Radical Conservatism

Niels Bohr, a master of the deductive construction of physical theory, had an uncanny ability to pinpoint and transform deficiencies within theories [9] [538]. Bohr evolved this ability into a process, wherein he would categorize the faults within different versions of the theory and play them off against each other revealing what J. L. Heilbron has called *partial truths* [539]. These were then used to make hypotheses that could be applied not only to the parts that agreed with experimental observation, but also used to isolate exceptions wherein he would begin another round of constructing partial truths [540]. This approach to theoretical physics requires great creativity and the ability to embrace and work with paradox and contradiction. However, deductive thinking also requires responsibility as well as a deep understanding of physics in order for such a process to successfully lead to a solid piece of science. John Wheeler, who regarded Bohr as his mentor and was part of his Copenhagen Institute in the 1930s, characterized him as a daring conservative [541],

> *Conservative against postulating any change in the battle-tested laws of physics, but in the application of them, daring.*

Inspired by Bohr, Wheeler would later call this principle *radical conservatism*, that of conservatively respecting great principles while pushing ideas into radically new directions and logically deducing the unexpected consequences and insights if still constrained by the great principles [542]. Wheeler's student Richard Feynman, who had discovered the sum-over-paths formulation of quantum mechanics, emphasized in an address at the 1961 Solvay Conference how the search for an *exception* or a *failure* is more prevalent in experiment than in theory [543, p. 89],

> *I now realize that there is much to be said for considering theoretically the possibility that Q.E.D. is exact, although incomplete. This assumption may be wrong, but it is precise and definite, and suggests many things to study theoretically, while the other negative assumption, (that it fails somehow) is not enough to suggest definite theoretical research. This is Wheeler's principle of "radical conservatism".*
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> *Things are, of course, quite the other way for experimental research. One should look very hard for an "expected" failure. I have probably been converted from my prejudice that it must fail, just in time to be caught off base by an experiment next month showing that indeed it does.*

The search for the exception is central to the process of deductive reasoning. Newton, Maxwell, Einstein, Bohr, and others used this strategy of deduction constrained by great principles to investigate the foundations of physics but it is seldom used today, particularly regarding the quantum measurement problem. Though Bohr's achievements are undeniable, his application of the deductive process to the problems in science has at times been surprisingly misunderstood. Deduction is explored at length in Chapter 6 where it is contrasted with the more commonly encountered practice of induction.

Besides Bohr's innate ability, he had been continually encouraged by the intellectual stimulation of a remarkable family life [9, p. 42] and by university teachers, such as family friend and philosopher Harald Høffding (1834-1931), who taught that the concept of a secure fact and the notion of a complete theory are at best ideals [540],

See the print edition of The Quantum Measurement Problem for quotation.

What Bohr would insist upon in discussing a proposed conjecture, was whether he could draw arguments in favor of it from the available evidence: logical analysis was not for him a mere verification of consistency, which he regarded as trivial, but a potent and productive device for directing the mind. Wheeler recalled Bohr's Copenhagen Institute in the 1930's:

> *"The central idea of the institute was clear. No progress without a paradox… Explanation was never dry pedagogy, but a one-man tennis match in which Bohr hit the ball from one side of the court, then ran to the other fast enough to hit it back – the more volleys, the more enjoyable the game: Such-and-such an effect leads one to expect thus-and-so…Indeed one does see thus-and-such, but then so-and-so observed such-and-such …That finding put us in immense difficulty. Just at this point so-and-so pointed out that the proper formulation of the principle is not what we thought, but thus-and-such…This discovery brought the whole subject in to order. But then so-and-so realized that this extended principle stands in absolute contradiction to the stability of such-and-such...This discrepancy convinced us that we were absolutely lost. But just today we find that the new formulation itself is really completely nonsense…What fools we have all been! We have only to recognize such-and-such and we see at last that absolutely everything has to be exactly as it is."*
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At a difficult point in a discussion, Bohr would sometimes make a joke based on the old saying about the two kinds of truths, one kind being so simple that the opposite was clearly false and the other so-called "deep truths" whose opposite also is a deep truth [503, p. 240].