VIDEO REVIEW

The Nature of Space and Time

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Stephen Hawking and Roger Penrose

Princeton, PA: Princeton University Press VHS 0 691 02609 2
US$295.00 for three tapes

The Nature of Space and Time is a seven and a half hour long video that comes in a three tape set. Professors Hawking and Penrose are shown giving a series of one hour lectures at the Isaac Newton Institute. The topics of their talks range from the structure of space-time to the quantum theory of gravitation. They are organized along three main lines.

Both speakers first discuss the singularities of space and time within the framework of classical general relativity, that is, as deduced from Einstein's equations. After giving arguments in favour of the existence of closed trapped surfaces (collapsing stars, black holes), Hawking draws a parallel between thermodynamic irreversibility and the loss of information coming from gravity trapped surfaces. Instead, Penrose insists on the mathematical structure of the singularities, using in particular the Weyl curvature to characterize them. From his analysis two classes of singularities emerge: those from which matter comes out (big bang) and those in which matter comes in (big crunch, black holes). The classical setting being recalled, the speakers turn to quantum theory.

Hawking's second talk is concerned with the quantum theory of black holes. In order to account for quantum effects, he introduces a path-integral formulation over Euclideanized metrics, Armed with this tool, the validity of which he merely assumes, he proves that black holes actually radiate so that he renders fully consistent the thermodynamic analogy, entropy being replaced by the area event horizon, and statistical fluctuations by quantum fluctuations. Basing his analysis upon an interpretation in terms of information theory, there exists, Hawking asserts, a new level of unpredictability. Penrose prefers not to expand on Hawking's interpretations and starts building upon quantum mechanics (analysis of the EPR experiment) and the density matrix formalism to stress the problems caused by the nonlocality of energy.

In his last lecture Hawking comes back in great detail over the definition of his integration measure over all compact Euclidean metrics and discusses the issue of boundary conditions, summarizing the difficulty of the procedure by `Gravity determines the topology of the manifold on which it lives'. As a conclusion he insists on the predictive power of his theory. He also explains the classical appearance of space-time as a decoherence effect due to the fact that only part of it is seen. Penrose develops twistor theory on a constructive basis from functions on 1D complex manifolds and shows how twistors can describe quantum particles. The wave function has become a complex function on twistor space. Quantum field theory is to be replaced by a twistor quantum field theory. The formalism has the advantage of incorporating in a natural fashion features described by conformal field theory. That twistor theory allows the recovery of existing results is not but a prerequisite, and Penrose remains elusive as to what new concrete results it could bring. Research is in progress.

In the last hour, Hawking and Penrose debate the most speculative parts of their talks and how to interpret or to understand the results.

The viewer should not be misled by the beautiful red apple swallowed by a black hole that is shown on the front cover of the package: it must be emphasized that the talks are highly technical and the authors assume the audience are researchers in the field. Hawking's less mathematical approach might be more accessible to some, who however could find his tendency to over-interpretation somewhat irritating. Others might be delighted by the mathematical beauty of Penrose's description, though it is undoubtedly much more opaque to the mathematically ignorant. The controversies between the two lie on choices of the interpretation, often rooted in their personal philosophical beliefs. As suggested by questions from the floor, another debate, perhaps not as easy to enclose on a videotape, would have involved other approaches such as superstrings.

Be that as it may, whether a researcher or not, the viewer watched half of the time a close shot, under two different angles, of a motionless protagonist, whose personal charisma is certainly not best conveyed through the vibrations of his voice synthesizer. Apart from the obvious intrinsic interest of the topic, nice summarizing transparencies along with puns scattered here and there are not enough to hold the concentration. Of course Penrose's style is livelier by far, though the viewer is given no chance to read the content of his numerous (hand-written) transparencies (shot from the back of the lecture hall), which would be compulsory to follow him in his formal approach. The tapes should at least have been accompanied by a copy of the speaker's documents.

Some European viewers will be spared due to a technical point: the tapes are distributed in the American NTSC format.

Frederic van Wijland

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