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Cosmological Coincidences and the Anthropic Principle

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Abstract

This paper includes a brief history of Anthropic Principle (AP) basic concepts and formulations. After the Large Number Hypothesis, presentation in Dirac – Eddington's formulation, are discussed some forms of Anthropic Principle (AP): AP in non-restrictive form (weak AP), AP in restrictive form (strong AP), AP and the multi-world interpretation given by Everett. Also here there are presented the analysis and proposals made by other scientists, Joe Rosen and Giancarlo Cavalleri.

Key words: *models of the Universe, cosmological coincidences, Anthropic Principle*

The Cosmological Coincidences. Dirac - Eddington Large Number Hypothesis

The large numbers hypothesis is assumed. This presupposes the existence of some physical parameters (with dimensions or dimensionless) which have an order of magnitude (in usual dimensions) very high with respect to other numbers, and have a well defined physical significance. This hypothesis is applied considering that the Universe is well described by a general relativistic model.

Dirac and Eddington [1, 2, 3, 4] asserted for a stationary model the link between: the number N_1 which is the inverse of the gravitational coupling constant for the proton ($N_1 = hc/Gm_p^2 \cong 10^{40}$), the number N_2 which is the ratio between the radius of the Universe R and the Compton wavelength for proton λ_p ($N_2 = R/(h/m_p c) \cong 10^{40}$) and N_3 which is the total number of protons ($N_3 = M/m_p = Rc^2/Gm_p \cong 10^{80}$; M is the mass of the Universe and m_p is the mass of the proton). The relation between these numbers is

$$N_1 = N_2 = N_3^{1/2}. \tag{1}$$

In the non-stationary model, where $R = c/H$ (H is the Hubble constant), the hypothesis is that at any moment during the Universe evolution, the numbers obtained from physical fundamental constant are linked to each other through simple relationships. In the expanding universe model, the radius of the Universe is not constant, so the relationship between large numbers is changing in time. Therefore, it is only a coincidence that these numbers are linked through a simple relationship just now, when they are experimentally measured [2, 4]. Taking into account this

point, Dirac considered, in order to preserve his hypothesis, that the "fundamental constants" are not *stricto sensu* constants but time dependent in such a way that the large number hypothesis is maintained.

Dicke used the Dirac-Eddington assumption considering a non stationary model. In this case using the theory developed by Dicke - Sciama [5, 6] about inertia (i.e. the Mach principle) the result is that N_1 and N_2 is dependent. From the fundamental law of mechanics: $\vec{a} \equiv \mathrm{d}^2\vec{r}/\mathrm{d}t^2 = \vec{F}/m$, and the Mach - Sciama hypothesis according to which the force $\vec{F}$ is the sum of forces with which the Universe acts on the particle $\vec{F} = \vec{a}\int_0^R G(m\mathrm{d}m/rc^2)$, with $\mathrm{d}m = \rho(4\pi r^2\mathrm{d}r) = nm_p((4\pi r^2\mathrm{d}r)$ and n is the protons density, we obtain the expression of inertial mass:

$$m_i = mm_p\left(\frac{4\pi R^3 n}{3}\right)\left(\frac{G}{Rc^2}\right). \tag{2}$$

If $N_3 = 4\pi R_3 n/3$, we get from eq. (2)

$$m_i = mm_p\left(\frac{N_3 G}{Rc^2}\right). \tag{3}$$

Using the principle of equivalence, $m_i = m$, in eq. (3) gives:

$$N_3 = \left(\frac{Rc^2}{Gm_p}\right) \text{ or } N_3 = \left(\frac{hc}{Gm_p^2}\right)\left(\frac{R}{h/(m_p c)}\right) = N_1 N_2. \tag{4}$$

Dicke considers that the relationship between N_1, N_2 and N_3 is valid only for the present time, i.e. time when the condition for the existence of an intelligent observer is accomplished in the Universe. It is considered that such a relationship characterizes any universe in which passive observers have been developed. Heavy elements are main constitutive elements of the physical and biotic part of the observers. In order to have these elements, the stars of the second generations must be formed, and therefore, the age of Universe must be at least equal to the age of the oldest star clusters and obtained from the theory of stellar evolution applied to the representative stars of the globular clasters.

The Anthropic Conjecture - "The Anthropic Principle"

Brandon Carter is the first (1973) to have used the phrase "Anthropic principle". B. Carter, refering to the situation of Man (as observer) in Universe, stated that: "Although our situation is not necessarily central, it is inevitably privileged to some extent" [7, 8, 9].

The consequences of the principle are illustrations of three types of theoretical predictions:

1. the traditional type where the AP is not used;
2. the type a weak AP (WAP);
3. the type with strong AP (SAP).

The traditional types of predictions use only physical models and observations, i.e. they do not refer to any active observers. Examples: the estimation of the average mass of star M, in the main sequence and, as a consequence, the prediction of the number of protons in the star $N = M/m_p$. This estimation is in accordance with a classical model of condensation starting from a gas cloud. The condensation becomes stable to fragmentation if the gravitational

attraction is balanced by the gas pressure [10]. The result is that the star mass has the same order of magnitude as the inverse of the interaction constant.

$$M \propto \frac{hc}{Gm_p^2} \propto m_p^{-2} \text{ and } N \propto \frac{M}{m_p} \propto m_p^{-3} = 10^{60}. \tag{5}$$

The Weak Anthropic Principle (WAP) defines the existence of compulsory and systematic link between the constants of Physics (including the cosmological constants) and the places (i.e. planets, stars of the second generation) where the life is developing (i.e. a characteristics of passive observers, too).

Some examples illustrate this conjecture. The universe age based on its expansion at a uniform rate is

$$\tau \cong \frac{r}{\upsilon} = \frac{1}{H_0}, \tag{6}$$

where r is the distance of a far galaxy having recessive speed υ and H_0 is the Hubble constant (actually H_0 change with t: it is constant with respect to τ at a fixed time t). The link with WAP consists of considering the age of the Universe as the mean life time of a star in the main sequence. For $t << \tau$ and for $t >> \tau$ respectively, in the Universe are few stars of the kind which allows the human being manifestation. If $t >> \tau$, the stars are old and have small energy. When $t << \tau$, the stars are young, i.e. their composition consists only of atomic hydrogen and cosmological helium [11, 12].

The Strong Anthropic Principle (SAP) requires the Universe (and its characteristic parameters) to be as such as to allow for the existence of passive observers. An example showing this conjecture is the link between cosmological parameters η and k ($\eta = n/T^3, k = K/T^2$) and the age of the Universe τ

$$\tau \propto \eta m_p k^{-3/2}, \tag{7}$$

where n is the baryons concentration, K is the Universe curvature and T is the temperature. Because $\tau \geq am_p^{-3}$ it is:

$$k \leq \left(\frac{\eta}{m_p}\right)^{1/3} m_p^3 \tag{8}$$

which is restrictive relationship between microscopic and cosmic parameters.

Taking into account these considerations the formulation of the SAP is "From the wholeness of universe (models of universe) compatible with a set of initial conditions and a set of fundamental constants, only those are real which allow for the manifestation of observers".

Many World Interpretation

Hugt Everett [8, 13] gives an original interpretation of quantum mechanics (QM) named "Many world interpretations". The features of this interpretation are:

1. in QM the microscopic system (particle/quanton) is described by a multidimensional wave function Ψ. The $|\Psi|^2$ gives the density of probability for particle localization;
2. because the probability density $\rho(r) \propto |\Psi|^2$ is non zero in a number of points in the space, it is not compatible with the particle localization in a point by measurement, i.e. in the point where the measurement is done;

3. in order to make points a) and b) compatible the author considers that the particle exists simultaneously in a number of worlds (universes) where it is well localized, i.e. in a deterministic way. By a measurement process only a single universe is selected from the set.

Using this hypothesis Carter considers the possibility of existence of infinite worlds (universes), the real ones being those that bring about observers which can make measurements. A possible interpretation of quantum determinism defined by the wave function Ψ is: the wave function is not giving the probability of localizing particle in various points of the Universe but, the probability with which the particle exists, in a deterministic way, in different possible universes, i.e. the probability of being real.

The Complexity of the Anthropic Principle

Following this idea Joe Rosen [14] assumed that: the existence of an intelligent being can be used to explain why the Universe and the laws of Physics are as they are. Therefore, AP is opposed to the deductive method which entirely explains as an outcome of the Universe evolution which is in agreement with the laws of Physics. AP is not approved by those physicists who learned to think that the evolution of phenomena is independent of the observers. The research developments of Physics in micro-world showed the limits of this view. The autonomy from the observer is false. It is revealed only in macroscopic experiments, observations and theoretical concepts. The findings of quantum phenomena and their theoretical background developed in QM showed without any doubt that the measuring process is not experiment (device) independent. Therefore, it is not independent of the observer.

The quantum mechanics is the theory of the physical object interacting with measuring device. The physical device is developed particularly for a given physical phenomenon, i.e. it is a natural system or artefact convenient for the investigation of desired process. As a consequence, the observer is included in the experimental action, i.e. the observer is involved in this interaction and in the relevant theory. Much more, there is a direct interaction between subject and object. A more general theory than quantum mechanics must include a description of the interaction between subject and object mediated by the instrument.

AP is profitable *pro gnoside,* finding after a survey of theoretical, experimental and interpretative data the present time status of universe required adjustments with respect to universe state after the Big Bang and/or to laws of Physics governing the universe development after the outburst. This adjustment cannot be explained in a conventional way. Examples: a) large number coincidence, b) large scale isotropy, c) the values of expansion rate very close to the critical value [7].

This concept presumes that:

- AP is the most important principle of scientific knowledge;
- Physics is the science dealing with ordering the reproducible phenomena: objective and reproducible are almost synonymous in science;
- the competitive criterion between various theories is their predictable character;
- metaphysics deals with unpredictable phenomena and/or phenomena which cannot be ordered. The unique (singular) phenomena, i.e. that which are produced only once are non-reproducible, non-ordered and non-predictable.

Therefore, AP is very closely linked to the holistic (wholeness) concept. According to this concept the whole universe is much more than the sum of its components. From a physical point of view it is necessary to find an internal explanation of the wholeness of all things, including our ideas. Actually, the most certain phenomenon is our existence. The essential physical

explanation is the one grounded, i.e. motivated, the certainty of the existence of intelligent beings in the universe. Therefore, AP is validated by ontological allegation.

Physics answers the question: Why do the laws of Physics exist? By the assertion: the laws of Physics exist because the physical phenomena are ordered, reproducible and predictable. This answer must be logically related with definition of AP.

AP answers the question: Why are the laws as they are? With the assertion: the laws are as they are because we are physicists. This means that laws exist because observers exist, thing that measures, correlates and interprets measurements in scientific way.

The stability of the entities/systems, of the human beings and human species is ensured by the physical, biological and psychological complexity of these "aggregates". As a consequence of their high degree of hierarchy/non-entropy these structures (*holos*) are not definitely affected by the disorders of the cosmological universe.

AP involves *ipso facto* the existence of human beings and of the Homo species as a total (whole) in order that these complex living entities, i.e. individuals and species, survive without any severe damaging of their unity. This means that *in essentiam* the entities have an (*quasi*) established individual and social memory. It is also assumed that non-reproducible phenomena are present on human scale. They are considered (named) abnormal events, transient phenomena. Seldom their appearance has (might have) an essential character when they influence the integrity of the considered living systems only, in a small degree.

J. Rosen considers metaphysics in all its complexity as an outlook and an activity of knowledge. A thinker has ways of approach to metaphysics [15, 16, 17, 18, 19, 20]:

1. the realistic approach considering the laws of Physics independent of the observer. Most physicists share this approach;
2. the idealistic approach considering the laws of Physics dependent on the observer. A small part of physicists support this approach.

Cavalleri [21] based his considerations on the reason that the finite age of the physical universe involves creation and the existence of the creator. Creation is defined as the passage from the virtual non-physical structure (with other laws than that know) to substance (particle, material observers). A spiritual existence definitely different from the physical existence oversees the creation.

The proposed model of the universe is funded on the frame of the stochastic physics [22, 23, 24, 25, 26, 27, 28]. The cosmological universe is grounded on the stochastic model of gravity considered as the gradient of the electromagnetic ether. This model explains: the accelerated expansion of the Universe, the existence of spherical macro-cells with the clusters of galaxies concentrated on the walls, the finite age of the physical universe, etc. Therefore the idea named AP is *verum tamen* very complex. It is expressed in a couple of live/dynamic statements which are polyvalent, linked, complementary, and multi-layered. We consider it fertile and with possibilities of development.

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Coincidenţe Cosmologice şi Principiul Antropic

Rezumat

Lucrarea conţine un scurt istoric al fundamentării şi formulărilor Principiului Antropic. După o prezentare a ipotezei numerelor mari formulată de Dirac şi Eddington, sunt prezentate diferite forme ale principiului Antropic (PA): PA sub forma nerestrictivă (weak AP), PA sub forma restrictivă (strong AP), PA şi interpretarea în mai multe lumi a lui Everett. Sunt prezentate, de asemenea, analizele şi propunerile făcute de alţi cercetători precum Joe Rosen şi Giancarlo Cavalleri.