A note on gravitational singularities

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An earlier cosmology paper, "On a finite universe with no beginning or end" [arXiv:physics/0612053], is introduced, and some supplementary detail concerning gravitational singularities, the Friedmann-Lemaître-Robertson-Walker (FLRW) metric, the Schwarzschild metric, and the Penrose-Hawking singularity theorems then provided. Without appealing to Brane cosmology and non-generic mechanisms in differing approaches to quantum gravity, singularities are avoided in all cases.

1 Introduction

In an earlier paper [1] it was conjectured that rather than the second of law of thermodynamics be violated as matter approaches a big crunch or a black hole singularity (due to the inability of heat to spontaneously flow to colder as the system exponentially compressed and heated), the order of events should reverse. As all of the laws of physics, with the exception of the second law of thermodynamics, are time reversible and work equally well in opposing directions, it was posited that no laws of physics would be contravened by such a reversal, while it would also enable the second law of thermodynamics to continue to hold. This is contrast to previous theories involving thermodynamic time reversal (see, for example [2, 3]) which all involve the second law being breached and also involve the same problems [1, 4, 5]. Using this revised conception of thermodynamic time reversal as a stepping stone, a model of the universe that resolves a number of problems and paradoxes in cosmology was then presented. The result is a closed 4-D universe that has no beginning (and no need for one), no ending, yet is finite, resolves Kant's finite vs. infinite time paradox, is without gravitational singularities, in which events are neither determined by initial or final conditions, and problems such as why the universe has a low entropy past, or conditions at the big bang appear to be so "special", require no causal explanation. In this short paper, some supplementary detail concerning gravitational singularities and the model is provided. In particular, without appealing to Brane cosmology models such as the "Ekpyrotic" model [6], or non-generic mechanisms in differing approaches to quantum gravity such as String theory (see, for example [7]) or Loop quantum gravity (see, for example [8]), singularities are shown to be avoided in all cases.

2 The FLRW and Schwarzschild metrics

Assuming general isotropy and homogeneity, the evolution of a positively spatially curved universe can be described by the time dependant FLRW metric:

$$ds^2 = c^2 dt^2 - a^2(t)\left(\frac{dr^2}{1-kr^2} + r^2 d\theta^2 + r^2 \sin^2\theta d\varphi^2\right) \qquad (1)$$

Where k = 1. t = 0 represents a big bang singularity, while a = 0 at some finite later time represents a big crunch singularity. Reversing the direction of evolution of t naturally gives the time reverse.

Likewise, the inside of a static, non-rotating and uncharged black hole can be described by the Schwarzschild metric:

$$ds^2 = \left(\frac{2M}{r} - 1\right)dt^2 - \frac{1}{\left(\frac{2M}{r} - 1\right)}dr^2 + r^2(d\theta^2 + \sin^2\theta d\varphi^2) \qquad (2)$$

Where $0 < r < 2M$. Inside the event horizon of a black hole, r replaces t as the timelike coordinate, and $2M/r$ approaches infinity as r approaches 0, thus indicating a singularity at $r = 0$. Treating r as convergent to 0 is equivalent to treating the singularity as being in the future of all $ds^2 > 0$ and $ds^2 = 0$ world lines inside $r = 2M$. However, in theory, there is an equally valid interpretation of the metric in which the singularity is in the past of all events inside $r = 2M$, where the paths of material particles and photons diverge along world lines from r = 0, and gravity remains attractive. This is a white hole, the time reverse of a black hole [9, 10].

In connection to the model detailed in [1], note that the point of reversal inside a black hole is not the same as the event horizon $r = 2M$. At this point, r would be substantially smaller. Because of this and that the reversed region is actually inside the black hole, also note that the similarity with a white hole goes no further than that detailed above. In addition, in relation to the model, further note that the Schwarzschild metric could equally be exchanged for the Kerr metric (rotating uncharged black hole), the Ressner-Nordstrom metric (charged non-rotating black hole), or the Kerr-Newman metric (rotating charged black hole).

To widen our view now to include both the FLRW and the black hole metrics, one can see that, if instead of convergent, the evolution of t (big bang, big crunch) or r (black hole) are treated to be divergent from 0 (or some other value in the case of a big crunch), such singular values would never be encountered. One can also see that assuming t or the scale factor $a(t)$ can be treated, in any physically meaningful way, to be convergent back to 0 at the big bang, is erroneous due to events and times always evolving in the direction of entropy increase and away from the low entropy big bang. Note that the Hawking-Penrose big bang singularity theorem – that, given certain reasonable conditions, past-directed spacetime paths terminate at a singularity at the big bang [11] – does not hold because of this. In relation to events always evolving in the direction of entropy increase and (when in close proximity to one) away from a potential singularity, further note that the same can be said in the context of the model for black hole and big crunch singularities, and that Penrose's 1965 future-directed singularity theorem [12] also does not hold because of this.

As a final remark, also note that because singular points do not represent intervals, and a t or r value must (for example, a t value of 1 second represents the interval of 1 and 1.999… seconds, and not an "instant" [13]), when the order of events reverse in the model, t and r values will never be 0 or some other singular t value in the case of a big crunch; they will be some interval, however small.

Although the knowledge that general relativity and the laws of physics are time reversible (with the exception of the second law of thermodynamics and some specific solutions to Einstein's equations), makes filling in the model with the relevant equations somewhat arbitrary (hence the brevity of this paper), it is hoped that it still may be of use.

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