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Hierarchical Ranks of the Cosmological Superstring Scenario

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Abstract

In two earlier papers [3, 4], it was indicated how certain properties of our scenario [6] could assist to explain the existence of dark matter and energy. Here the scenario with the interplay of the various hierarchical ranks shall be compared with standard knowledge and opinion.

Keywords: Astronomical hierarchy; Superstring scenario

1. Introduction

Our scenario [6] was originally aimed to understand the observed hierarchy of astronomical objects. As a by-product we obtained big amounts of energy radiated away by gravitational waves. At that time the latter were not yet detected. Today, it turns out that this opens a possibility to understand "dark matter" and "dark energy" [3, 4].

2. Principles

It is assumed that the universe starts with an especially strong "fluctuation" in form of a few bosonic macroscopic superstrings with Mass $M \approx 10^{18}\ M_{\odot}$ (a mild extrapolation of the largest observed structures) and an angular momentum J derived from the observed *(J, M)*-relation [2] for lower hierarchical rank objects

$$J \approx \kappa \cdot M^2. \tag{1}$$

We prefer the empirical value $\kappa \approx 1000\, G/c$, which in turn leads to a string tension

$$\mu \approx \frac{c}{4\pi\kappa}; \qquad \mu \approx 8 \cdot 10^{-5}\ \frac{c^2}{G}\ ; \tag{2}$$

(see equ. (3.5) of [6]).
The string of maximum angular momentum for given mass or minimum mass for given angular momentum is named yrast string in analogy to the use of "yrast" in nuclear physics. For given J, the difference between the maximum total mass and the minimal mass is given by

$$M - \bar{M} = \left(1 - \frac{2}{\pi}\right) M \approx 0.36\, M\, ; \tag{3}$$

(see equ. (3.18) of [6]).
The common interpretation of supernovae Ia data is a constant "dark mass" fraction and a – recently found variable – "dark energy" which acts as acceleration. Here we propose that both are of the same nature, namely energy or mass equivalent of gravitational waves, whereby the redshift of those leads to diminishing gravitational attraction. The empirical evidence of special supernovae Ia with the corrections implied is – in our view – not strong enough to exclude this possibility, see also the results of [7].

3. Time scales

The important time scales for the existence and evolution of an yrast superstring are the following:

a) The rotation time

$$\tau_{rot} = \frac{2}{3}\,\frac{M}{\mu c}\ ; \tag{4}$$

(see equ.s (3.13) and (3.14) of [6]).

b) The shortest signal time along the yrast string, that is, the shortest time for a disturbation to travel along the string, is of course of the same order of magnitude

$$\tau_t = \frac{1}{\pi}\,\frac{M}{\mu c}\, ; \tag{5}$$

(see equ.5.8 of [6]).

c) The time scale for gravitational radiation is about

$$\tau_g \approx \frac{Mc}{100G\mu^2} \approx 30\frac{M}{\mu c} \tag{6}$$

(see equ.s (5.4) and (5.5) of [6]).

Note that τ_g is about 10^2 larger than τ_t and about 50 larger than τ_{rot} .

d) Among the above mentioned quantities, τ_{rot} , is an upper limit and τ_g a lower limit for the time in which the string decays in fragments, that is, strings of lower rank. As a preliminary guess, we will adopt the geometric mean of the two bounds

$$\tau_f \approx \sqrt{\tau_{rot}\,\tau_g} \approx 5\frac{M}{\mu c} \tag{7}$$

The assumption $\tau_f \approx \tau_g$ of [4] is revoked!

e) So far it was assumed that after the end of the gravitational radiation time τ_g a period starts in which the string fragments expand due to their large kinetic energy. This time scale is usually named in textbooks "free fall time", hence this terminus was used in [6]. Therefore we keep it here, although free throw time would be more adequate in the present situation. It was found in [6] equ. (6.1) that the fragments expand towards a presumably flat object with a characteristic radius *R* (about the 10^3 fold of the string length)

$$R = \frac{50}{3\pi}\kappa^2\,\frac{M}{G} = \frac{50}{48\,\pi^3}\,\frac{c^2}{G\mu^2}\,M = 8\,\cdot\,10^{11}\,\frac{M}{M_\odot}\text{ cm}\;; \tag{8}$$

with the afore mentioned value of κ.

With this *R* value one obtains the free fall or throw time as

$$\tau_{ff} = \frac{\pi}{2\sqrt{2}}\sqrt{\frac{R^3}{GM}} = \frac{R/AU}{2^{5/2}}\sqrt{\frac{R/AU}{M/M_\odot}}\text{years}\;; \tag{9}$$

(AU = astronomical unit = $1.5 \cdot 10^{13}$ cm
$M_\odot$ = solar mass = $2 \cdot 10^{33}$g
year = $3 \cdot 10^7$ seconds).

4. The evolution

The essential numbers for the different ranks of the astronomical hierarchy are repeated in Table 1, containing also the new guess for the fragmentation time from equ. (7).

Starting from the existence and evolution of the assumed highest rank = 7, the acting together of the various ranks appears intricate, because the higher ranks start earlier but finish later than the lower ranks. It becomes somewhat easier by considering the very different orders of magnitude.

First of all, it should be noted that the classical beginning (as a 'fireball'), is not the "zero-point of time" within the present scenario. In contrast, probably one can identify the end of the last fragmentation (when normal elementary particles are produced) with the 'fireball'era.

In passing by, it should be noted why the highest rank was just selected as it is. Of course, a finite number of higher ranks would be likewise compatible with our scheme. But Lindsay Tassie had sympathy for an infinite number, and since this implies a begin at a time of minus ∞, I could not see how to reach 'today'within a finite time. Therefore the highest rank was chosen just one factor 10 beyond the estimates for the largest observed entities which start to emerge.

As a recent such finding [1] should be quoted. For the structure 'Quipu' the authors estimate a mass of $2.4 \cdot 10^{17}\, M_{\odot}$ and an extension of 0.5 Mpc. According to the present scenario it should be possible to find a slight gradient in radial velocities along the object – if the velocities are precise enough and if, by chance, the residual rotation has a component perpendicular to the celestial plane.

Our rank 7 objects radiate right from the begin gravitational waves. After ~ $10^{10.4}$ years fragmentation into rank 6 strings starts. Those fragments have nearly the macroscopic velocities as before and continue to radiate for $9 \cdot 10^{10.4}$ years – more than the customary age of the universe. This highest rank radiation diminishes the inward acceleration of the universe which is our interpretation of dark energy [4]. Already after the first $10^{10.4}$ years the next generation superstrings radiate at higher frequency and fragment after $10^{5.9}$ years – very soon for cosmological times. Their gravitational radiation is finished $10^{6.9}$ years after their origin. The further generations evolve faster and faster, so that practically (and within the poor accuracy of our estimates) $10^{10.4}$ years after our begin the lowest rank fragmentation is reached, and thereby a plausible equivalent to the 'fireball' or 'big bang'. In our case it is a multitude of 'small bangs' of the lowest hierarchical rank.

5. Conclusions

The main advantages of our scenario are:

(a) It does not require a new, so far undetected particle.

(b) Dark matter and dark energy could be of the same nature, the first being only a (constant) part of the split-up of energy/mass forced by the standard model.

(c) Gravitational waves with such a low frequency could not have been registered until now and in the next future.

(d) In addition, the hierarchy of astronomical objects is constructed and especially, the observed early appearance of galaxies is in agreement with the time scales of the scenario. Also, the highest ranks are not yet virialized – in agreement with their appearance.

(e) As we have shown earlier [5], our scenario provides an explanation of the observed upper limit of the mass ratio of central black holes to their host galaxies, which is about $\frac{G}{\kappa \cdot c} \approx 10^{-3}$.

Table 1

Rank	Present astronomical objects	Decadic logarithm of				
		$M/M_\odot$	τ_r/yr	τ_f/yr	τ_g/yr	τ_{ff}/yr
7	Largest structures	18	9.3	10.4	11.4	15.3
6	Superclusters, rich clusters of galaxies	13.5	4.8	5.9	6.9	10.8
5	Galaxies	9	0.3	1.4	2.4	6.3
4	Stellar clusters	4.5	–4.2	–3.1	–2.1	1.8
3	Double stars and stars with planetary systems	0	–8.7	–7.6	–6.6	–2.7
2	Planet-satellite-systems	–4.5	–13.2	–12.1	–11.1	–7.2
1	Moons, asteroids, comets	–9	–17.7	–16.6	–15.6	–11.7

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