General Relativity and Quantum Cosmology

Consistent Histories in Quantum Cosmology

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We illustrate the crucial role played by decoherence (consistency of quantum histories) in extracting consistent quantum probabilities for alternative histories in quantum cosmology. Specifically, within a Wheeler-DeWitt quantization of a flat Friedmann-Robertson-Walker cosmological model sourced with a free massless scalar field, we calculate the probability that the univese is singular in the sense that it assumes zero volume. Classical solutions of this model are a disjoint set of expanding and contracting singular branches. A naive assessment of the behavior of quantum states which are superpositions of expanding and contracting universes may suggest that a "quantum bounce" is possible i.e. that the wave function of the universe may remain peaked on a non-singular classical solution throughout its history. However, a more careful consistent histories analysis shows that for arbitrary states in the physical Hilbert space the probability of this Wheeler-DeWitt quantum universe encountering the big bang/crunch singularity is equal to unity. A quantum Wheeler-DeWitt universe is inevitably singular, and a "quantum bounce" is thus not possible in these models.

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