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QUANTUM GRAVITY: HISTORY, HISTORIOGRAPHY, AND PHILOSOPHY

ABSTRACT:

The problem of how to construct and make sense of a theory that unites the principles of general relativity (Einstein's classical field theory of space, time, and gravitation) with those of quantum field theory (our framework for constructing theories for the three remaining forces: strong, weak, and electromagnetic) is widely and rightly believed to be the greatest unsolved puzzle of theoretical physics. The puzzle exposes a deep schism in the foundations of physics and, if we believe that fundamental physics tells us what kind of universe we inhabit, a deep conceptual schism in our world-view.

However, despite nearly eighty years of hard labour by the best physicists of the 20th Century (including multiple Nobel Laureates, such as Dirac, Feynman, t'Hooft, and Weinberg), there is still no theory that solves the puzzle, nor is there even a consensus on how best to proceed in the struggle (though a few 'principles' are beginning to emerge: background independence, holography, etc.). Thus, the revolutionary episodes initiated by general relativity and quantum theory are left incomplete, leaving us with a fragmented conceptual scheme that we do not know how to piece together into a coherent whole. Some believe that the two sets of principles can be made to peacefully coexist; others disagree and view the modification of one or the other set of principles as an ineluctable casualty of the eventual merger.

This is the problem of quantum gravity. Its legacy is a theoretical landscape littered with research programmes engaged in combat (M-theory, loop quantum gravity, causal sets, etc.), and the corpses of once-promising programmes (the covariant perturbative approach, quantum geometrodynamics, etc.). Occasionally one can find a wounded programme recovering and joining with a quite different programme (for example, twistor theory's merger with string theory).

Part of the problem (due to the scales at which quantum gravity is expected to make its mark) is that there is no experimental basis, beyond 'old evidence', to guide the research. Despite this one can, as suggested, find adherence to programmes and the rejection of programmes. Perhaps (though not always) something other than experimental evidence is playing a role in theory selection here? One can certainly find mathematical beauty and the belief in the unity of Nature playing fundamental roles, for example. It is my contention that as a case study, the history of quantum gravity has much to offer philosophy of science: one can see what guides theory selection 'in action'. Old evidence and theoretical and mathematical consistency are central. If we are to believe the historical reconstructions of Stephen Brush, as regards general relativity, then there is nothing novel about this: it is very much science as usual. I agree with this claim, and will attempt to defend it. Given this defense, the claims of string theory—so often subject to attacks on the grounds of 'untestability'—are seen in a much more positive light.

It is, however, primarily the history and historiography of this problem that I propose to consider, albeit from a philosophical perspective. It is a curious fact that despite its age and importance, very little historical work on the problem exists. What little does exist is very small scale, and invariably lop-sided. I have recently begun work on a large-scale study of this fascinating history, and given the nature of the puzzle of quantum gravity (involving, as it does, conflicts between the conceptions of space, time and matter in the ingredient theories), philosophical issues simply cannot (and should not) be shelved. Given the untilled nature of the history of quantum gravity, I also consider various historiographic challenges facing such a study and attempt to motivate its pressing need.