Gauge-invariant observables in perturbative quantum gravity

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It is well known that the diffeomorphism invariance of gravitational theories makes it impossible to define local and gauge-invariant observables in perturbative (quantum) gravity, except at linear order. While in flat space on can study the S-Matrix, which is a gauge-invariant global observable, no analogue exists in a general curved space. Relational observables (i.e., the value of one field at the point where a second field has a prescribed value) are natural candidates for observables in (quantum) gravity, but they are not local when constructed around a cosmological (FLRW) background spacetime due to the high symmetry of the latter. In this talk, we present a different construction of „almost local" gauge-invariant observables which

- can be computed algorithmically up to arbitrary orders in perturbation theory
- is renormalizable, and gives finite results without uncontrolled approximations and/or smearings
- is independent of the dynamics of the gravitational theory, and thus can be used to compare different models of gravity and inflation including corrections from graviton loops
- reduces at linear order to the well-known gauge-invariant cosmological perturbations.

We furthermore present fully renormalized results for one-graviton-loop corrections to two- point functions and coupling constants.