Appendix R

Quntum Gravity Phenomenology

"An accelerator powerful enough to study ... Planckian objects would have to be as large as the entire galaxy."

- Leonard Susskind 2006.

phenomenology comes from small deviations away from classical effects. In LQG the techniques for obtaining the classical limit of the theory have not yet been developed.

R.1 Gamma ray bursts

Each burst is as powerful as a billion trillion suns

might see a lag in photon arrival times as they travel through the

Time delay Interferomtry [gr-qc/0409034].

cosmic rays and photons from gamma-ray bursts are used to probe the structure of space-time at the Planck scale. This is because the discrete geometry is expected to modify energy-momentum relations at very high energies, thereby affecting the propagation of particles and photons over cosmological distances [348]

Below the Plank scale the classical picture of spacetime breaks down. Eisnsten's special theory of relativity is part of the classical picture, so we migh expect it to breakdown at this point.

R.2 Bose-Einstein Experiment of Quantum Gravity Decoherence

Plank-scale-induced deviations whose detection is a function of the number of particles.

[345]

$$\rho_{2_{nm}}(t) = \rho_{2_{nm}}(0)e^{-i\omega_{nm}t}e^{(-\sigma(\omega_{nm})^2)t} \tag{R.0}$$

One could exect to confirm this type of equation by studying some mesoscopic quatum systems.

R.3 Nonlinearities may be Observable in the Next Generation of Molecular Interferometry Experiments

While it is widely believed that gravity should ultimately be treated as a quantum theory, there remains a possibility that general relativity should not be quantized. If this is the case, the coupling of classical gravity to the expectation value of the quantum stress-energy tensor will naturally lead to nonlinearities in the Schrodinger equation. By numerically investigating time evolution in the nonrelativistic "Schrodinger-Newton" approximation, we show that such nonlinearities may be observable in the next generation of molecular interferometry experiments.

R.4 Spectrum of Fluctuations in Singularity-free Inflation

The control that loop quantum gravity has made it possible to compute predictions for real observations. They have been able to derive precise predictions for quatum gravity effects that may be seen in future observations of the cosmic microwave background, [347].

R.5 Formation and Evolution of Structure in Loop Cosmology

Abstract:

Inhomogeneous cosmological perturbation equations are derived in loop quantum gravity, taking into account corrections in particular in gravitational parts. This provides a framework for calcu- lating the evolution of modes in structure formation scenarios related to inflationary or bouncing models. Applications here are corrections to the Newton potential and to the evolution of large scale modes which imply non-conservation of curvature perturbations possibly noticeable in a run- ning spectral index. These e ects are sensitive to quantization procedures and test the characteristic behavior of correction terms derived from quantum gravity

Loop quantum gravity is one of the approaches where singularity resolution has been investigated using loop quantum cosmology [?] which results in the resolution of singularities in various situations including inhomogeneous ones [??]. Semiclassical bounce pictures in special models have been described in [??]. A key role is played by the underlying quantum nature of spatial geometry [??]. With such a discrete structure underlying classical space-time, effects not captured by low energy effective theory become possible. In particular, there are large dimensionless parameters, such as the number of spatial lattice sites in a discrete state, which can always spoil dimensional arguments. In such a context, orders of magnitude of quantum corrections can only be estimated with a detailed analysis of the effective equations arising from quantum gravity. Suitable techniques going beyond low energy effective theory are now available and are applied here.

R.6 Physical effects of the Immirzi parameter

[350]. Effects that are observable in principle, even independent of non-perturbative qunatum gravity.