in his first book (10, p. 18):

> *The camp was rocking with excitement. That first night we never went to bed at all. We talked and talked. We drank beer after beer. There was a tape recorder in the camp, and a tape of the Beatles song "Lucy in the Sky with Diamonds" went belting out into the night sky, and was played at full volume over and over again out of sheer exuberance. At some point during that unforgettable evening—I no longer remember exactly when—the*

> *new fossil picked up the name of Lucy, and has been so known ever since, although its proper name—its acquisition number in the Hadar collection—is AL 288-1.*

Within a few days, Johanson contacted government authorities and arranged for a press conference (12), p. 8). After publicly announcing such a sensational success, it would be difficult for Johanson to doubt his fossil's authenticity. But we should doubt it. In 2015, experts studying a Lucy replica suspected that a neck vertebra belonged to a baboon. One of them flew to Ethiopia to study the original material, and confirmed their suspicion (15).

It took paleoanthropology 40 years to discover that mistake. But the abstract of the published paper included a sentence to downplay the scandal (15): "*This work does not refute previous work on Lucy or its importance for human evolution, but rather highlights the importance of studying original fossils, as well as the efficacy of the scientific method.*"

The Lucy-bones were found in an obvious place that had been visited many times before. In his memoir, geologist Jon Kalb wrote: (14, p. 151):

> *The Lucy locality, L288, was surrounded by a cluster of seven other fossil localities mapped by Dennis Peak and myself. At one time or another in 1973, probably everyone in camp had walked across L288, Johanson included.*

Gray's friends may have known that these bones were planted there, and that Gray took Johanson out to find them. Johanson wrote how Gray announced the recovery of the Lucy fossils to others in the team (10, p. 17):

> *"Cool it," I said.*
>
> *But about a quarter of a mile from camp, Gray could not cool it. He pressed his thumb on the Land-Rover's horn, and the long blast brought a scurry of scientists who had been bathing in the river. "We've got it," he yelled. "Oh, Jesus, we've got it. We've got The Whole Thing!"*

The Lucy bones were found toward the end of the 1974 field season, after little else of interest had been found. The same thing had happened in 1973. Johanson and Gray were together, when Johanson made a sensational find that saved the 1973 field season from failure (11), p. 82):

> *Day after day I scrambled around in the stifling heat. But if there were hominids to be found, they were keeping themselves well hidden. After several weeks of exploring, I had exhausted most of a grant that was supposed to have lasted two years, and had nothing to show for it. I wondered how I was going to explain that to the NSF.*
>
> *Then, near the limit of our time in the field, Hadar suddenly fulfilled its promise. While surveying late one afternoon with a colleague named Tom Gray, I uncovered what looked to be a monkey's proximal tibia—the top end of a shinbone. A few yards away, I noticed a distal femur—the lower end of a thighbone—lying in two pieces on the ground. I put the two pieces of femur together, and then carefully fit them against the tibia. That they matched perfectly was not surprising, since they were the same color, lay next to each other, and thus might be expected to form the knee joint of a single individual. What was surprising—astonishing, in fact—was the way they fit together. The thigh and shin bones*

> *met at an angle, the femur slanting outward. There was only one living primate endowed with such a knee joint. Human femurs angle outward in order to give balance for walking on two legs. I could scarcely believe the evidence in my hands. If our preliminary dating of the Hadar deposits was correct, I was holding the knee joint of a hominid over three million years old: the earliest record of a bipedal ancestor yet discovered.*

Johanson then wanted a modern human femur to compare with this 3 Ma-old one. He and Gray knew just where to get one, only a short walk from their camp. As Johanson explained in his previous book: (10, p.159):

> *"I have to have a femur."*
>
> *By that time we had arrived at the burial mound. It was a loosely made dome of boulders and was probably a good many years old, because one side had fallen away. I looked in. There was a large heap of bones inside—a family burial place. Lying on the top, almost asking to be taken, was a femur. Tom took it. We looked around. There was no one in sight. Tom put the bone in his shirt and carried it back to camp. That night I compared it with the fossil. Except for size, they were virtually identical.*

The burial vault had probably been raided earlier, since a femur was now lying on top. The fossil knee-joint and the Lucy bones are said to be smaller than those of a human, but so was the cranium of Piltdown Man. The geologist Jon Kalb shared camp with Johanson's team on the day Johanson supposedly discovered the knee joint. Kalb noted irregularties with Johanson's behavior and his registration of this fossil discovery. Kalb summarized his suspicions by writing: *"there was something rotten in Denmark"* (14, p.105).

My current hypothesis is that Gray returned to this burial vault, carefully chose some human bones, and planted them and some baboon bones near the pig-skull locality, in order to guarantee that the 1974 field season would be successful. This hypothesis might now be tested by analyzing the bones for fluorine, carbon 14, or DNA.

If the Lucy bones are indeed true fossils, they were nevertheless a surface-find, that is now being misrepresented on IHO's webpage (13). Johanson made it clear how desperate he was to succeed. It is naïve to accept Johanson's claim that these fossils are from the KH-1s sandstone, between the Kada Hadar Tuff and Confetti Clay, and are therefore as old as 3.2 Ma.

Laetoli footprints (Tanzania)

Thousands of animal tracks, together with footprints of bipedal hominins, were discovered at Laetoli, south of Olduvai Gorge (Figs. 4, 5) in 1978. The tracks were said to be about 3.5 Ma old. They were published by Mary Leakey and geology professor Richard Hay, first in an article in *Nature* in 1979 (16), and then in an article in *Scientific American* in 1982 (17). Already in 1979, before independent scientists could visit the site, Leakey and Hay had the hominin footprints covered up by soil and boulders to protect them (Fig. 6). They have remained covered since, only opened a few times to remove acacia trees and document the damage that soil and tree roots had caused (18).

The cover-up made it difficult for independent geologists to study the footprint layer, and no one has corrected what I think are significant errors in the geological interpretation. I have studied the published works on Laetoli and Olduvai (19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35). I contend that the 3.5 Ma dating of the hominin tracks is invalid, because the rock layers are sedimentary, not volcanic. I think the footprints are *Homo sapiens*, similar to fossil footprints that occur near Lake Natron, about 100 kilometers to the northeast (36). A local animal tracking expert engaged by Mary Leakey thought that the Laetoli animal tracks looked modern (24), p. 7), and they have never been properly described or identified.

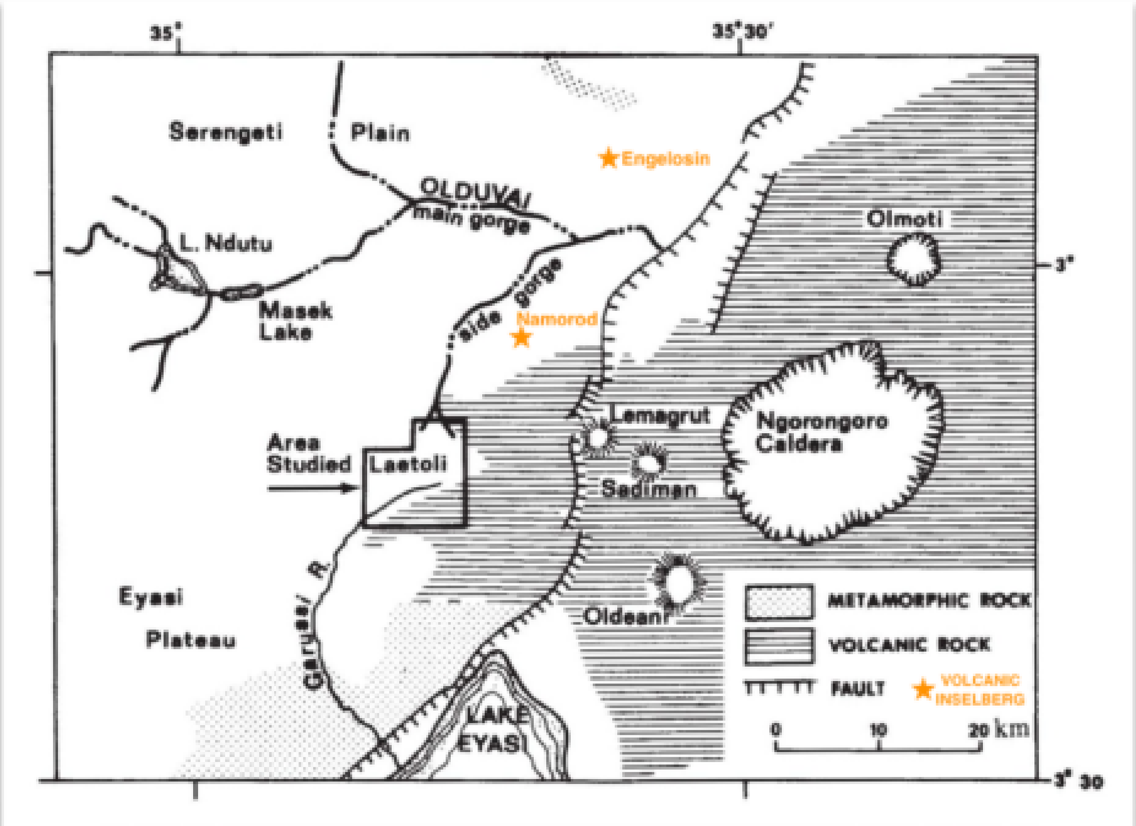
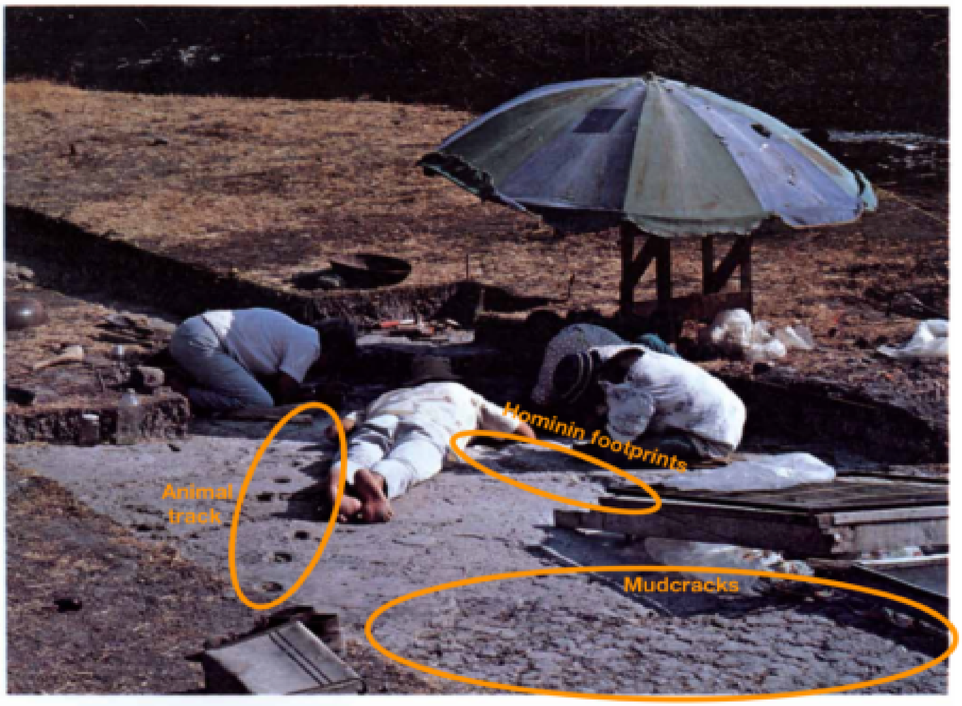


Figure 4: Geological map showing horizontal layers as white (From 16). Basement (including inselbergs) consists of Precambrian metamorphic rocks in the west and volcanic rocks in the east. My orange stars indicate volcanic inselberg basement.



PORTABLE SUNSHADE offered some protection to Mary Leakey (*left*), R. J. Clarke of the National Museum of Bloemfontein (*center*) and two technicians as they cleared overlying tuff from the hominid trails at Site *G* in 1979. Trails were discovered in 1978.

Figure 5: Figure from Hay & Leakey (17). My orange annotations added.

The reburial mound prior to removal of boulders

Figure 6: The footprint layer was covered up in 1979 by soil and boulders, purportedly to protect it.

The cover-up also kept visiting geologists from seeing it. (Photo from Getty Conservation Institute, 18).

The footprint layer is one of 18 layers, averaging about 1 centimeter thick, that are perfectly flat and horizontal. Over half of the layers show animal tracks, pits from raindrops, and mudcracks. One layer shows hominin footprints. The obvious geological hypothesis would be that these were muds on the margin of a large shallow lake. In the rainy season, a layer of mud is deposited and tracks are made by animals near the lake. In a dry period, the layer dries and hardens, while mudcracks form and the tracks are preserved. In the next rainy season, the process is repeated, and this can easily occur 18 times. The minerals of such sedimentary layers have different source ages, all older than the layers themselves. The minerals can be dated, but they do not give the age of the layers.

The lake-margin hypothesis was never mentioned in the publications by Hay. His explanation was outlandish: each thin layer represented a volcanic eruption that left an ash-fall on a smooth flat landscape (16, 17). After each eruption, there came enough rain to moisten the ash and make it cohesive and able to record tracks, but not enough rain to wash the ash away. It hardened to form the rock called ash-fall tuff. But there is no ash preserved (23), and no angular volcanic shards in these supposed tuffs. The layers are carbonate-rich, like lake sediments and unlike volcanic ash (24). There are rounded sand grains (35), typical of sediments. Hay wrote that most of the layers have a "*polygonal fracture pattern*", which in his photograph (his figure 4, 24) looks like the mudcracks of sediments. Such fractures are unknown in tuffs. Mudcracks and rounded grains would be easily seen by visitors if the rocks were not covered.

The dated minerals show a spread of radiometric ages, which also argues against the layers being from volcanic eruptions of about the same age. But Alan Deino, who did the dating, simply accepted Hay's volcanic interpretation. He also accepted the conclusion from the dating study decades earlier in the same laboratory, that the layer of footprints was about 3.5 Ma old (31, p. 78). To improve the precision of the previously determined ages, he analyzed 325 feldspar mineral grains from different layers. First he threw out 23 of his analyses, because they were inappropriately young. Then he threw out 119 because they were inappropriately old (31, p. 80):

> *Of the remaining 302 analyses, many are simply too old to reflect a true eruptive age. These are most likely xenocrysts, acquired immediately prior to or during the eruptive process, or during transport to the site of deposition. At Laetoli, where the current dating effort, as well as prior work, indicates that the oldest strata of the Laetoli Beds are ~4.2–4.4 Ma, a cutoff of 4.7 Ma is used to classify 119 grains as 'obvious xenocrysts.' The most precise of these (< 3% error in age) are up to 600 Ma, with prominent modes at ~7.6, 6.5, and 5.5 Ma.*

He used the grains that gave the ages and precisions that he needed to publish this paper. The others he called *xenocrysts*, or foreign grains in volcanic rocks. He did not describe or show any thin-section pictures of rocks or mineral grains. I think all his analyses are actually correct, including the young and old ones. But they are all detrital grains in sedimentary rocks, and he should have thrown them all out.

I contend that the beds of Laetoli are sedimentary, which makes the ages invalid. There is one valid dating result: a 2.3 Ma age of the volcanic basalt of the Ogol Lavas (see Fig. 7, right column). However, I am convinced that Hay misinterpreted the position of the Ogol Lavas, by thinking that they occur above some beds. Neither Hay nor others discuss exactly which beds the lavas supposedly occur above. Also at Olduvai Gorge, Hay interpreted some Ngorongoro volcanics to lie above some layers of Bed I (see Fig. 7, left column). Louis Leakey wrote that Hay was probably wrong about that stratigraphic position (19, p. 2).

Anyone can see that the footprint layer at Laetoli is covered up. Only a geologist who has studied the regional literature would be able to see that geologic information at Laetoli and Olduvai is covered up and that the Laetoli ages are incorrect.

The incorrect ages have led to regional geologic problems. The Olduvai Gorge (see Fig. 4) cuts through the horizontal beds of the Serengeti Plain like a mini version of the Grand Canyon. Unlike the Grand Canyon, there is no published geologic map or cross-section showing the beds and their continuity. This is because the incorrect Laetoli dates make a map and cross-section impossible. It is like the M. C. Escher waterfall: the beds at Laetolil are supposedly old, at a low level, while similar beds at Olduvai are young, at a high level. To put more distance between Olduvai and Laetoli, at least mentally, geologists now call the Laetoli land surface the *Eyasi Plateau* instead of the *Serengeti Plain* (as in Fig. 4).

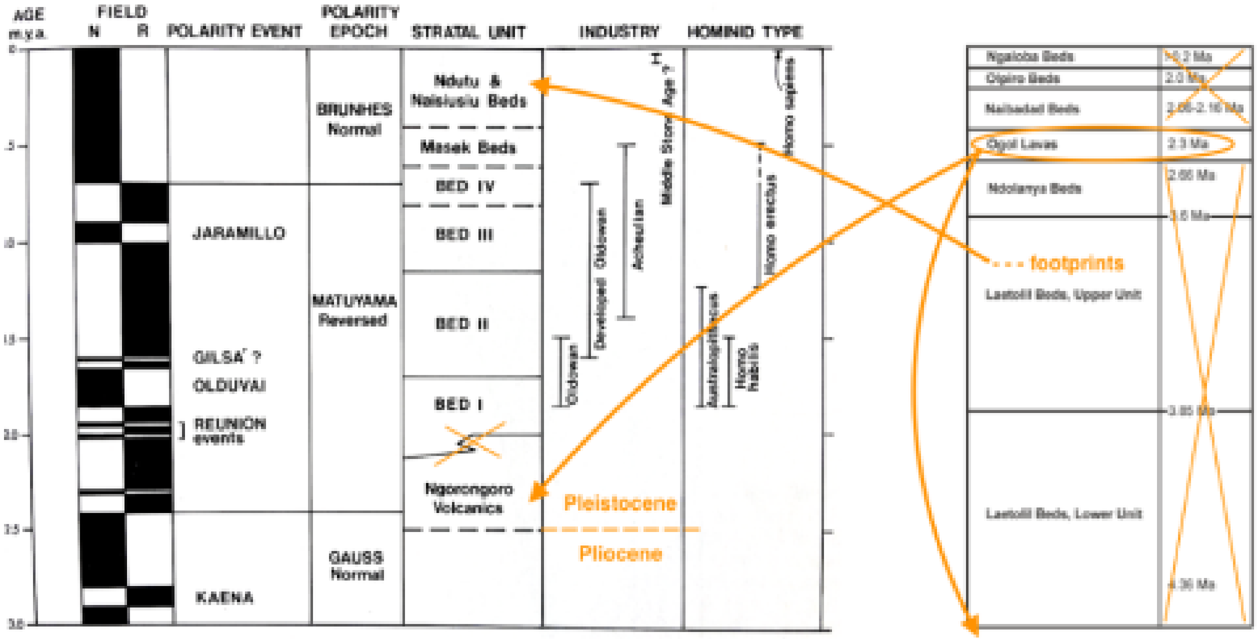


Fig. 7: Horizontal strata at Olduvai (left diagram, from 18) and Laetoli (right diagram, from 19). Hay (20) thought Ogol volcanics lie over Laetolil Beds. I think the Ogol Lavas are volcanic basement, which includes inselbergs like Namorod and Engelosin.

The academic books (19, 21, 24, 27, 28) that one needs in order to study the geology of Olduvai and Laetoli are expensive and not easily available. Few independent geologists have gotten involved in the regional geology there. As I read the scientific papers in these books, I notice the avoidance of obvious geological hypotheses, types of data, and routine descriptions. Key omissions have helped keep the incorrect 3.5 Ma age covered up until now. Only a geologist with all the sources could notice that the information is missing:

- Geological maps and cross sections of the beds of Olduvai and the beds of Laetoli. • The hypothesis that the ash-fall tuffs could be sedimentary and not volcanic. • The hypothesis that Hay's "polygonal fracture pattern" could be sedimentary mudcracks.

- Chemical analyses (whole-rock, trace-element, and isotopes) of the supposed ash fall tuffs, which would be needed to properly show they are volcanic and not sedimentary.
- Thin-section descriptions and photomicrographs of the dated rocks and minerals, which would be needed to show volcanic ash-fall origin.
- Information on the stratigraphic position of the Ogol Lavas, and contact relationships of these lavas with supposedly underlying beds.

My hypothesis is that the layers and animal tracks at Laetoli are of Pleistocene age, and the footprints are *Homo sapiens*. Geological data that would show this have been covered up, just as the geological features at the Laetoli tourist locality have been covered up by soil and boulders.

Protsch discoveries

Reiner Protsch was a respected German anthropology professor whose career ended in disgrace in 2004. Some of the fossil material he had dated was taken from him and sent to an independent laboratory for testing. It was shown that he had faked discovery locations and dates of bones for decades, in order to publish exciting scientific results (37, 38, 39).

His *Hahnhöfersand Man*, supposedly from a bog in northern Germany, was not a fossil at all. Neither were two other of his discoveries, the *Binshof-Speyer Woman* and the *Paderborn-Sande Man*. A 50-million-year-old primate fossil that Protsch had said was from Switzerland was actually from a previously known site in France.

Protsch's background was at Olduvai Gorge and Laetoli. As part of his Ph.D. thesis at UCLA in 1973, he dated a *Homo sapiens* fossil that had once been thought to be from the million-year-old Bed II of Olduvai (see Figure 6). It was debunked by fluorine analysis, and then Protsch helped to correctly date it, at about 17,000 years old (40, see 22, p.165). In a later report (41), Protsch noted that there were location discrepencies and missing fossil items in the Laetoli area (see 34, p.143, p.147). He must have realized that errors in paleoanthropology can go uncorrected, and that falsehoods can lead to success.

Turkana Boy (Nariokotome, Kenya)

Turkana Boy is the most complete skeleton of a hominin ever found. It was found in 1984 in the dry Nariokotome River valley, just west of Lake Turkana, Kenya (42). The braincase of 880 cc is smaller than a modern human's, but otherwise the bones and teeth are strikingly human.

The skeleton is described in a book of scientific papers *The Nariokotome Homo erectus skeleton,* edited by Alan Walker and Richard Leakey (42). The skeleton was determined to be a boy that was about 12 years of age when he died, possibly because of a tooth infection (43, p.53, 7, p.24). Although he lived about 1.5 Ma ago, the bone proportions are similar to modern Africans, and unlike Neanderthals or modern Eskimos (7, p. 161).

A detailed account of the discovery and context are available in a popular-science book by Walker, co-authored by his wife Pat Shipman, an anthropology professor: *"It is my story, but she wrote most of the words.*" (7), p. xii). Turkana Boy was discovered by the hominin fossil hunter Kamoya Kimeu. Here is how Walker and Shipman described the discovery (46) p. 11):

> *He went to an improbable place, a little hill on the opposite bank of the sand river, near a small acacia tree and a good-size salvadora tree. ... Not only had the place been trampled and scuffed and walked over, but it wasn't much of an erosional surface anyway, not a place to find fossils.*
>
> *Kamoya went anyway. And amidst the litter of black lava pebbles and dried leaves and sticks, he found a piece of hominid frontal bone. It was the size of a matchbook and the color of the pebbles. Lord knows how he saw it. He picked it up because it was lying loose on the surface, and then he turned it over. To him, it was obviously a fragment of bone from the cranial vault, the bony covering of the brain. The inside was smooth, from the impression of a large brain – not as it would be on a pig or gazelle but as it would be on a hominid. He knew from the thickness that it was Homo erectus, the species that immediately precedes modern humans.*

How did Kimeu know that this piece was a *Homo erectus*, and not a modern human fragment? And how did he know that more of the fossil could be found by digging in that little hill? Since Kimeu began working for the Leakey family in 1960, he has shown an uncanny ability to find sensational hominin fossils. He said on various occasions that hominins talk to him in a mystical language, *Kikishwa* (7, p.22). Scientists think it is quaint when people have unscientific beliefs.

Kimeu found the fragment on August 22, 1984, and reported to Alan Walker and Richard Leakey, who were in Nairobi. They arrived the next day by private plane, to a landing strip that Kimeu had previously prepared (7, p.12). Kimeu and his coworkers excavated the skull bones in a few days, and nearly all the other bones within four weeks. The first results were published in *Nature* in 1985 (44).

The skeleton is remarkable, because it lacks bones of the hands and feet. All the vertebrae were present, except the upper six vertebrae of the neck. Why were these particular bones not found?

Here is my hypothesis: The skeleton was not a *Homo erectus* at all. It was one of thousands of children who had been killed and mutilated in the Congo Free State between 1885 and 1908. Those atrocities were carried out under orders of King Leopold II of Belgium. To terrorize families, soldiers routinely cut off a hand or foot of a child. Hands were delivered to the soldiers' superiors, as proof of their work. Hundreds of Congo children survived and many were photographed with a missing hand. But many others had their heads, hands, and feet chopped off. These missing parts are a sort of fingerprint to these Congo corpses. Maybe the ghost of one of these boys moved his bones to Nariokotome, and then used the language *Kikishwa* to tell Kimeu where to find them.

Walker glued the fragments of the cranium (calvaria) in the field, working together with Leakey's wife (7, p.19). The pieces were "*corrected by adjusting the glue joins.*" They made the braincase appropriate for a *Homo erectus*. Here is Walker's description of that process (45, p.328):

> *The calvaria was recovered from the disturbed surface sediment and desert lag at Nariokotome. Only the facial skeleton was seen* in situ *and that was embedded in the roots of an Acacia tree. The individual skull bones were assembled in the field by gluing many fragments with Durofix (Rawlplug Ltd.) Most of the nearly 70 pieces did not have much adhering matrix, but any still present was removed in the laboratory using pneumatic*

> *Airscribes (Chicago Pneumatic Corp.) The individual bones were then reassembled into the calvaria and the slight distortion in the curvatures of the fossilied bones were corrected for as much as possible by adjusting the glue joins.*

The facial skeleton was said to be dug out of the 1.5 Ma layers, in other words *in situ*. But this bone had roots of an Acacia tree growing in it. Roots grow in soil, and bones in soil can only survive for a few thousand years at most. So I do not accept that this is *in situ*. Photographs (42, p. 94b, 94c) of supposedly *in situ* bones show that they lie in coarse deposits, not in the 1.5 Ma-old layers, which are fine-grained mudstone. These coarse deposits would be moved and replaced during occasional floods in the Nariokotome River within a few hundred years at most.

The 1.5 Ma mudstone layers were excavated after the bones were found (Fig. 7). Many paleoanthropologists visited while the layers were being excavated in 1985-1988 (7, p. 23). Hippo, tortoise, and catfish bones were found in those layers, but nothing more of the boy's skeleton. The debris from this excavation was dumped in mounds, about where the bones had been taken from the little hill in 1984 (Figs. 8, 9). The excavation documented the geological and environmental conditions of the supposed source of the fossils.

By 1985 it was clear that the skeleton was missing hands and feet, and neck bones. Mary Leakey thought that they might be found by further excavation (7, p.23). In 1986, Kimeu and coworkers did find a few more bones, about 15 meters away from the little hill (see Figs. 7, 8). They were hand, foot, and a vertebra, from a juvenile, just what was needed. But Walker determined that they were not from Turkana Boy. I think he had to write about these bones, because they were known to the others. But he wrote about them without using the words hand, foot, or neck (43, p.46):

> *A word must be said here about three bones that may belong to the skeleton but were situated a long way from the main hominid concentration. These bones are definitely metapodials of a juvenile mammal. If they are hominid, then two are first metacarpals and the other is a first metatarsal. They were found in 1986 about 15 m northeast of the main hominid concentration. Nearby was an immature vertebra that was thought to be hominid but, when cleaned, proved not to be. All three metapodial bones are from immature individuals and lack their epiphyses and articular ends. What remains of the details of morphology is sufficient to cast doubt on their hominid status, but they cannot be securely placed in another taxon either. That they were widely separated from the main concentration of hominid bones is yet another hint that they might not belong to the hominid skeleton.*

My hypothesis is that these new hand and foot bones, and one vertebra, came from the grave of some other boy. I think they were planted to be discovered during the excavation in 1986 to match the defective skeleton from the little hill. But they didn't match. So we have bones of two different juveniles here: one with no hands and feet, and the other with no bones of the body, only hands and feet.

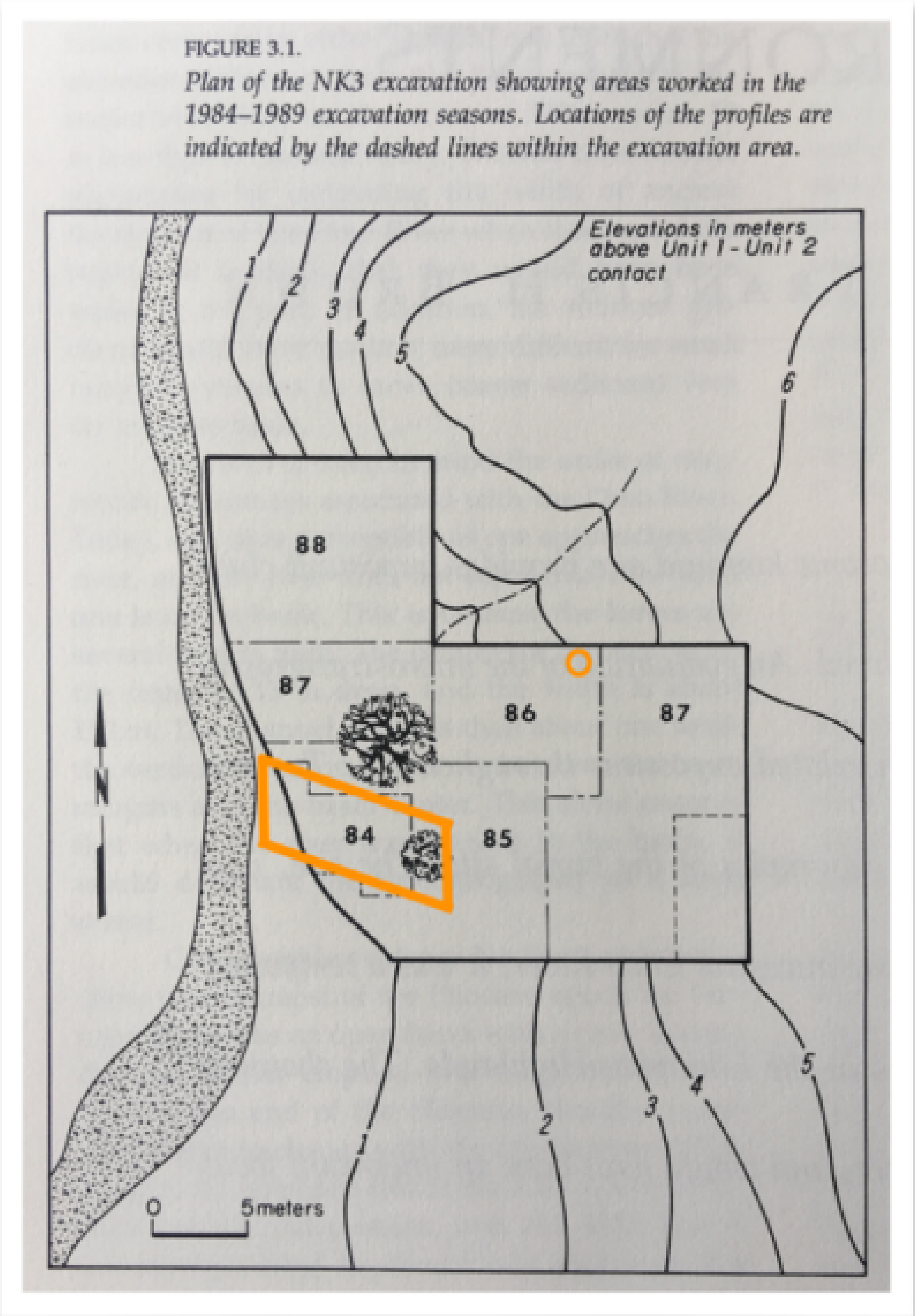


FIGURE 3.1.

Plan of the NK3 excavation showing areas worked in the 1984–1989 excavation seasons. Locations of the profiles are indicated by the dashed lines within the excavation area.

Fig. 8: Figure from (46, p. 22). The area of the orange parallelogram, redrawn from folding Maps 1 and 2, includes all the bones of the skeleton. The orange circle indicates the location of two hand-bones, one foot bone, and one vertebra from another juvenile.

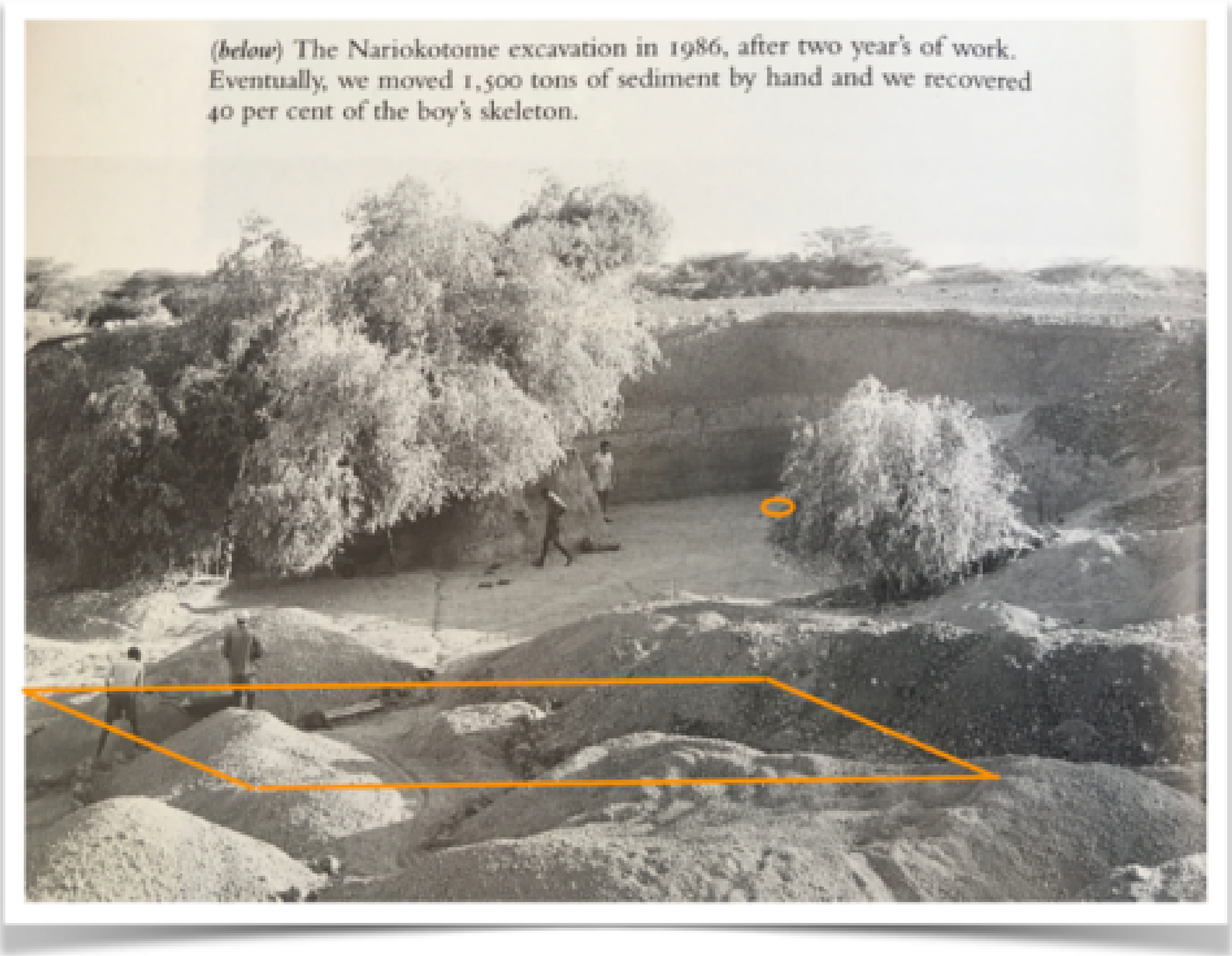


Fig. 9: The piles of rock from excavations in 1986 cover the area where the bones of the skeleton were found in 1984. (Photograph from 7, p.148b), with orange annotations added.

Modern bones are hard and porous and do not feel like fossils. But Walker made the bones heavy and hard, by saturating them in plastic that filled the pores. He wrote: "*The bones are relatively hard, by and large, but a plastic preservative (vinyl acetate solution) was used to make them stronger*." (42, p.434). This process also made it impossible for anyone to later carry out carbon-14 dating, or DNA-analysis, or fluorine testing.

Experts who studied these bones were told that they were 1.5 Ma old. They were not given evidence that might cause doubt. For example, the original teeth were not actually seen by the expert who studied them. Casts of the teeth and jaw had been made in Nairobi, where the originals were kept. Walker and Shipman had this statement from the expert: (7, p. 149.)

> *"They were really nice, sharp casts," she remembered later, "quite beautiful. I could see every tooth on at least one side. There were nice X rays of the mandible. You could see everything."*

Turkana Boy was actually the second *Homo erectus* skeleton that was found. The first was a mature woman, found east of Lake Turkana. Walker and Shipman wrote (7, p.128):

> *Kamoya first noticed the fragments of skull and teeth, which he knew immediately were hominid, in 1973, though it took some years before we unraveled their meaning. They were terribly broken up and they seemed to be scattered over an area roughly the size of a football field. That was bad enough, but the area was liberally sprinkled with other fossils too: crocodiles, turtles, hippos, antelopes, elephants, giant baboons, and giraffes, all in hundreds of pieces. In all, the team collected enough fossils to fill five museum drawers (wooden boxes about two and a half feet long by one and a half feet wide) to a depth of several inches and left piles of very large or otherwise obviously nonhominid bones at the site.*

Like the Turkana Boy, this skeleton also turned out to be defective: all the bones, except the skull, were damaged by excessive bone growth (7, p.128). Walker concluded that this *Homo erectus* woman suffered from Hypervitaminosis A, a sickness that causes bone growth. Walker was impressed that as early as 1.5 Ma years ago, a sick woman was kept alive by the care of others (7, p.134). I suspect that these were human bones from a modern grave, and that the healthy skull bones belonged to a different individual, not the woman with the diseased body. Did these bones come from the Congo? And the three chimpanzee teeth that Kimeu found 30 years later (5, p.108) south of Lake Turkana – did they come from the Congo, where chimpanzees currently live? It seems unlikely that chimpanzees ever lived in the arid region of ancient Lake Turkana.

Together with the bone fragments of the sick *Homo erectus* woman, there were about 40,000 fragments (7, p.128) of crocodiles, turtles, hippos, antelopes, elephants, giant baboons, and giraffes. Maybe these are still in five museum drawers and can be tested. The larger bones were left in piles at the site and not saved – do fossil bones associated with *Homo erectus* have so little value?

It does not seem geologically reasonable that such an assortment of bones and fragments could occur in this way. I think that Kimeu was playing games with gullible scientists by breaking and planting modern bones. Maybe if there had been some kangaroo bones, scientists would have questioned whether any of them really belonged there. Kimeu has been involved in the discovery of some of the world's most important hominin bones, beginning with the famous "Zinj" found by Mary Leakey in Olduvai Gorge in 1959.

Little-Foot (Sterkfontein Cave, South Africa)

In South Africa there is a region of limestone caves with crevasses and small openings to the surface. Animals have fallen in and died. There are bones of large monkeys, hyenas, leopards, and bovids. There may be human bones. Some of the bones were transported by streams in the caves, some were covered by rock falls, and all are cemented by limestone dripstone. Bones are visible in the cave walls, and more can be found by excavating. Cave-fill of this type is chaotic, and dating is uncertain.

A few of the caves are being touted as *The Cradle of Humankind*. They are registered as an UNESCO World Heritage Site. The Sterkfontein Cave is currently the leading paleoanthropological tourist attraction in Africa, with 15 guided tours a day, year round. The most famous fossil from Sterkfontein is the skeleton called Little-Foot.

In the 1920's, miners blasted out some of the limestone. Bones lying outside of the caves were taken away by visitors as souvenirs. In the 1970's, some of these bones were saved at Wits University. In 1994 the paleoanthropologist Ronald J. Clarke found a few human like foot bones in storage, and then in 1997 he found more, including parts of lower legs at the Wits University Medical School (48, video time 1:45). Foot bones of hominins are typically missing. Clarke realized that with these human-like foot bones as a starting point, he could make a more complete *Australopithecus* skeleton than any that had been made before.

Clarke explained the project in a lecture at CARTA, the Center for Academic Research and Training in Anthropogeny, in California. The lecture is available on Youtube. Here is my exact transcript of five minutes of his lecture (49) (video time 13:55-18:54) and three screen shots (Fig. 10):

> *In 1978, miner's rubble such as this was removed from this very deep shaft, which we call the Silberberg Grotto in Sterkfontein Cave. It was taken to the surface and the fossils were developed out of it. They were cleaned out of the rocks and put into bags and boxes.*
>
> *One day in 1994 I was looking through one of these boxes when I found this ankle bone that I recognized as being an* Australopithecus *ankle bone. And this was quite astonishing because there were no other fossils, not even a single tooth or tooth fragment, of an* Australopithecus *from that particular part of the cave.*
>
> *And then I found more. There's the ankle bone that I found among these the other bones that fitted in front of it leading down to the big toe. And what was important about it, as I said, that it showed that it had this slightly divergent big toe. Now at the time I and Philip Tobias published this, and Owen Lovejoy was very skeptical, and said we were, this was patently absurd to say it had a divergent big toe. But now with* Ardipithecus, *he's found that that has an even more divergent big toe.*
>
> *Then in 1997, I found more of the same foot, several more foot bones, and the lower part of a tibia, a shin bone. Not only, here they are put together, and compared to the same region in a modern human foot and lower leg. Not only that, but I found a piece of tibia from the other side, and part of another foot bone from the other side.*
>
> *So I had the lower legs and the feet from the left and the right side. And I said if that's the case, the rest of the skeleton must be down there in the cave. So I gave this piece of tibia to my two assistants Stephen Motsumi and Nkwane Molefe and said go into the cave with torches and see if you can find anywhere that that will fit on. After one and a half days of searching, they found the spot. There's the piece in his hand and there's where it fits on.*
>
> *So we began excavating. There's the slope on which it was found, just in this spot here. We began excavating, and we uncovered the lower legs, up to the knee joints here, and we uncovered the lower thigh bones. This is the radius of a monkey, lying next to it.*
>
> *And when we got up to here there was no more. And we carried on and we carried on up the slope and didn't find any more. And we were in a state of despair. And we said "How can this be? You cannot have two lower legs side by side and not the rest of the skeleton."*

Figure 10: Screen shots of Clarke's lecture on Youtube (49), with his green circles and these spoken comments: "we uncovered the lower legs", "we uncovered the lower thigh bones", "This is the radius of a monkey"

> *And obviously we couldn't make this public. We worked in secrecy. We didn't want to make this public and make fools of ourselves by saying we'd got a complete skeleton, when we'd only got the lower legs. So we kept looking and we kept chiseling away month after month in this solid rock. This is solid very very hard rock.*
>
> *And then I realized that there was a cavity beneath this skeleton. And I remembered this saying of Sherlock Holmes who said. "When you've eliminated the impossible, whatever remains, however improbable, must be the truth." And the impossible was that there could not be any more of the skeleton. That was impossible. It was unthinkable. It had to be there! So the improbable was that it was situated beneath a thick layer of stalagmite.*
>
> *We chiseled through that stalagmite, and we got the rest of the skeleton. Firstly the skull. And these are the stages in revealing the skull. The back of the mandible here and part of the cheekbone. And next to it was the upper arm bone, the humerus. A bit more cleaning and a bit more and then we got this and then this is the final stage of the cleaning. A complete skull with the jaw in articulation and the humerus next to it.*
>
> *We continued up the slope, and to our delight we got the arm and the hand. Here's my hand next to it for comparison, showing you how the fingers are curled across the palm.*

My hypothesis is that Little-Foot skeleton was put together from four different individuals: 1. From Wits University Medical School storage: *Homo sapiens* ankle-bones and foot bones. 2. From the cave: lower legs, knee joints, lower thigh bones, and an arm bone that were all found together. Although the arm bone was in correct position relative to the legs, Clarke could not use it, because it was too long. He did not say the word "arm": it was *"the radius of a monkey"*. 3. From elsewhere in the cave: a skull and arm of suitable length. 4. From a third location in the cave: another arm and a hand.

Clarke gave this lecture in 2010 to professional paleoanthropologists of CARTA. I doubt that anyone asked about the monkey arm bone. Such a question would be uncomfortable for paleoanthropologists. CARTA has decided not to include an aquatic-ape paper (4) on their list of 2807 publications (50). That paper would be uncomfortable for paleoanthropologists to read.

Clarke had the attitude of a successful paleoanthropologist: the fossils that we need must exist, so we will do what we must to get them. *"...that there could not be any more of the skeleton. That was impossible. It was unthinkable. It had to be there!"* He knew that with the foot bones from the medical school they could eventually make a nearly complete skeleton. But it took many months to find appropriate bones. *"We worked in secrecy. We didn't want to make this public and make fools of ourselves by saying we'd got a complete skeleton, when we'd only got the lower legs."*

In 1979, Clarke had helped with the Laetoli footprint layer (his bare feet are seen in my Fig. 3). There, too, they worked in secrecy. Then the layer was covered up, and the secrecy was maintained.

II. CONCLUDING REMARKS

For scientific claims that cannot be repeated or reproduced by impartial scientists, the default hypothesis should be that the claims are incorrect or even possibly falsified. But in paleoanthropology, there seems to be no place for this sort of normal scientific skepticism. It is considered impolite or unprofessional for a paleoanthropologist to suggest that a fossil-find might be a hoax.

I think that one-time fossil finds, especially surface-finds, should be highly suspect.The bone material may be modern, like Piltdown Man, and therefore not too old for DNA analysis or carbon-14 dating. Hominin bones and other fossils from the same sedimentary layers should be fluorine tested, to help demonstrate that the hominin bones actually came from those layers.

The century-old story of human evolution on the savanna is a story. It is like a historical fiction novel, in which details have been invented to make the story more educational, interesting, and convincing to readers. Fossils have been needed to argue against the unscientific belief in creationism. Only a few people have been aware of the false fossil evidence that I have uncovered. Most paleoanthropologists have put doubts aside, to publish papers that advance their careers within the paradigm of the science. Now we have DNA analyses that convincingly prove human evolution, so fossils are no longer needed for that purpose. It is time to actually test all of the claimed hominin fossils.

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