Euclidean, Lorentzian, and Physical Time

ROLAND ALLEN, ZORAWAR WADIASINGH, Texas A&M University — Lorentzian time is the time which occurs in the standard equations of physics, with a different status than a spatial coordinate $x$. Euclidean time is obtained from Lorentzian time by a Wick rotation in the complex $t$ plane, and enters into the resulting equations exactly in the same way as a spatial coordinate $x$. It seems obvious that the physical time we experience must be Lorentzian time, and that Euclidean time is just a mathematical artifice which we employ for convenience in calculations. However, Hawking has suggested, in both his popular book (“A Brief History of Time”) and in a more technical context (“Euclidean Quantum Gravity”) that exactly the opposite may be true: Euclidean time may be more fundamental, making quantum mechanics formally identical to statistical mechanics, and Lorenzian time is introduced by human observers because it is more convenient for calculations. We present an argument, based on the path integral formulation of quantum mechanics, which supports this latter point of view. In addition, we propose that the breaking of the symmetry between space and time has a simple cosmological origin.