An Eternal Steady State Universe

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Abstract

Some cosmological theories, such as many versions of eternal inflation and ΛCDM involve creation processes which continue indefinitely with no defined termination.

Such processes can only occur in a temporally unbounded but finite universe. This requirement imposes serious constraints on any theory but the issue is often ignored.

I propose an eternal steady state cosmological model in which past- or future-incomplete processes with no defined beginning or end are not permitted.

Much well regarded theory is incompatible with this model; however there are viable alternatives.

1 Introduction

Steady State Cosmology as proposed by Sir James Jeans and later revised by Hermann Bondi, Thomas Gold, Fred Hoyle and others[1], postulated an eternal, exponentially expanding universe with matter creation such that the average matter density was always constant.

This theory was effectively refuted by the discovery of cosmic microwave background radiation (CMBR) in 1965.

There was also a serious problem with this theory which did not affect its verifiable predictions but dealt a fatal blow to the 'steady state' description:-

If it is assumed that at some past time the universe had a countably infinite (i.e. $\aleph_0$) volume and number of discrete particles, and exponential expansion continued for countably infinite time, the volume of space and the number of particles in it become uncountably infinite. That is, the volume and number of particles increases by the factor $n^{\aleph_0}$, where $n > 1$.

Since $\aleph_0 * n^{\aleph_0} = \aleph_1$ the volume of space and the number of particles in it would become equal to the uncountable (or non-denumerable) infinity $\aleph_1$. The number of particles each occupying a separate finite volume would be equal to the number of (zero volume) points, which is physically impossible.

This problem was analysed in depth by Richard Schlegel[2].

Before observational refutation, Steady State Cosmology could only be kept viable by assuming exponential inflation started at an indefinitely distant but finite time in the past and will end at an indefinitely distant but finite future time.

More formally, exponential expansion must be past-incomplete and future-incomplete.

The same problem occurs with most versions of a newer theory of an eternal, exponentially expanding universe i.e. eternal inflation, which also predicts exponentially increasing space and number of particles, and with ΛCDM models which predict eternal exponential expansion of space.

Past-incompleteness is not necessarily a problem as it may be possible to have precursor conditions which after infinite time gave rise to inflation at some finitely distant past time[3]. Future-incompleteness requires that inflation must somehow end within finite time. Any attempt to develop a theory of past- and future-complete inflation e.g.[4] must fail. The most common indication of such a failure is an intractable singularity.

There are informal conventions e.g. describing indefinitely continuing future-incomplete inflation as ‘everlasting’ or ‘eternal’ or ’eternal into the future’ [5][3] which are not helpful.

In this article I define eternal as having existed for $\aleph_0$ units of time and continuing to exist for a further $\aleph_0$ units of time.

2 An Eternal Steady State Universe

My model assumes episodes of finite inflation initiated by low entropy random fluctuations as proposed by Dr. Schuetz[6] in an eternal (i.e. past and future complete), flat, static, spatially infinite universe which, on a large scale, has asymptotically zero energy and no matter and maximum entropy i.e. Minkowski space.

It is then necessary that there be a nonzero possibility of inflation and it is convenient and perhaps necessary to assume that the probability of producing Boltzmann Brains[7][8] (an awkward prediction of many theories) is much lower than the probability of inflation. Andreas Albrecht and Lorenzo Sorbo propose that this is a viable assumption[8].

I will follow a convention[3] and call ’local’ universes like ours created by inflation ’pocket universes’.

3 Requirements

In an eternal universe no process which requires the unlimited exponential creation of space or discrete particles is possible. After infinite time there would be $n^{\aleph_0}$ i.e. $\aleph_1$ units of space or discrete particles. Therefor all models where quintessence, cosmological constant etc. cause such expansion are not consistent with an eternal universe.

If, as is certainly plausible, new instances of inflation can start within an inflation field or pocket universe, finite inflation requires on average less than one new instance in each instance of inflation. Otherwise such inflation would not be finite.

As the expansion of space during finite inflation is of course finite, after sufficient time has elapsed all created space must eventually be separated by time-like intervals, with the possible exception of singularities created by black holes etc.. This may lead to the complete disappearance of everything created by the inflation episode.

However, the possibility of a finite inflation episode ending with a finite volume/number of particles and no possibility of infinite inflation is not precluded.

In that case, the effect on the volume of the universe would be linear, not exponential. Over $\aleph_0$ units of time, the universe’s volume would be subject to change by the factor $\aleph_0$. Since $\aleph_0 * \aleph_0 = \aleph_0$ the volume would not in fact be changed.

If it is possible for intelligent life to initiate inflation[3], this sets a further constraint on the probability of any single inflation episode producing intelligent life. If on average each instance of intelligent life creates x new inflation episodes, then all inflation episodes must on average produce less than 1/x instances of intelligent life. if this is the case, the total duration of inflation is further limited and there is a slightly better chance of observing transients dating back to the inception of inflation.

4 Conclusion

My main intent in this article is to present one of many possible theories of an eternal universe and highlight the problems associated with future-incomplete processes.

A significant advantage of an eternal universe theory is that there is arguably only one unanswerable question: why is there something rather than nothing?

While the eternal Minkowski space I posited may well not be fundamental, there is at least no requirement to assume acausal creation or find another rationale for a finite universe.

References

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