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CPT Conservation in the Oscillating Model of the Universe

DAVIES[1] has proposed an oscillating model of the Universe in which the direction of time flow reverses between alternate cycles. The present epoch is considered to be in the expansion phase of the half-cycle AB (Fig. 1). It is supposed that at the catastrophe B the arrow of time reverses, thus imposing symmetry. One may then further identify the points A and C thus imposing completeness; the interval ABC then comprises the whole of space-time.

In considering the behaviour of matter at the catastrophes A and B it seems sensible to ask whether we may expect any conservation laws to hold. In the speculative spirit of the model, I make the hypothesis that CPT is rigorously conserved[2], where C = charge conjugation, P = parity and T = time reversal. From experiments it is known at the present time that C and P are maximally violated in weak interactions, and that CP and T are violated in weak interactions at a level of the order of 10^{-3}. In spite of careful searches no evidence has ever been found for violation of the combined symmetry operation CPT.

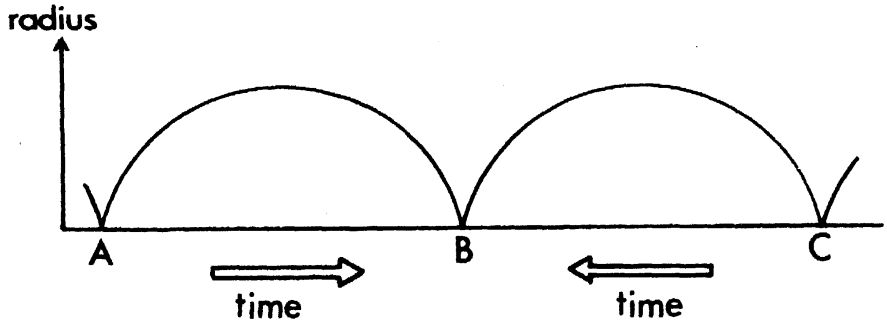

Fig. 1 Oscillating model of the Universe, after Davies[1].

By way of example, assume that the present observable Universe consists predominantly of matter (nucleons with baryon number $B=+1$); the interval BC will then consist predominantly of antimatter ($B=-1$). I redraw Fig. 1 in a way which clarifies the statements of the model (Fig. 2). I have folded the diagram to superimpose geometrically the identified points A and C. The thickness of the segments is now meant to represent the radius of the Universe, and the open arrows give the direction of time in the sense of the arrows in Fig. 1. Further, I have drawn a typical baryon world-line, which forms a closed loop with a (conventional) directionality. In the upper segment baryons flow with the direction of time (matter), and in the lower segment baryons flow against the direction of time (antimatter). The idea that antiparticles can be considered as particles moving towards earlier times is of course not recent[3].

The simplicity of this picture of the Universe is appealing. We now have complete symmetry between matter and antimatter, even if the observable Universe is primarily of one type. We may also have absolute conservation (according to

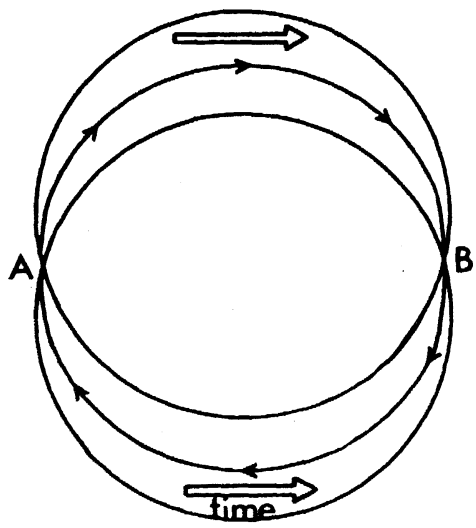

Fig. 2 "Closed loop" representation of the Davies model.

an internal observer) even at the catastrophes A, B of those quantum numbers which as far as we know are absolutely conserved, for example, charge Q, baryon number B and lepton number L. It is amusing to note that the diagram (Fig. 2) is reminiscent of the well-known fluctuations of the vacuum in quantum electrodynamics, in which a virtual particle-antiparticle pair appear in free space and then annihilate. This process is normally considered as a closed loop diagram with again a (conventional) directionality. By analogy I call this model a "closed loop model".

At present, I see no testable observational consequences of the model; nevertheless I believe it forms a viable and interesting basis for further investigation. In particular one line of enquiry is possible: the testing of "absolute" conservation laws at extremely high energy densities (the CERN Intersecting Storage Rings produce densities up to the order of 10^{17} g cm^{-3}, comparable with densities prevailing in the early (late) Universe).

It may be argued that physics must not in principle ask questions about the Universe beyond the catastrophes A and B. I believe, however, that, in the absence of evidence to the contrary, it is correct to assume that charge, baryon number and so on are conserved throughout. Further, I believe that a model of the Universe consisting predominantly of matter is aesthetically unpleasant and that it is worth while to point out that the model may be made symmetrical in a simple way.

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