Bohr-Einstein Debates Begin

Bohr had significant reservations regarding Einstein's 1905 concept of the light-quanta for the next twenty years as it did not fit into his understanding of radiation. For example, in Bohr's 1922 Nobel address he stated:

> *In spite of its heuristic value…the hypothesis of light-quanta, which is quite irreconcilable with so-called interference phenomena, is not able to throw light on the nature of radiation.*

Bohr joked with Heisenberg [439, p. 6]:

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

As will be discussed, Bohr backed himself into a corner, weighing conceptual arguments against the available experiment evidence. Over the years, he allowed himself to consider several consistent possibilities to address the quantum, including on-average violation of energy conservation. However, in 1925 he finally ran out of alternative arguments to explain electron-radiation scattering phenomena when the development of new coincidence-counting techniques permitted definitive experiments to be performed confirming the existence of light-quanta. This was one more step in the evolution of Bohr's thinking. Just as Einstein had been struggling behind the scenes to understand questions of wave-particle duality that were ultimately related to entanglement, Bohr had gone on his own journey to come to terms with the quantum issues. Even before he had accepted light-quanta and had to confront wave-particle duality, he had been thinking about issues that were also ultimately related to coherence and entanglement. For example, he was perplexed by experiments of Ramsauer from 1920 showing the counterintuitive result that the mean free path of electrons passing through noble gases can increase without bound so that the atoms of the gas become virtually invisible to the electrons [3].

Bohr and Einstein first met in 1919 during a visit by Bohr to Berlin and then the following year when Einstein stopped in Copenhagen. This is where the bond between them really materialized, including losing track of time on an apocryphal streetcar ride, arguing over quanta [440, p. 56]:

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

They immediately developed respect for each other although their subsequent meetings and correspondence were rare but important. But this mutual respect would set the stage for the next three decades for both of them struggling over the essence of quantum theory and each of them coming to terms with a problem that was ultimately about the role of entanglement in the measurement problem.

Bohr was not the only one to initially reject Einstein's light-quanta. This included Planck ("That he may sometimes have missed the target in his speculation, as for

example, in his hypothesis of light quanta, cannot really be held against him") and Millikan who later confirmed Einstein's prediction of the photoelectric effect ("The semi-corpuscular theory by which Einstein arrived at this equation seems at present to be wholly untenable").