General Relativity and Quantum Cosmology

Spacetime geometry in (2+1)-gravity via measurements with returning lightrays

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We consider an observer in a (2+1)-spacetime without matter and cosmological constant who measures spacetime geometry by emitting lightrays which return to him at a later time. We investigate several quantities associated with such lightrays: the return time, the directions into which light needs to be emitted to return and the frequency shift between the lightray at its emission and its return. We derive explicit expressions for these quantities as functions on the reduced phase space and show how they allow the observer to reconstruct the full geometry of the spacetime in finite eigentime. We comment on conceptual issues. In particular, we clarify the relation between these quantities and Dirac observables and show that Wilson loops arise naturally in these quantities.

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