"Big Bang" versus "Steady State"

The γ-factor as Arbiter in a New Contest

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Summary

In the present paper it is shown how it is possible to use the strict "light principle" as a point of departure for deriving three new "steady state" models of the universe which are at variance with the Robertson Walker Metric but fulfil Milne's cosmological principle.

Contents

A. *Introduction.*

The γ-factor, which is defined as the quotient between an element of frame time dt and an element of proper time dT, is the most noticeable consequence of special relativity (SR).

A standard clock passing along a series of slave clocks, distributed spatially over the co-moving ("stationary") frame of an observer and synchronized in the conventional way to the master clock of that observer, will thus appear retarded according to: $\gamma = dt/dT = \sqrt{1-dr^2/dt^2}$.

On the other hand, $dT^2 = dt^2 - dr^2 = dt'^2 - dr'^2$ is usually seen as a direct consequence of the differential Lorentz Transformations (LT') in accordance with the relativity principle (RP) and the principle of a constant light speed, here termed the "light principle" (LP).

How can dT be delayed relative to dt and yet be invariant? In order to solve this problem we must proceed to cosmology. One of the first "big bang" (BB) models and the only one based on the integral Lorentz Transformations (LT) is the uniform expansion model of E.A. Milne, cf. his [1935,1958]. In a paper on Milne's theory of kinematic relativity (KR), his former student A.G. Walker [1937] showed how the model can be restated so as to accomodate a cosmic time, $\widehat{\mathcal{T}}$:

$$t = \mathcal{T} ch\sigma \ , \ r = \mathcal{T} sh\sigma$$
$$d\widehat{\mathcal{T}}^{\,2} = dt^2 - dr^2 = d\mathcal{T}^2 - \mathcal{T}^2 d\sigma^2$$
$$d\sigma \rightarrow 0 \Rightarrow d\mathcal{T} \rightarrow d\widehat{\mathcal{T}}$$

This result inspired him to construct a method for the development of models incompatible with LT, and thereby to develop his own version of the famous Robertson-Walker metric (RWM):

$$d\widehat{\mathcal{T}}^{\,2} = d\mathcal{T}^2 - \mathcal{S}^2(\mathcal{T})\, d\sigma^2 = \text{invariant}$$

Here $\mathcal{T}$ is a universal parameter, $\mathcal{S}(\mathcal{T})$ is a universal scale factor, and σ is a co-moving coordinate characterizing one fundamental observer relative to another.

It seems probable that the Milne model is unique in the manner that it is the only model to combine LP in the strict sense with RWM. Thus, when Bondi & Gold presented their "steady state" (SS) model they explicitly based it on RWM, noticing that the model is incompatible with LT.

The scale factor of an SS universe being $\mathcal{S}_1(\mathcal{T}) \equiv e^{\mathcal{T}}$, it is easy to demonstrate that the model of Bondi & Gold with standard definitions of t & r is incompatible with the strict LP:

$$d\widehat{\mathcal{T}}^{\,2} = d\mathcal{T}^2 - \mathrm{e}^{2\mathcal{T}} d\sigma^2 = (dt^2 - dr^2)(1 - th^2 r) \neq dt^2/\gamma^2$$

This is shown in the appendix where also two other models with scaling functions $\mathcal{S}_2(\mathcal{T}) \equiv sh\,\mathcal{T}$ and $\mathcal{S}_3(\mathcal{T}) \equiv ch\,\mathcal{T}$, both asymptotic approximations to $\mathcal{S}_1(\mathcal{T}) \equiv e^{\mathcal{T}}$, are derived from RWM.

But incompatibility of $\mathcal{S}_1(\mathcal{T})$ with LT does not entail incompatibility of $\mathcal{S}_1(\mathcal{T})$ with LT', i.e., the differential LT. So we may ask if it is possible to devise a new SS model by means of LT' & LP, applying the method of Milne, instead of basing it on RWM, employing the method of Walker.

We are therefore faced with the choice between $d\widehat{\mathcal{T}}^{\,2} = dt^2 - dr^2$ together with LT', and $d\widehat{\mathcal{T}}^{\,2} = d\mathcal{T}^2 - \mathrm{e}^{2\mathcal{T}} d\sigma^2$ in combination with some other and hitherto unknown transformations. Following Bondi and choosing the standard solution we have not only a cosmic time, but also what Milne called a 'public' 3-space. Making the other choice our 3-space remains 'private' in the sense that it can only be described in the perspective of an observer. But we still have a cosmic time, $\widehat{\mathcal{T}}$.

Hence our problem: Is a cosmology based on LP in the strict sense at all feasible?