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The Hamilton-Jacobi analysis by Peter Bergmann and Arthur Komar of classical general relativity

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Peter Bergmann initiated in 1966 an application of Hamilton-Jacobi techniques to general relativity. Little had been done by this time on extending this analysis to gauge theories. He proved that when, as in the case of Einstein's theory, the phase space generator of evolution consisted of a linear combination of constraints, the Hamilton principal function must be independent of spacetime coordinates. Also the Hamilton Jacobi equations that determined this functional of the 3-metric retained their form under phase space functionals that were invariant under the action of the spacetime diffeomorphism group. Komar followed up beginning in 1967 with a series of paper in which he proved that a complete solution of the Hamilton Jacobi equations was determined by a commuting set of diffeomorphism invariants. These invariants thereby labeled equivalence classes of solutions of Einstein's equations under the action of the full four-dimensional diffeomorphism group. Furthermore, this set satisfied canonical commutation relations with another invariant set. The hope and expectation was that these invariants could be promoted to quantum operators in a quantum theory of gravity. This framework will be contrasted with J. A. Wheeler's geometrodynamical program in which the only underlying covariance group is spatial diffeomorphisms. The full spacetime diffeomorphism symmetry is replaced by the notion of 'multi-fingered'time. A related dispute concerning the 'sandwich conjecture'will be discussed, relevant to the functional integral approach to quantum gravity. Two three geometries cannot determine a corresponding four geometry if they lie in distinct four dimensional diffeomorphism equivalence classes.

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