Why some stars seem to be older than the Universe?

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Abstract

There is some experimental evidence that some stars are older than the Universe in General Relativity based cosmology. In TGD based cosmology the paradox has explanation. Photons can be either topologically condensed on background spacetime surface or in 'vapour phase' that is propagate in $M_4^+ \times CP_2$ as small surfaces. The time for propagation from A to B is in general larger in condensate than in vapour phase. In principle observer detects from a given astrophysical object both vapour phase and condensate photons, vapour phase photons being emitted later than condensate photons. Therefore the erroneous identification of vapour phase photons as condensate photons leads to an over estimate for the age of the star and star can look older than the Universe. The Hubble constant for vapour phase photons is that associated with $M_4^+$ and smaller than the Hubble constant of matter dominated cosmology. This could explain the measured two widely different values of Hubble constant if smaller Hubble constant corresponds to the Hubble constant of the future light cone $M_4^+$. The ratio of propagation velocities of vapour phase and condensate photons equals to the ratio of the two Hubble constants, which in turn is depends on the ratio of mass density and critical mass density, only. Anomalously large redshifts are possible since vapour phase photons can come also from region outside the horizon.
1 Why some stars seem to be older than the Universe?

There exists experimental evidence that some stars are older than Universe [Pierce et al., Freedman et al., Saha et al.]. A related problem is the problem of two Hubble constants. These paradoxical results can be understood in TGD:eish cosmology. In TGD light can propagate in two manners. In topological condensate light ray propagates along curved spacetime surface as a small condensed particle and in vapour phase as a small 3-surface in imbedding space $H = M_4^+ \times CP_2$, where $M_4^+$ is future light cone of $M^4$. The time needed to travel from point A to point B is shorter in vapour phase since the geodesic length along spacetime surface in the induced metric is obviously longer than in free Minkowski space. The failure to regard vapour phase photons as condensate photons leads to the paradox as following arguments shows and also to a problem of two different Hubble constants. Moreover, the possibility of vapour phase photons emitted by objects outside the spacetime horizon explains also objects with anomalously large redshifts.

To understand these results one must study TGD:eish cosmology in more quantitative level.

a) The most general cosmological imbedding of $M_4^+$ to $M_4^+ \times CP_2$, is of form

$$s^k = s^k(a)$$

$$g_{aa} = 1 - s_{kl} \frac{ds^k ds^l}{da da}$$

$$ds^2 = g_{aa} da^2 - a^2 \left( \frac{dr^2}{1 + r^2} + r^2 d\Omega^2 \right)$$  \(1\)

Here $s_{kl}$ is $CP_2$ metric tensor and describes always expanding cosmology with subcritical or at most critical mass density [PitkänEn].

b) The age of the Universe detefined as $M_4^+$ proper time $a$ of the comoving observer (comoving observer on spacetime surfaces is also comoving in $M_4^+$) is larger than the age defined as the proper time $s(a)$ of the comoving observer on spacetime surface. For the matter dominated Universe one has $g_{aa} = Ka$ so that one has
\[
\frac{\text{age(\text{cond})}}{\text{age(\text{vapour})}} = \frac{s(a)}{a} = \frac{2}{3} \sqrt{g_{aa}}
\]  
(2)

for the ratio of the ages.

c) \(g_{aa}\) can estimated from the expression for mass density in expanding cosmology

\[
\rho = \frac{3}{8\pi G} \left( \frac{1}{g_{aa}} + k \right)
\]

\[
k = -1
\]  
(3)

\(k = 0\) mass density corresponds to critical mass density \(\rho_c\). The mass density is believed to be a fraction of order \(\epsilon = 0.1 - 0.5\) of the critical mass density and this gives estimate for \(\sqrt{g_{aa}}\):

\[
\sqrt{g_{aa}} = \sqrt{1 - \epsilon}
\]

\[
\epsilon = \frac{\rho}{\rho_c}
\]  
(4)

\(\sqrt{g_{aa}} = 2/3\) suggested by the proposed solution to Hubble constant discrepancy gives \(\epsilon = \frac{2}{3}\). \(\epsilon = .1\) gives \(\sqrt{g_{aa}} \approx .95\).

d) The ratio of the condensate travel time to vapour phase travel time for short distances is given by

\[
\frac{\tau(\text{cond})}{\tau(\text{vapour})} = \frac{1}{\sqrt{g_{aa}}}
\]  
(5)

This effect is in principle observable and the considerations of Pitkänen suggest that \(g_{aa}\) can differ from unity by a factor as large as one half. The effect provides also a means of measuring the mass density of the Universe.

e) The light travelling in vapour phase can reach observer from a region, which is the intersection of the past light cone of the observer with the boundary of \(M_4^+\) and therefore finite region of \(M^4\). The \(M^4\) radius of this region in the rest frame of the observer is equal \(r_M = a/2\) by elementary
geometry.

f) For a null geodesic of spacetime surface starting at \((a_0, r)\) and ending at \((a, 0)\) one has

\[
r = \sinh\left(\int_{a_0}^{a} \sqrt{g_{aa}} \, da\right)
\]

(6)

If \(g_{aa}\) approaches zero for \(a_0 \to 0\) as it does for radiation dominated cosmology the integral on the right hand side is finite. This means that the value of \(r_M(a_0)\) (M⁴ distance of the object from observer) approaches zero at this limit. All radiation from the moment of big bang comes from the dip of the light cone. In TGD the Planck time cosmology with critical mass density corresponds to \(g_{aa} = K\), \(K\) very small number and also in this case the radiation comes from origin.

g) The radius \(r_M(a_0)\) has maximum for some finite value of \(a_0\) and this radius defines the M⁴ radius of the Universe observed by condensate photons. The maximum corresponds to rather large value of \(a_0\) so that one can approximate the cosmology with matter dominated cosmology: \(g_{aa} = K a\) and one has the condition

\[
\begin{align*}
    u_0 &= 2 \tanh(u - u_0) \\
    u &= \sqrt{Ka} \\
    u_0 &= \sqrt{Ka_0}
\end{align*}
\]

(7)

(8)

The following table gives the values of \(\sqrt{\frac{g_{aa}}{a}}\) and \(\frac{r_M(max,cond)}{r_M(max,vapour)}\) for \(\sqrt{g_{aa}} = \sqrt{Ka} = 2/3\) and 1 respectively.

| \(\sqrt{Ka}\) | \(\sqrt{\frac{g_{aa}}{a}}\) | \(\frac{r_M(max,cond)}{r_M(max,vapour)}\) |
|----------------|-----------------|----------------------------------|
| \(\frac{2}{3}\) | .663            | .2                               |
| 1               | .658            | .3                               |

Note that anomalously large redshifts are possible for vapour phase photons emitted by comoving objects outside the horizon and \(r_M \geq r_M(max)\).

h) Vapour phase and condensate photons provide in principle a possibility to obtain simultaneous information about the astrophysical object in two
different phases of its development. For object situated at distance \( r \) and observed at \((a, r = 0)\) the emission moments \( a_0 \) and \( a_1 > a_0 \) (in Minkowski proper time) for condensate photon and vapour phase photon are related by the formula

\[
\frac{a}{a_1} = \exp(2\sqrt{K_1(a^{1/2} - a_0^{1/2}))}
\]

in matter dominated cosmology \( g_{aa} = K_1 a \ (K_1 a \sim 1) \). Sufficiently nearby Super Nova would provide a test for this effect. The first burst of light corresponds to vapour phase photons and second burst to condensate photons. The time lag between bursts provides a manner to measure the value of \( \sqrt{g_{aa}} \). Unfortunately, the time lag in case of SN1987A is quite too large since the distance of order \( 1.5 \cdot 10^5 \) \( ly \). The observation of same spectral line with two different cosmological redshifts is second effect of this kind and might be erroneously interpreted as existence of two different objects on same line of sight.

Consider now the solution of the two puzzles. The previous formula explains why certain stars seem to be older than the Universe. If one erroneously identifies vapour phase photons as condensate photons the age of the star at time \( a_0 < a_1 \) is erroneously identified as the age at later time \( a_1 \) and this implies that the apparent age is given by

\[
s(a)_{app} = Xs(a) \\
X = \left(\frac{a_1}{a_0}\right)^{3/2} \\
\frac{a_1}{a_0} = \frac{a}{a_0}\exp\left(-2\sqrt{K}(a^{1/2} - a_0^{1/2})\right)
\]

and larger than the actual age in matter dominated cosmology. The apparent ages of lowest stars are roughly by a factor \( 3/2 \) larger than the age of the Universe. For \( \sqrt{Ka} = 1 \) and \( X = 1.57 \) this requires \( s(a_0) \approx .15s(a) \). For \( \sqrt{Ka} = 2/3 \) and \( X = 1.57 \) one has \( s(a_0) \approx .36s(a) \).

Vapour phase photons provide a possible solution to the puzzle of two different Hubble constants if the mass density is sufficiently large. The distances derived from type Ia supernovae give \( H_0^g = 54 \pm 8 \) \( kms^{-1}Mpc^{-1} \) to be compared with the Hubble result \( H_0^b = 80 \pm 17 \) \( kms^{-1}Mpc^{-1} \) [Freedman et al].
The discrepancy is resolved if the measurement of distance is correct and made using vapour phase photons and $H_0^a$ corresponds to the Hubble constant of $M^4_+$, which is by a factor

$$\frac{H_0^a}{H_0^b} = \frac{H_0(M^4_+)}{H_0(X^4)} = \sqrt{g_{aa}} = \sqrt{1 - \epsilon} \sim 2/3$$

(11)

smaller than the Hubble constant of spacetime surface. The needed mass density $\epsilon = 5/9$ and the ratio of propagation velocities of light differs considerably from unity. For $\epsilon = .1$ the ratio of two Hubble constants is predicted to be .95 and some other explanation for discrepancy is needed.

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