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Review of the doctoral thesis of Lenart Brocki
"Aspects of BMS symmetry"

The Bondi-Metzner-Sachs (BMS) group is the asymptotic symmetry group of solutions of the Einstein equations at null infinity. This thesis is devoted to studies of applications of this group similar to those for the Poincare group: charges and Hamiltonian related to asymptotics at spacelike infinity, gauge fields with values in the Lie algebra, deformations leading to quantum algebras. Additionally, there is a section in which the Bekenstein-Hawking formula for entropy of a black hole is derived in the framework of a field theory. The content of the thesis is presented in the Overview.

Section 2 contains an introduction to the Bondi-Sachs metrics, their asymptotic behaviour in the null infinity and origin of the BMS group in dimension 4 and 3. Moreover extensions of this group are introduced and their Poincare subalgebras are classified.

In section 3 the ADM 3+1 decomposition and the related Hamiltonian formalism are described with emphasis on definition of charges corresponding to asymptotic symmetries. Then these methods are applied to symmetries obtained in the process of continuation of the Bondi-Sachs metric from null infinity to spacelike infinity. Unfortunately, this continuation is performed under very strong assumptions (existence of limits of metric coefficents when the retarded time tends to minus infinity), what restricts considerably a space of asymptoticaly flat metrics. Hence, conclusions about symmetries and charges have rather limited value.

Section 4 contains a kind of a no-go theorem on a construction of the gauge theory based on the BMS group. The main reason for this result is a lack of an ad-invariant bilinear form for the BMS algebra. In this situation Author tests action related to the Poincare algebra of the BMS algebra. It turns out that fields with values in a bigger algebra are not admitted in this case. The same happens if the cosmological constant is present.

In Section 5 Author shows how the Poincare group generates the Hopf algebra which can be deformed to obtain a quantum group. Then this procedure is extended to the BMS group in dimension 3 and 4. It is shown that in the resulting structure the Poincare sector cannot be separated.

The main part of section 6 is not directly related to the BMS group. It contains an approximate derivation of the Bekenstein-Hawking formula relating entropy of a black hole to its surface area. This derivation is similar to t'Hooft's proof based on a theory of a scalar field. Here, instead of a brick wall dumping the field to zero, a backreaction of the black hole evaporation on spacetime metric is taken into account. This allows to eliminate a freedom in the choice of a position of the wall. In the second part of the section the information loss paradox in a presence of a BH is discussed. In order to explain this paradox some authors use the BMS group but this approach is questioned by other authors.

Results of Brocki on the deformation of the BMS group (section 5) suport the first point of view.

Summarizing, this thesis contains several interesting results: new calculation of entropy of a black hole, construction of quantum groups related to the BMS group, classification of the Poincare subalgebras of extended BMS algebras and the no-go theorem for gauging the BMS group. In my opinion, the linkage between gravitational field near null infinity and spacelike infinity is defined under too strong asssumptions to have a real value. All main results are already published in physical journals with high impact factor. The thesis is well writen and contains a very useful section Overview. Only the list of references should be improved in two respects. For this number of positions an alphabetical order would be better. Also titles of some references should be completed.

I conclude that the presented dissertation meets the formal requirements for a Ph.D. thesis and recommend admission of the Candidate to the subsequent stages of the procedure, including the public defense.

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