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[colloquium] The Route from Black-Hole Singularities to a Cyclic Cosmology

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The "singularity theorems" of the 1960s, demonstrated that large enough celestial bodies, or collections of such bodies, would, collapse gravitationally, to singularities, where the equations and usual assumptions of Einstein's classical theory of general relativity cannot be mathematically continued. These singularities are normally expected to lie deep within what are now referred to as black holes, and would, themselves, not be observable from the outside. Nevertheless, their presence is fundamentally problematic for classical physics and it is normally argued that a quantum theory of gravity would be needed to resolve the issue.

Similar arguments (developed largely by Stephen Hawking) apply to the "Big-Bang" picture of the origin of the universe, showing, again, the inevitability of a singularity in the universe's initial state. However, a puzzling yet fundamental distinction between these two types of singularity is found, deeply connected with the 2nd law of thermodynamics. Accordingly, it is hard to see how any ordinary procedures of "quantization" of the gravitational field can resolve this fundamental problem. A possible route to addressing this issue, namely to "gravitize" quantum mechanics, aimed at providing an objective theory of wave-function collapse, will be briefly discussed.

Nevertheless, a deeper understanding of the special nature of the Big Bang can be illuminated by examining it from the perspective of conformal geometry, according to which the Big-Bang singularity becomes non-singular, this being quite different from the situation arising from the singularities in black holes. In conformal geometry, big and small become equivalent, which can only hold for a singularity of the type we seem to find at the Big Bang. This situation is also relevant in relating the extremely hot and dense Big Bang to the extremely cold and rarefied remote future of a previous "cosmic aeon", leading to the picture of conformal cyclic cosmology (CCC) according to which our Big Bang is viewed as the conformally continued remote future of a previous cosmic aeon. It turns out that there are now certain strong observational signals, providing some remarkable support for this highly non-intuitive but mathematically consistent CCC picture.

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