mathematical programs in quantum gravity

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There are several distinct research programs aimed at developing the mathematical foundations of quantum gravity theories. These include, but are not limited to, the following.

0.1 Mathematical programs developments in quantum gravity

1. The twistors program applied to an open curved space-time (see refs. [**?**, **?**]), (which is presumably a globally hyperbolic, relativistic space-time). This may also include the idea of developing a *'sheaf cohomology'* for twistors (see ref. [**?**]) but still needs to justify the assumption in this approach of a charged, fundamental fermion of spin-3/2 of undefined mass and unitary 'homogeneity' (which has not been observed so far);

2. The *supergravity* theory program, which is consistent with supersymmetry and superalgebra, and utilizes *graded Lie algebras* and *matter-coupled superfields* in the presence of *weak* gravitational fields;

3. The no boundary (closed), *continuous* space-time programme (ref. [**?**]) in quantum cosmology, concerned with singularities, such as black and 'white' holes; S. W. Hawking combines, joins, or glues an initially flat Euclidean metric with convex Lorentzian metrics in the expanding, and then contracting, space-times with a very small value of Einstein's cosmological 'constant'. Such Hawking, double-pear shaped, space-times also have an initial Weyl tensor value close to zero and, ultimately, a largely fluctuating Weyl tensor during the 'final crunch' of our universe, presumed to determine the irreversible arrow of time; furthermore, an observer will always be able to access through measurements only *a limited part* of the global space-times in our universe;

4. The TQFT/HQFT approach that aims at finding the topological invariants of a manifold embedded in an abstract vector space related to the statistical mechanics problem of defining extensions of the partition function for many-particle quantum systems;

5. The string and superstring theories/M-theory that 'live' in higher dimensional spaces (e.g., $n \geq 6$, preferred $n - dim = 11$), and can be considered to be topological representations of physical entities that vibrate, are quantized, interact, and that might also be able to predict fundamental masses relevant to quantum particles;

6. The 'categorification' and groupoidification programs ([**?**, **?**]) that aims to deal with quantum field and QG problems at the abstract level of categories and functors in what seems to be mostly a global approach;

7. The 'monoidal category' and valuation approach initiated by Isham to the quantum measurement problem and its possible solution through local-to-global, finite constructions in small categories.

References

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[4] Baez, J. and Dolan, J., 2001, From Finite Sets to Feynman Diagrams, in *Mathematics Unlimited – 2001 and Beyond*, Berlin: Springer, pp. 29–50.