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The Pursuit of Quantum Gravity

Memoirs of Bryce DeWitt from 1946 to 2004, by Cécile DeWitt-Morette. Springer, ISBN 978-3-642-14269-7/14270-3

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Writing a short and vivid account of the life and work of a giant in mathematical physics such as Bryce S. DeWitt is no mean task, but nobody could have been better equipped to do so than his wife and fellow scientist, Cécile DeWitt-Morette. Elegantly written, this book begins by displaying a picture of a young Bryce, who was told by his grandmother that he would live to see the Messiah descend from heaven. Bryce thought this was neat—something like science fiction, but he wondered how this could be managed!

Was this what motivated him later to become a physicist, determined to study gravity? In any case, he would devote much of his career to pursue what would turn out to be one of the deepest mysteries of the physical sciences of our time: the nature of the gravitational force. In particular, we have the question how it can be reconciled with the fundamental features of the particles of matter, even if it is crystal clear that matter does act as a source of gravity. The most salient feature of the dynamical laws of matter is that they have to be phrased in terms of a peculiar twist of logic called quantum mechanics. Quantum mechanics is a package deal: once you accept that this is how fundamental particles move when they interact, everything else in this universe must move in accordance with the same logic.

As a graduate student Bryce learned about the marvelous improvement that Albert Einstein had brought about in gravity theory, called General Relativity, while in turn quantum mechanics was further elaborated in terms of a relativistically invariant doctrine called Quantum Field Theory. The problem was staring him in the face: these two grandiose products of the human intellect had to be basically true, but it was not understood how to fit one with the other. This would be his calling, and he set out to solve this difficulty.

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Today, practically all theoretical physicists agree about the fundamental importance of this question, but it has not always been like that. There were two reasons to advise a young guy to waste his energy on something else. One was, of course, that no experimental settings could be imagined to test the quantum nature of gravity; gravity is generated mainly by astronomically large objects, becoming excessively weak when the sources are small, and even the effects of the Earth's gravitational field on the quantum features of elementary particles are notoriously difficult to detect, although this has been realized, only a few years ago.[1]

The second reason was that, before the 1970s, the properties of matter itself were so poorly understood that questions about the gravitational force seemed to be highly premature: there was so much not known about most of the other forces, even though these *could* be studied experimentally.

There have been pioneers. Bryce recounts that, in 1930, Rosenfeld tried to apply quantum mechanics to gravity, the one other basic force known in nature besides electro magnetism. But, as Bryce recounts: "You have no idea how hostile the physics community was, in those days, to persons who studied general relativity." Sam Goudsmit, then Editor-in-Chief of the *Physical Review* and *Physical Review Letters* was tempted to reject all papers on gravitation and fundamental theory.

And so it happened that Bryce was one of the first few mavericks ready to tackle the problem. There were just a few others, such as Richard Feynman and Ludwig Faddeev. Was his genius undervalued? Bryce once complained about the name "Faddeev Popov ghosts" for the fictitious particles that appear in the Feynman rules for gauge- and gravity theories. His paper contained the same expressions and had been published earlier. But the difference was only two weeks, and, characteristically, Bryce had buried his result in three extremely lengthy and technical papers, where Faddeev and Popov only needed two pages, which was all that was really needed. If you want completeness, Feynman's name should also have been added; he was the first to notice these ghosts, although he could only handle the one-loop case, and hadn't done it quite correctly.[2]

Bryce did research on numerous other topics. Gauge theories of the fundamental particles are closely related to gravity theory, although the most obnoxious difficulty with gravity is absent: the gauge theories are renormalizable. That makes these theories more amenable to the perturbative procedures the early pioneers came up with, and here marvelous successes were obtained. DeWitt, being very mathematical-minded, was enthusiastic about the Batalin-Vilkovisky formalism. Supersymmetry and supergravity and superspace also had his keen interest.

On the more practical side, there was his involvement with computational aspects of black holes and collisions between them.

Bryce was not the only theorist who, later in his career, began to ask questions about the interpretation of quantum mechanics. I vividly remember a meeting in Moscow where Bryce stated that "by now, Everett's 'many-worlds' interpretation of quantum mechanics is accepted by a great majority of physicists...". I stared to

[1] The quantum jumps of neutrons bound by Earth's gravity to a horizontal surface have been observed.

[2] Fenman had added mass terms, to ease the infrared problem, causing his ghost to be a mix of the Faddeev Popov ghost and the Higgs ghosts.

him in disbelief. Certainly I am not among those physicists. At that time, I already had a quite different view on these matters, but now I understand better what drove Everett, and why Bryce went along with the idea. And why they were both wrong, but that is another story. Bryce DeWitt was a colorful member of the theoretical physics community, and Cécile's book fully does him justice.