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(SUMMARIES)

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QUANTUM GRAVITATION

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The objective of any quantum theory is to predict values of physical quantities. Accordingly, even at the classical level one should ask which quantities are observables. This depends on the invariance group, which in the case of general-relativistic theories is "peculiar": it involves the choice of space-time frame.

There are three distinct groups that may be considered to be invariance groups of general relativity [1]: a) mappings of the space-time manifold on itself, $\bar{x}^{\rho}(x^{\alpha})$; b) mappings that depend on the metric field, $\bar{x}^{\rho}(x^{\alpha}, g_{\mu\nu}(x'))$; and c) mappings of one set of canonical Cauchy data, $g_{mn}(\vec{x})$, $p^{mn}(\vec{x})$ on another [2]. a) and c) are non-invariant subgroups of b). Their Lie algebras have distinct structures.

Observables are invariants under any of the above groups (whose orbits are equivalent) and hence constants of the motion. These three concepts, normally distinct, coincide in general-relativistic theories. With the help of the canonical formalism [2] one can form Poisson brackets, which may provide some guidance towards uncertainty relations in a future quantum theory of gravitation. G. Smith [3] has provided the beginnings of a Bohr-Rosenfeld analysis of measurements of relativistic observables, so far only in a linearized (weak-field) version of general relativity.

Hamilton-Jacobi theory is of interest as a preliminary to quantization (via WKB), as it involves no weak-field approximation, though it is open to the usual objections. It is re-interpreted as generating a mapping from the large phase space of Dirac [2] to a factor space whose points are the physically distinct solutions of the field equations, the so-called reduced phase space. All functions on the reduced phase space are ipso facto observables ("frozen" formalism)[4]. By fixing the values of some observables and by considering the subspace generated by them, one is led to an invariant formulation of phase integrals $\oint p\, dq$, which may perhaps indicate the discrete spectra of some observables via Bohr-Sommerfeld-Wilson [5].

Some conjectures and personal opinions:

a) Quantization remains a programme of fundamental interest.

b) Weak-field approximations are of limited value.

c) Because of the potential impact of singularities on the global scale, local approaches are important.

d) All divers approaches to quantization retain interest as long as none is completely successful.

e) Though in the present theories the carrier of the gravitational field ($g_{\mu\nu}$) is distinguished from all other fields, some fusion might succeed in the years to come (e.g. f-g theory).

REFERENCES

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4) P. Bergmann, NY Acad. Sci. (in process of publication - preprints from Syracuse University).

5) P. Bergmann, J. Gen. Rel. & Gravitation, 1970 or 1971 (presented at the Gwatt Seminar, 1970).