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Research Article

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Redshifting Cosmic Photons in a Non-Expanding Universe

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Abstract

Cosmologists present clear observational evidences that stellar objects like stars and galaxies do carry out pronounced proper motions, and the question may be raising how these peculiar motions might evolve in time. In this article we study these peculiar motions of single objects, independent whether of microscopic or macroscopic nature, embedded in a globally homogeneous, static, massive universe with inherent gravity.

Aims: *We show that these objects at their motions, even in a homogeneous universe around them, are permanently subject to net gravitational forces due to the fact that in a post-Newtonian relativistic treatment the sources of cosmic masses are seen under retarded positions, retarded by the time it takes to communicate via gravitons the positions of these masses to the moving object.*

Methods: *This "aberrational" recognition of massive source points on the one hand leads to a braking power permanently decelerating the peculiar motion of any cosmic object, on the other hand it also effects the wave lengths of all photons freely propagating through cosmic space under the action of cosmic gravity. Photons, even in a static homogeneous universe, undergo a permanent red-shifting, since working permanently against a net gravitational force from the direction opposite to the photon's propagation direction.*

Results: *We do show that the observationally confirmed redshifts of photons from distant galaxies under the new auspices appear as a pure measure of the distance which the photons passed from its galactic emitter to us. In this view redshifts have nothing to do with the Hubble dynamics of the universe and its emitters. Since, however, the existence of Hubble-induced redshifts cannot be excluded, we also look into a combination of both, gravitationally induced redshifts zg and Hubble-induced redshifts zH. We show that gravitationally induced redshifts zg of course also appear in an expanding universe, and it can be demonstrated that for instance in a "coasting universe" with a constant expansion rate $\dot{R}$ and with R α t both these redshifts zg and zH would lead to similar results.*

Keywords: Dark Energy, High-Redshift

Introduction

Since the time of Hubble's famous paper in 1929 we are prepared to believe that we are living in an expanding universe, since 1998 even in a universe with accelerated expansion [1-4]. One of the strongest supports for the existence of a cosmological vacuum energy density Λ is given by the supernovae SN-Ia luminosities as function of the redshift z of the host galaxies, since they, according to their advocates, seem to indicate an accelerated expansion of the universe in more recent cosmic times which otherwise would stay unexplained. All these big cosmological claims thereby are built on the assumption that the photon redshifts of galactic radiations are due to the relative motions of the distant stellar or galactic emitters and thus indicators of the expansion dynamics of our universe. The latter, in case of a homogeneous isotropic universe, leads to the well-known Friedman-Lemaître cosmological models which are the basis of the modern ΛCDM - cosmologies [5].

Nowadays, however, there appear serious reasons to doubt that on the basis of such models the astrophysical truth of the universe can really and well enough be understood. Already in the years following 1989 it had been recognized that even at largest distances pronounced mass in homogeneitie exist in the universe, like e.g. in the direction towards the Hydra-Centaurus or the Pavo-Indus super-cluster systems where the general Hubble expansion of the universe, perhaps due to the action of a local cosmic gravitational attractor, appears to be strongly perturbed, - with galaxies on our side of the attractor moving faster, galaxies beyond this attractor moving slower than the general Hubble expansion would predict [6, 7].

This phenomenon of a non-isotropic Hubble expansion has most recently again been confirmed by newly obtained redshift data of motions of the most distant galaxies and clusters which seem to show evidences for the anisotropy of cosmic acceleration [8]. This anisotropy in view of the authors either can be interpreted as due to certain cosmic mass voids or bulges perturbing the normal Hubble flow, - or by the unconsidered fact that we in fact are not "co-moving cosmic observers" (i.e. our system of observations is not a cosmic rest frame system), but we are moving with a strongly pronounced peculiar velocity of the order of 370 km/s tilted relative to the idealized, general Hubble flow.

This controversial finding was also most recently confirmed by observations made by Migkas et al. (2020) using the well approved relation between X-ray luminosities LX and temperatures T of the emitting cluster gas in X -ray galaxy clusters [9]. These authors specifically investigate anisotropies associated with this otherwise and in general well approved LX− T− relation and find, based on a sample of 313 clusters that the behavior of the LX− T−relation heavily depends on the direction of the sky. These results thus demonstrate that X-ray studies assuming perfect cosmic isotropy in the properties of galaxy clusters and their scaling relations produce strongly misleading conclusions. Whether these anisotropies are due to anisotropies in the Hubble expansion or due to anisotropic properties of X-ray clusters is not yet clear from this study.

Nevertheless, the above mentioned studies might provide the astronomical community with certain doubts whether distances of X-ray emitting clusters can reliably well be measured by means of cluster redshifts when these are solely ascribed to the general Hubble expansion dynamics of the universe and its objects. This then might perhaps open up some encouragement to present alternative interpretations for photon redshifts not connected with the general Hubble expansion, but simply with the distance a photon since its emission had freely to propagate in cosmic space before it is registered. In the following paper we shall present an investigation of photons moving in the effective, collective gravitational field of the surrounding cosmic masses and show that thereby they undergo a permanent red-shifting the longer they propagate through cosmic space.

Cosmic Gravitational Fields Acting On Peculiar Mass Motions Relative to the Local Standard of Rest

We start considering a single mass m embedded in a homogeneous mass distribution of an infinite universe and study the question what happens, if this mass carries out a peculiar motion with a certain velocity U with respect to the local standard of rest of the ambient universe? How does this velocity U behave in time? In case this peculiar motion changes in time, say by an amount $b = dU/dt$, a local force must be recognizable which is responsible for causing this acceleration b. *It* may be justified to exclude any cosmic forces of viscous or electromagnetic nature. Consequently, the remaining force causing an effective deceleration can only be due the net, collective gravitational pull of all the cosmic masses surrounding this peculiar mass m.

One should thus be able to quantify a locally acting force even in a homogeneous universe. Sitting in the center of a system of homogeneous mass shells hence a net gravitational force of the ambient massive universe should be identifiable influencing this peculiar mass m in its peculiar motion U. To study this problem more quantitatively one could follow an approach already used by Thirring (1918) or Soergel-Fabricius (1960) studying centrifugal forces that act on a central mass rotating with respect to the rest of a homogeneous massive universe [10]. The idea of these authors was to represent the mass of the universe as a system of congruent spherical mass shells. While Thirring (1918) or later Fahr and Zoennchen (2006) along this way had approached the problem of a rotating central mass to study the origin of cosmic centrifugal forces, we here for our purpose have to solve the problem connected with a central mass m in peculiar motion U with respect to the rest of the universe [11]. Question: Would this motion persist or would it be changed in time by the cosmic masses in an otherwise homogeneous universe around?

To answer this question on the basis of post-Newtonian SRT gravity, taking into account the finite propagation velocity of gravitons as carriers of the field, one has to realize that due to the finite propagation speed of gravitons, communicating the surrounding mass constellations to the position of the moving central mass m with their propagation velocity, i.e. the velocity of light c, then the individual mass and field sources δM_U of the surrounding gravity field of the universe are all effectively acting from "apparently retarded" positions when judged from the position of the moving central mass (a phenomenon analogous to stars appearing at positions shifted from their true positions in the sky due to the motion of the observer: i.e. the so-called and well known "stellar aberration phenomenon"!.

That means, if the mass element δM_U on a spherical mass shell is gravitationally seen by a central object at rest under an angle θ, it instead acts effectively not from this direction, but from an apparently different direction with an aberration angle θ' viewed from the central object, as soon as the latter moves with the velocity $\boldsymbol{U}$ with respect to the local standard of rest. According to SRT relations these two angles θ and θ' are connected by the following STR Doppler relation [12]:

$$\cos \theta' = \frac{cos\theta + ß}{1 + ßcos\theta} \qquad 1$$

where β is given by $\beta = U/c$.

Assuming a homogeneous and constant cosmic mass distribution with an average density of $\rho = \rho U$, then one arrives at the following effective gravitational force $K_{\|} = (K_U . U)/U$, aligned with the direction of the peculiar velocity U, acting in the direction **(-U)** on the central mass m, due to the net gravitational pull of the surrounding cosmic mass assembly of the universe:

$$K_{\|} = -\int_0^{R_{\max}} \rho_U R_U^2 \frac{Gm}{R_U^2} dR_U \int_0^{\pi} \cos\theta' \sin\theta d\theta \int_0^{2\pi} d\phi \quad 2$$

evidently leading to

$$K_{\|} = -2\pi\rho_U Gm \int_0^{R_{\max}} dR_U \int_0^{\pi} \cos\theta' \sin\theta d\theta \quad 3$$

and further to

$$K_{\|} = -2\pi\rho_U GmR_{\max} \int_0^{\pi} \cos\theta' \sin\theta d\theta \quad 4$$

The latter expression reveals that $K\|$ only then can be a finite quantity, if the product ρ_U Rmax stays finite, requiring in an infinite universe, that the average density should be either strictly zero or proportional to $\rho_U \sim R^{-1}{}_{max}$.

On the other hand, with the average cosmic density ρ_U, expressed through the total mass M_U for the Euclidean universe, given by $\rho_U = (3/4\pi)M_U/R^3{}_{max}$, with R_{max} denoting the radius of the matter-filled universe, this leads to the following expression:

$$K_{\|} = -\frac{3}{2}Gm\frac{M_U}{R_{\max}^2}\int_0^{\pi} \frac{\cos\theta + ß}{1 + ß\ cos\theta} \cdot \sin\theta d\theta \quad 5$$

To obtain a finite quantity for $K\|$, would then obviously require $M_U \sim R^2\backslash_{max}$.

By substituting now, the coordinate θ *by* $x = \cos\theta$ one then obtains the expression:

$$K_{\|} = \frac{3}{2}Gm\frac{M_U}{R_{\max}^2}\int_1^{-1} \frac{x + ß}{1 + ß\ x} \cdot dx \quad 6$$

or:

$$K_{\|} = \frac{3}{2}Gm\frac{M_U}{R_{\max}^2}\int_1^{-1} [\frac{x}{1 + ß\ x} + \frac{ß}{1 + ßx}] \cdot dx \quad 7$$

which then can be further integrated to yield:

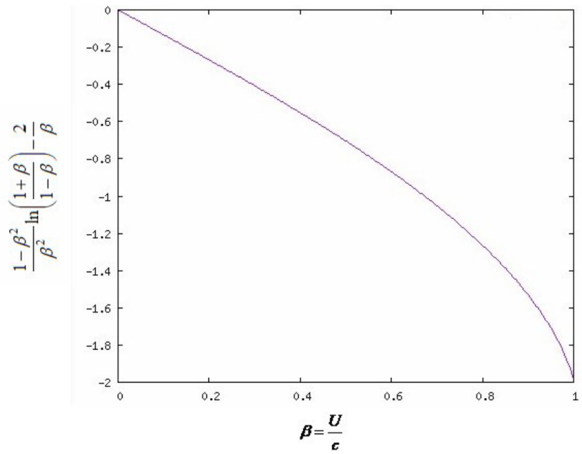

Figure 1: The cosmic braking power $K_{\|}$ as function of $\beta = U/_c$ decelerating peculiar motions U of stars or galaxies in a homogeneous universe with a constant value of $\rho_U R_{max}$, say characterizing our actual universe by this quantity.

$$K_{\|} = \frac{3}{2}Gm\frac{M_U}{R_{\max}^2}[\frac{1}{ß^2}\int_{1+ß}^{1-ß} \frac{(y-1)dy}{y} + [\ln(1-ß) - \ln(1+ß)]] \quad 8$$

or:

$$K_{\|} = \frac{3}{2}Gm\frac{M_U}{R_{\max}^2}[\frac{1}{ß^2}\int_{+ß}^{-ß} \frac{zdz}{z+1} + \ln\frac{1-ß}{1+ß}] \quad 9$$

This finally then leads to the following expression:

$$K_{\|}(ß) = \frac{3}{2}Gm\frac{M_U}{R_{\max}^2}[\frac{1-ß^2}{ß^2}\ln[\frac{1+ß}{1-ß}) - \frac{2}{ß}] \quad 10$$

In Figure 1 this force $K\|\ (\beta)$ is shown as function of β, showing at first that $K\|\ (\beta)$ vanishes for $\beta \to 0$, i.e. for the case of a vanishing peculiar velocity U. This, however, is a natural and evident requirement, since for an object at rest, the masses of the homogeneous universe around, due to symmetry reasons, should not induce any net vectorial force.

In an infinite universe $R_{max} \to \infty$ with finite density ρ_U the expression for $K\|\ (\beta)$ consequently can only be finite, if this density in such a universe scales with $\rho_U \sim 1/_{Rmax}$. Otherwise, if such a physical relation is not evident or somehow supported by any physics behind, the density in such a universe should then simply vanish; i.e.$\rho_U = 0$!, as it does for instance in a scale-invariant hierarchically structured universe with vanishing or negative curvature $k = 0, k = -1$ [13, 14].

Redshifting of Cosmic Photons in A Static, Homogeneous Universe

In the section above the asymmetric action of cosmic mass distributions on a single mass m with a peculiar motion by a velocity U with respect to the rest of the universe (i.e. relative to the local standard of rest!) was considered which lead to the following expression:

$$K_{\|}(ß) = \frac{3}{2}Gm\frac{M_U}{R_{\max}^2}[\frac{1-ß^2}{ß^2}\ln[\frac{1+ß}{1-ß}) - \frac{2}{ß}] \quad 11$$

In principle this force as well acts on sub relativistic masses like e.g. stars as well as on relativistic masses like cosmic ray particles or photons. As can be seen in Figure 1, the expression *K*‖ *(β)* of course can also be used and is valid for the case $U \to c$, i.e. $ß \to 1$, i.e. for relativistic particles like cosmic rays or photons moving with the velocity of light $U = c$. In the following part of the paper we now especially want to evaluate the above expression just for photons, and thus for cases ß=1. One then obtains from the above formula the following result:

$$K_{\|}(ß = 1) = \frac{3}{2}Gm\frac{M_U}{R_{\max}^2} \cdot [-2] \quad 12$$

Since we talk about photons now, one can interpret the upper equation as stating that the temporal change of the momentum of the photon, i.e. $dp_\nu /dt = d/dt(h\nu/c)$, is given as a function of the mass of the photon, i.e. $m = h\nu/c^2$, through the relation:

$$\frac{h}{c}\frac{d\nu}{dt} = -3G\frac{h\nu}{c^2}\frac{M_U}{R_{\max}^2} \quad 13$$

or describing the temporal change of the photon frequency v by

$$\frac{d\nu}{dt} = -3G\frac{\nu}{c}\frac{M_U}{R_{\max}^2} \quad 14$$

yielding the following solution for the cosmic frequency shift of cosmic photons during the course of cosmic time $(t - te)$ between the moment of emission t_e till the present time t:

$$\nu(t) = v(t_e)\exp[-3G\frac{M_U}{cR_{\max}^2}(t - t_e)] \quad 15$$

Interestingly enough, this result must be interpreted as representing a photon redshift which is caused by the asymmetric action of cosmic gravity during the mere photon passage over the time $(t - te)$ or the photon travel distance $D = c(t - t_e)$ since the time t_e of its emission till the present time t counted in units of the cosmic world time. Expressing the frequency v by the photon wavelength λ through $v = c/\lambda$ and introducing the photon redshift $z = z_g$ due to the action of the cosmic gravity through $z = z_g = \lambda(t)/\lambda_0(t_e) - 1$, then the upper expression can also be rewritten in the following form:

$$1 + z_g = \exp[3G\frac{M_U D}{c^2 R_{\max}^2}] \quad 16$$

expressing the redshift-dependence of photons on the distance $D = c(t - t_e)$ traveled by the photon since the event t_e of its emission. As one can see, in this expression again the same crucial cosmic parameter (M_U/R^2_{max}) appears, as it appeared already for the sub-relativistic case.

This cosmic gravity-induced redshift z_g, in contrast to the well known Hubble redshift z_H , would thus be a pure indicator of the distance D which the photon has covered since its emission at the cosmic source, and it would not have anything to do with the cosmic expansion dynamics of the universe or, connected with that, the Hubble constant $H = \dot{R}/R$ and its cosmic time-history. Galactic photon redshifts z_g, if cosmic gravity is their only physical reason, would thus not have to be ascribed to the Hubble recession velocity of the photon emitting galaxies, i.e. the cosmic expansion dynamics, but simply to the gravity action of cosmic masses distributed in the universe.

In the diagram below one can for instance display these redshifts z_g as a pure function of the distance D which the photons have covered from their origin - and e.g. compare them with those for a coasting universe as done by Casado (2020). Only for small distances D this redshift z_g would linearly depend on the distance D , while for larger values of D an exponential dependence would have to be expected. The linear range would, however, interestingly enough correspond to the claim made by Casado (2020) that within a range of redshifts $z \leq 1$ the distances of SN-1a supernovae are also linearly growing, a phenomenon that this author, in the frame of the standard cosmology, then tried to explain by a so called "coasting cosmology" of the universe with $R \sim t$ (see e.g. Kolb, 1989, or more recently Fahr and Heyl, 2007) that is responsible for red-shifting the photons of the distant supernovae, rather than by a CDMcosmology relying on vacuum energy as did Perlmutter et al. (1998), Schmidt et al. (1998) or Riess et al.(1998).

Thinking of the Most Distant Emitters and the Cosmic Microwave Background Radiation

We now want to think of the most distant stars whose radiation emissions we may see as the most red-shifted with correspondingly large values of z_g. The question may arise then whether or not with this newly proposed red-shifting process as discussed above we may also be able to explain the phenomenon of the *3K CMB* background emission,- a solid observational phenomenon normally explained by the afterglow of the Big-Bang at the phase of matter recombination, thought to have occurred at a temperature of about 3000K. Would it therefore be realistic to assume that the radiation of very distant stellar emitters with Planckian radiation temperatures of about *3000K*, by the gravitational red-shifting mechanism discussed above, will nowadays arrive at us with a radiation temperature $T_g = T_{CMB} \simeq 3K$?

For Planckian emitters like stars and the *CMB* the famous Wien's law of spectral maximum shifts would then require the following relation between Planckian spectral peak wave lengths λ_{max} (z = 0) at the origin and λ_{max} $(z = z_g)$ at present time, respectively, given by the following relation [18]:

$$\lambda_{\max}(z=0)\cdot T_{CMB}(z=0)=\lambda_{\max}(z=z_g)\cdot T_{CMB}(z=z_g) \quad 17$$

Taking the temperature of the initial Planck emitter to be $T_{CMB}(z = 0) = 3000K$ and the temperature of the presently seen CMB emitter as $T_{CMB}(z = zg) = 3K$ this would mean the following request:

$$\frac{\lambda_{\max}(z=z_g)}{\lambda_{\max}(z=0)}=z_g+1=\frac{T_{CMB}(z=0)}{T_{CMB}(z=z_g)}=\frac{3000}{3}=1000 \quad 18$$

meaning that with the above discussed gravitational redshifting process leading to $z = z_g$ one should be able to even explain a redshift by the order of $z_g = 10^3$. Looking back to the expression derived for the gravity-caused redshift zg we thus would arrive at a request:

$$1000=\exp[3G\frac{M_U D}{c^2 R_{\max}^2}] \quad 19$$

or simply meaning

$$6.9=3G\frac{M_U D}{c^2 R_{\max}^2} \quad 20$$

When reminding that in Fahr and Heyl (2020) we had estimated from galactic redshift data the necessary number for the relevant cosmic quantity $M_U /R\ max^2$ to be of the order:

$$\frac{M_U}{R_{\max}^2}\simeq 10^4[g/m^2]=1[g/cm^2] \quad 21$$

we would then arrive at the following request for the needed travel distance D:

$$D=\frac{6.9c^2}{3G}\frac{R_{\max}^2}{M_U}=2.3\frac{c^2}{G}[cm^2/g]=3.91\cdot 10^{28}[cm]=4.2\cdot 10^{10}Lj \quad 22$$

which interestingly enough expresses the fact that stellar photons from distances beyond 10^{10} light-years in a static universe would appear as something equivalent to strongly red-shifted CMB photons.

In view of the fact that according to the classical Hubble cosmology and the most recent *ΛCDM* - cosmological models the universe should have an age of $\tau = 13.7\ 10^9$years , this surprisingly well corresponds to the above Hubble age request and hence expresses the fact that all known photon redshift phenomena, included the appearance of the CMB radiation, can also well be explained by the gravitational redshift process $z = z_g$ proposed here in this paper caused by the gravity of cosmic masses alone.

Does One Need a Twofold Explanation of the Cosmic Photon Redshifts?

Reading the foregoing section, it seems, as if explanations of cosmic photon redshift phenomena can be given equally well either as given by conventional Hubble redshifts $z = z_H$ or by gravity-induced redshifts $z = z_g$, as introduced in this paper here. This perhaps then suggests the need to study the joint red-shifting action by both these processes in order to perhaps thereby arrive at a more complete and more satisfying explanation. In the following we shall therefore look into this possibility a little deeper whether or not this option could perhaps help in finding a more convincing explanation. The theory of red-shifting photons purely due to the gravitational action on propagating photons by the masses of the universe distributed around the actual place of the photon was in our above presented first approach based on the assumption that we are living in a static universe with a static mass distribution around. If instead of that we now want to consider a cosmic mass distribution which is undergoing a universal and isotropic Hubble expansion then our earlier considerations are still valid and relevant, but evidently they become more complicated due to the fact that cosmic masses at greater distances are constituted by earlier states of the expanding universe.

In that latter case taking into account the gravitational action of distant masses, besides the aberration effect, one needs to also and simultaneously, take into account the expansion of the universe with decreasing cosmic mass densities in the course of the growing world time t, or vice versa increasing mass densities with increasing look-back times (t_0-t) , i.e. with $t_0 > t$ as the present world time, and the fact connected with it, that since more distant regions are "gravitationally felt" by the local object at times $t' = t_0-R/c$ retarded with respect to the present time necessarily requiring the introduction of mass densities $\rho_U = \rho_U(t') \geq \rho_U(t_0)$ at these retarded, cosmologically earlier times t´.

The effect of this retardation in time, however, immediately brings the whole cosmological evolution of the expanding universe into the game. This above consideration may thus become correspondingly more complicated, if also hereby the history of the expanding universe has to be taken into account in this problem. Then looking into larger distances may mean that evolutionary earlier cosmic phases of cosmic matter distribution are determining the considered gravitational influences, but the retarded mass spheres according to the retardation have had higher mass densities $\rho_U(t')$ compared to those at present time $\rho_{U0} = \rho_U(t_0)$. This means that, with growing distances and longer times, it takes to communicate through gravitons, the cosmic mass positions and mass strengths to the local position, gravitational influences of earlier evolutionary states of the universe with a gradually higher mass density physically come into the cosmic game, thus pronouncing the earlier phases of the universe correspondingly stronger than in our first approach for the static universe.

This may be taken into account by correspondingly modifying the formulated expression (Equation (2)) for the braking power $K\|$ replacing it now by the following expression:

$$K_{\|} = -2\pi Gm \int_0^{\infty} \rho_U(t')dR_U \int_0^{\pi} \cos\theta' \cdot \sin\theta d\theta \quad 23$$

This then leads by inclusion of the cosmologically retarded densities $\rho_U (t')$ to the following expression:

$$K_{\|} = -2\pi Gm \int_0^{\infty} \rho_U(t_0 - R_u/c)dR_U \int_0^{\pi} \cos\theta' \cdot \sin\theta d\theta \quad 24$$

with t_0 denoting the present world time. This leads with $R_{U0} = R_U(t_0)$ in an evolving, homogeneous, flat ($k = 0$) universe to:

$$K_{\|} = -2\pi Gm\rho_{U0} \cdot \int_0^{\infty} (\frac{R_{U0}}{R_U(t_0 - R_u/c)})^3 dR_U \int_0^{\pi} \cos\theta' \cdot \sin\theta d\theta \quad 25$$

In the above expression one can now recognize that the more distant areas have a cosmologically pronounced higher influence in the integral.Taking now for instance here, as a basis, the case of a matter-dominated, flat universe ($k = 0$), then one obtains a scale evolution according to $R(t) \sim t^{2/3}$. With this latter scale evolution, the above integral then would write in the following form:

$$K_{\|} = -2\pi Gm\rho_{U0} \cdot \int_0^{\infty} (\frac{t_0}{(t_0 - R_u/c)})^2 dR_U \int_0^{\pi} \cos\theta' \cdot \sin\theta d\theta \quad 26$$

or finally, after carrying out the R − (space) integration, then yielding

$$K_{\|} = -2\pi Gm\rho_{U0}ct_0 \int_0^{\pi} \cos\theta' \cdot \sin\theta d\theta \quad 27$$

With the time t0 permanently growing during the existence of the universe thus it would become clear that during the growing times the force $K\|$ would become larger and larger, and thus reddening of all cosmic photons till their invisibility would occur. This, however, is not true, since with growing t0 also the density ρ_{U0} will correspondingly decrease and cannot be treated as a constant in this case anymore.

To better study this point one can again bring the earlier cosmic quantity $[M_u/R^2_{max}]$ into the upper expression when identifying $R_{U\,max}$ with $R_{U,max} = ct0$, and thus one obtains:

$$K_{\|} = -\frac{3}{2}Gm[\frac{M_U}{R^2_{\max}}] \int_0^{\pi} \cos\theta' \cdot \sin\theta d\theta \quad 28$$

The conclusion now from this expression could be either:

A) The red-shifting forces $K\| = K\|(t_0)$ would permanently decrease with the growth of the universe, i.e. with time t0, and would finally completely disappear in the forthcoming future of the universe, if the mass of the universe M_U must be taken to be a constant,

or:

B) The red-shifting forces would be constant with time t_0, if the quantity M_U/R^2_{max} could again serve as a constant even in an expanding universe which, however, this time would imply the need that MU grows proportional to R^2_{max}.

A growth of the mass of the universe has in fact been discussed already by several authors in the past, like e.g. by Thirring (1918), Hoyle (1948), Dehnen and Hönl (1962), Sciama (1953), Fahr and Zoennchen (2006), Fahr and Sokaliwska (2012) [19-23]. Mostly in view of Machian ideas of the behavior of mass inertia in the universe [24-26].

However, just the above requested form of a needed dependence of M_U on the cosmic scale R_{max} has as yet never been claimed for, while M_U being proportional to R_{max} has been seriously discussed as a possibility [11]. Hence most probably one has to predict a decrease of red-shifting forces $K\| = K\|(t)$ with the ongoing of the expansion of the universe.

Conclusions

In this paper we have developed a theoretical study of the gravitational influence of distant cosmic masses on the motion of non-relativistic and relativistic objects. Due to the aberration of the physically recognized positions of the mass source points by the moving object it turns out, that even in a completely homogeneous cosmic mass distribution finite forces are in fact permanently operating and changing the momentum of the moving object. For photons propagating in the universe this has the surprising consequence that a permanent red-shifting of these photons also occurs in a static universe, not only, as generally thought, in an expanding Hubble universe. As we do show here, even the observationally well approved phenomenon of the 3*K* CMB background radiation can be understood in the frame of the here discussed gravitational red-shifting of cosmic photons, since stellar emissions from stellar 3000*K* emitters would, after a passage time of 10^{10}years, appear as photons of a 3*K* Planck emitter.

This effect of gravitationally red-shifting freely propagating photons, as we did show in the last section of this paper, is not only applicable in a static universe, but also can be applied in an expanding Hubble universe. That means in this latter universe we would have two different forms of photon redshifts occurring, the classical one due to the expansion dynamics of the universe, and the newly discussed process, presented in this paper here, by the gravitational action of ambient cosmic masses. As shown for the case of a coasting universe with $R(t) \sim t$ the two forms causing a redshift would produce qualitatively similar results, with the only difference that the gravitationally induced redshifts would decrease in magnitude with the age t0 of the universe, contrary to Hubble redshifts in a ΛCDM-universe.

It is interesting to recognize that the linear increase of the gravitational redshift with distance from the emitter, as coming out from this theory here in this paper, is just identical to the form of increasing Hubble redshifts in a universe with a coasting cosmology according to an expansion law $R(t) \sim t$ [16, 27]. The latter point was recently again recognized and stressed by Casado (2020) who showed that a "coasting universe", i.e. a universe with an un-accelerated scale expansion velocity $\dot{R}=const,$ may well explain the redshifts of distant supernovae SN-Ia. These puzzling redshifts had led authors like Permutter et al. (1998), Riess et al. (1998, 2001), Schmidt et al. [2, 28-30]. (1998, Tonry et al. (2003) and Wang et al. (2003) to the conclusion that in the more recent cosmic evolution times the universe shows an accelerated expansion and thus requires a non-vanishing positive vacuum energy density Λ. In order, however, to accept a coasting universe one would need to see very specific cosmic conditions fulfilled. Kolb (1989) was the first to study such conditions and concluded that, for this case to be fulfilled, pressure P and matter density ρ of the relevant cosmic matter should be related by a very specific polytrophic relation of the form $P = (1/3)\ \rho$. As shown by the second Friedman equation, this then leads to a vanishing scale acceleration $\ddot{R} = 0$. The needed polytrophic relation would characterize a form of matter behavior between baryonic and photonic matter, called by the author "K-matter" (Koino-matter or "Kolb"-matter).

In more recent papers by Fahr (2006) or Fahr and Heyl (2006, 2007) it was then shown that a coasting universe also results for the Machian case of scale-related cosmic masses leading to a mass density behavior according to $\rho \tilde{} R^{-2}$. In Fahr and Heyl (2020) demonstrated a further possibility to have a coasting universe realized, namely by having a vanishing cosmic mass density. This, however, looks as being quite improbable in view of the massive stars around us, but as we did show such an "empty universe" with $\langle\rho\rangle_R=0$ naturally results for universes with a pervasive scale-invariant mass structuring as indicated by the observed two-point correlation functions describing stellar or galactic positions [31]. For such universes namely, it can be shown that the average mass density ρ only is finite in a positively curved universe with $k = +1$, while for universes with $k = 0$ or $k = -1$ the mass density vanishes, i.e. $\langle\rho\rangle_R = 0$! [14]. These latter universes would be "coasting ones" and thus would, as pointed out by Casado (2020), explain the distances of supernovae of type SN-Ia without any need for a vacuum energy Λ and in addition would lead to a redshift-distance behavior as developed in this paper here for purely gravitational redshifts [32, 33].

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