Cosmological Singularity Problem

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ABSTRACT

We present the big bounce transition of the quantum FRW model in the setting of the loop quantum cosmology (LQC). We use the reduced phase space quantization method (nonstandard LQC), which is an alternative to the Dirac quantization scheme (standard LQC). Elementary observables are used to quantize compound observables. The spectrum of the energy density operator is bounded and continuous. The spectrum of the volume operator is bounded from below and discrete. The discreteness may imply a foamy structure of spacetime at semiclassical level which may be detected in astro-cosmo observations. We identify physical self-adjoint Hamiltonian. It is used to define an evolution operator of the quantum system via Stone's theorem. We examine properties of expectation values of physical observables in the process of the quantum big bounce transition. The dispersion of observables are studied in the context of the Heisenberg uncertainty principle.
We have generalized our method to sophisticated cosmological models including the Bianchi type universes. We suggest that the real nature of the bounce may become known only after we quantize the Belinskii-Khalatnikov-Lifshitz scenario, which concerns the generic cosmological singularity. Quantization of simple cosmological models carried out during the last decade may be treated as warming up before meeting this challenge.[0.6cm]
Talk would be based (to some extent) on my recent papers:

[1] P. Dzierzak, P. Malkiewicz and W. Piechocki, "Turning big bang into big bounce. 1.Classical dynamics", Phys. Rev. D 80(2009) 104001, arXiv:0907.3436.

[2] P. Malkiewicz and W. Piechocki, "Turning big bang into big bounce: II. Quantum dynamics", Class. Quant. Grav. 27 (2010) 225018, arXiv:0908.4029.

[3] J. Mielczarek and W. Piechocki, "Observables for FRW model with cosmological constant in the framework of loop cosmology", Phys. Rev. D 82 (2010) 043529, arXiv:1001.3999.

[4] J. Mielczarek and W. Piechocki, "Quantum of volume in de Sitter space", Phys. Rev. D 83 (2011) 104003, arXiv:1011.3418.

[5] P. Dzierzak and W. Piechocki, "Bianchi I model in terms of nonstandard loop quantum cosmology: Classical dynamics ", Phys. Rev. D 80, 124033 (2009), arXiv:0909.4211.

[6] P. Malkiewicz, W. Piechocki and P. Dzierzak, "Bianchi I model in terms of nonstandard loop quantum cosmology: Quantum dynamics", Class. Quant. Grav. 28 (2011) 085020, arXiv:1010.2930.

[7] J. Mielczarek and W. Piechocki,"Evolution in bouncing quantum cosmology", arXiv:1107.4686 [gr-qc].