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Space-time singularities and microwave background radiation

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Abstract. A general relativistic space-time universe is considered together with a radiation such as the microwave background radiation. It is shown that if certain reasonable conditions are satisfied, then the presence of such a radiation would imply space-time singularities in the sense that all time-like curves will be incomplete in the past. The considerations provide an upperbound to the age of the universe, which is consistent with present data.

Keywords. Space-time singularity; microwave radiation; energy conditions; causal structure.

1. Introduction

The observations of radio frequencies between 20 cm and 1 mm indicate that there is a radiation background in the universe whose spectrum seems to be close to that of a black body at 2·7° K. The observed pattern is highly isotropic spatially and so it is widely believed that it must have an extragalactic origin, since we are not symmetrically placed in the plane of our galaxy. Various beliefs exist concerning the origin of this radiation, however, the general opinion is that this is a blackbody radiation left over from a hot early stage of the universe (See Sciama 1971 for more discussion on microwave radiation.)

In view of the observational support to the existence of microwave radiation, the considerations concerning the global structure of the universe must take it into account suitably. Hawking and Ellis (1968, 1973) considered the microwave background radiation in a general relativistic space-time universe and showed that this implies a possibility of singularity at the beginning of the present phase of expansion of the universe. Such a singularity would exist if together with certain physically reasonable assumptions it is taken that the microwave radiation was exactly spatially isotropic or is partially thermalised by scattering. Here the singularity exhibits itself in the form of geodesic incompleteness.

We further study here the relationship between the presence of such a radiation in the universe and space-time singularities. We consider a class of general relativistic space-times which are globally hyperbolic. The only assumption made concerning the microwave radiation is that its energy density at all events in the past of a given event p be greater or equal to that at p. This is eminently reasonable if universe had a radiation dominant region in the past or the radiation was emanated from a hot early stage, etc. It is then shown that if other matter fields have positive energy density, *all timelike curves* must be incomplete in the *past*, and also that the