From Hawking's A BRIEF HISTORY OF TIME to his THE UNIVERSE IN A NUTSHELL

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1 Introduction

Following his *A BRIEF HISTORY OF TIME* (BHT) [1] Professor Hawking has once again published a book for the lay readers of science, *THE UNIVERSE IN A NUTSHELL* (UIN) [2]. As attractive as this well-written book is, with abundant pictures and discussions of ideas of contemporary theoretical physics, it certainly misses the mark of explaining why it is that we can now understand the 'universe in a nutshell'.

As in his BHT, Hawking's 'nutshell understanding' of the universe is based on a false premise. It is that there is indeed a coherent, single, consistent theory that unifies the quantum theory and the theory of general relativity. The fact is that to the present time in the history of physics, a quantum theory of gravity has not been formulated in theoretical physics, after many years of frustrated attempts by some very brilliant scientists. The reason is simple. It is that the bases of the quantum theory and the theory of general relativity are mutually incompatible, both conceptually and mathematically.[1]

To ignore this situation and instead to claim their unification is like trying to force a square peg into a round hole! Indeed, it does not help real progress in theoretical physics and cosmology if leaders in the field tell the lay public and prospective physicists that the basic problems have already been solved in terms of present day ideas. Nothing could be further from the truth!

In an article on Hawking's BHT, [3] I criticized his claim that physics is near the end of its search for all truth. In UIN, I was glad to see that Hawking took back his earlier claim, when he said (in his Forward) that the situation has changed since his writing of BHT – "it is an ongoing journey still and the end is not yet in sight"! I fully agree with this conclusion.

From the rigorous point of view of physics, there has been no conclusive indication that the ongoing speculations that Hawking discusses as the basis of his 'nutshell universe', about strings, 10-dimensional membranes, superstrings, and quantum fluctuations, have anything to do with the underlying physical laws of the real universe.

2 From science to science fiction?

One of the errors in Hawking's discussion that leads to a diversion from science to science fiction is a faulty interpretation of space and time in the theory of relativity. This interpretation leads to logical paradoxes. Thus it cannot be the basis of a scientific explanation of any domain of matter – from elementary particles to cosmology.

An example is Hawking's discussion of 'time travel'. In Chapter 5,[2] he bases his claim of the possibility of time travel on a cyclic solution that Goedel found for Einstein's equations,[4a] in the case of a constant matter density of the universe. Goedel's result led to a rotating universe and geodesics that are cyclic, implying to him (with the standard interpretation) that a person could meet himself (or herself) after one cycle and tell the younger self that he (or she) is identical with himself (or herself). Goedel saw the absurdity of this paradoxical conclusion and advised, "a philosophical view leading to such consequences can hardly be considered satisfactory" [4b].

In my view, the error made in Goedel's initial analysis is the same error made by Hawking (and the majority of physicists today). It is the assumption that 't', that is a parameter that *measures* duration in the expressions of the laws of nature, is a physical experience in itself. This leads to the 'twin paradox'[3], the 'grandfather paradox'[4] (that Hawking discusses in UIN, but does not resolve) and the paradox of travel to a distant star.

The latter is the following: A pilot may travel at close to the speed of light to a star that is 50 light-years from Earth. From the view of the star, it 'sees' the spaceship approaching it from Earth, at close to the speed of light. Without relativity theory, it would take the pilot 50 years to reach the star. But because of the time contraction formula of special relativity, it is claimed (with, in my analysis, a faulty interpretation) that it may take the pilot only one hour to reach the star, while the star would have aged 50 years – that is, the star would have used up 50 years worth of its nuclear fuel during the pilot's trip. However, because of the subjectivity of motion, from the view of the pilot, who would see the Earth departing and the star approaching him, it would take him 50 years to reach the star, while the star would have aged only one hour; that is, it would have used up only one hour's worth of its

nuclear fuel during the pilots' trip. This is a logical paradox - both statements cannot be simultaneously true! Then how is this problem resolved?

The answer must be, as Goedel suggests, that we rethink the interpretation of the time (and space) parameters in the expressions of the laws of nature. We must discard the idea that the time parameter 't' in the expression of these laws is a physical experience! Indeed, 't' is not more than a language parameter that is invented by us and used to express a measure of duration, in one reference frame or another. But this parameter is not in itself the physical duration! In order to ensure the covariance of the laws of nature (i.e. their objectivity with regard to all possible reference frames – the underlying axiom of the theory of relativity) the time measure in a frame that is in motion relative to a fixed observer must be contracted in his expression of the law in that frame. This is the role of the Lorentz transformation in special relativity and the corresponding transformation in general relativity theory. It is analogous to the translation of verbal languages so as to preserve the meanings of the sentences expressed with them. Thus, if one is observing a physical phenomenon in a moving frame, to describe its law of nature there, one may have to put eight numbers on the face of a clock in that frame, rather than twelve. But this does not mean that anything physical has happened to the workings of the traveling clock, behind its face! Similarly, the observer in the moving frame could call his reference frame the 'fixed frame', and use a contracted time measure in the moving frame that was formerly the fixed frame of reference. This is not a paradox! It is simply a statement that the time measure is determined by the reference frame in which it is used to *describe* a physical law, *from any other reference frame*.[5] The physical basis of the theory of relativity (special or general) is *the principle of covariance* – prescribing that the laws of nature are independent of any reference frame in which they may be represented, from any other.

Therein lies the difference between science and science fiction. Science is based on logical consistency and empirical verification or refutation. Science fiction is based on neither. Its sole purpose is *entertainment.* Personally, I have enjoyed reading science fiction since my youth. But, as a scientist, I take great care not to confuse the stories of science fiction with scientific truth.

The idea of many universes, wormholes, travel at superluminal speeds, that one sees in TV shows, such as *Star Trek*, are science fiction, they are not real science! The idea of the wormhole originated in the analysis of Einstein and Rosen [5], whereby the authors tried to generalize the spacetime language for the laws of matter from a simply connected domain to a multiply connected domain. But this was only meant as a generalization of the lan-

guage that one uses to express the laws of matter. It was not meant to be a physical tunnel that one may carve out of a piece of foam, called 'spacetime', and then physically travel through this foam to another universe! The latter is the stuff of science fiction (as in the stories of *Star Trek*), it is not real science!

Finally, Prof. Hawking says that his philosophy of science is one of positivism. This should mean to him that no concept is meaningful unless it is directly verifiable with our human senses or the measurements of our instruments. But the ingredients of Hawking's 'nutshell universe' – strings, superstrings, 10-dimensional membranes, p-branes, quantum fluctuations, … are not now (or ever have been) directly verifiable with our senses or instruments. Neither has a coherent, self-consistent and finite quantum field theory ever been demonstrated for these concepts, interesting and popular as they are in modern-day thinking in theoretical physics.

Notes

1 Many physicists have discussed this problem. See, for example, Dirac [6] and Sachs [7].

2 Hawking's claim (UIN, p. 9) that the aging of a physical entity evolves asymmetrically, by virtue of its motion relative to another body, is confirmed experimentally, has recently been shown to be false. He refers to an experiment whereby the readings of equivalent clocks, one stationary on Earth, one flying eastward and another westward in aircraft, are compared. In a recent paper by Kelly [8], it is shown that the actual data from this experiment (of Hafele and Keating) does not show any conclusive difference between the readings of the compared clocks.

3 In an earlier analysis [9], I showed, both mathematically and logically, that the theory of relativity, in its most general expression, does not in itself predict any asymmetric aging, as it is commonly claimed in discussions of the 'twin paradox'. I discussed this problem further [10, 11] and with Harada in [12].

4 When Hawking says (UIN, p. 153) that the probability of Kip Thorne traveling back in time to meet his grandfather and kill him before he could have any offspring, therefore leading to Kip Thorne's

simultaneous existence and non-existence, is small enough to ignore – it is only one part in ten with a trillion, trillion … zeros, this does not solve the problem! Small as this probability may be, *it is non-zero*! Therefore, Hawking predicts that there is a finite probability that Kip Thorne does and does not exist! This is an intolerable conclusion for a scientific theory! It must mean that the interpretation that Hawking uses for the space and time parameters in the laws of physics is unacceptable.

5 Later on in his career, Einstein changed his mind about what he said earlier regarding the physical attributes of the time parameter 't'. In his 'Autobiographical Notes' [13], Einstein said: "Strictly speaking, measuring rods and clocks would have to be represented as the solutions of basic equations (objects consisting of moving atomic configurations), not, as it were, as theoretically self-sufficient entities."

References

[1] S. W. Hawking, *A Brief History of Time* (Bantam Books, 1988).

[2] S. W. Hawking, *The Universe in a Nutshell* (Bantam Books, 2001).

[3] M. Sachs, 'On Hawking's *A Brief History of Time* and the Present State of Physics', *British Journal for the Philosophy of Science* **44**, 543 (1993).

[4] [4a] K. Goedel: 'An Example of a New Type of Cosmological Solution of Einstein's Field Equations of Gravitation', *Reviews of Modern Physics* **21**, 447 (1949).
[4b] K. Goedel: 'A Remark about Relationship Between Relativity Theory and Idealist Philosophy', in P. A. Schilpp (*ed*.), *Albert Einstein: Philosopher-Scientist* (Open Court, 1949), 557-562.

[5] A. Einstein and N. Rosen: 'The Particle Problem in the General Theory of Relativity', *Physical Review* **48**, 73 (1935).

[6] P. A. M. Dirac: 'The Early Years of Relativity', in G. Holton and Y. Elkana (*eds*.), *Albert Einstein: Historical and Cultural Perspectives* (Princeton, 1982), 79-90.

[7] M. Sachs: *Einstein Versus Bohr* (Open Court, 1988), Chapter 10.

[8] A. G. Kelly: 'Heaefele and Keating Tests: Did They Prove Anything?' *Physics Essays* **13**, 616 (2000).

[9] M. Sachs: 'A Resolution of the Clock Paradox', *Physics Today* **24**, 23 (1971).

[10] M. Sachs: *Relativity In Our Time* (Taylor and Francis, 1993), Chapter 12.

[11] M. Sachs: *Dialogues on Modern Physics* (World Scientific, 1998), Chapter 3.

[12] M. Harada and M. Sachs: 'Reinterpretation of the Fitzgerald-Lorentz Contraction', *Physics Essays* **11**, 521 (1998).

[13] P. A. Schilpp (*ed*.), *Albert Einstein: Philosopher-Scientist* (Open Court, 1949), A. Einstein: "Autobiographical Notes".

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