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Jędrzej Świeżewski
Faculty of Physics,
Univeristy of Warsaw

Observer's observables.
Definition and applications

Abstract

The thesis discusses a novel construction of observables in canonical general relativity and their applications in two approaches to quantum gravity.

To explain the necessary background, canonical general relativity is reviewed. After highlighting the issue of observables and diffeomorphism invariance, a scheme of dealing with it, coined deparametrisation, is presented. Its relation with relational formalism for observables is also explained. A technical result considering the evolution of relational observables is mentioned and a result clarifying the properties of the irrotational dust model is discussed.

The main result of the thesis, the construction of observer's observables, is presented with all the details. The variations of the observables are found and hence their Poisson algebra is computed. The simplicity of that algebra is an important result of the thesis.

Translating the construction of the observables to the language of a gauge fixing, the radial gauge is discussed. Together with a deparametrisation with respect to the irrotational dust, it allows a reduction of the canonical description of general relativity to variables parametrising only physical degrees of freedom.

Moreover, the variables have a clean geometrical interpretation, which proves useful for the application of the radial gauge in the context of loop quantum gravity. There, it is used to provide a framework capable of providing insights concerning the robustness of the results obtained in a midisuperspace type of quantisation. The importance of the result lies in the fact that the consequences of the sequence in which symmetry reduction and quantisation is applied had not been satisfactorily adressed in the context of loop quantum gravity.

Lastly, the spacetime radial gauge, an application of a variant of the observer's observables, is shown to be present in the AdS/CFT literature, concerned with the gauge/gravity duality approach to quantum gravity. Applying the techniques employed in the derivations of the above results, it is shown that, contrary to the hopes and claims of some authors, the spacetime radial gauge possesses some unwanted features. Namely, the Dirac bracket algebra of the matter sector does not retain its canonical form, but it acquires additional terms. This renders the usage of the spacetime radial gauge very intricate.