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New Discoveries from Schrödinger's Research Notes**

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Erwin Schrödinger, one of the founding fathers of quantum theory, remained throughout his life a critic of the “statistical” interpretation of quantum mechanics championed by Born, Heisenberg, and Bohr and accepted by almost all of his contemporaries. In particular, his coinage of the term “entanglement” and his famous cat paradox in 1935 were intended to bring out what he saw as fundamental problems of the mainstream position. Together with the paper by Albert Einstein, Boris Podolsky, and Nathan Rosen (EPR) of 1935, which used an entangled state to argue that quantum mechanics cannot be a complete description of physical reality, it has become the foundation of a flourishing field of research in the nature and applications of quantum mechanical entanglement, such as quantum information theory and quantum computation.

However, Schrödinger's worries about entanglement and its implications for the interpretation of quantum theory did not start in 1935. Using his extensive research notes, I discuss how the emergence of his worries can be dated all the way back to 1926, when quantum theory was first developed. Schrödinger was well aware of the fact that wave mechanics required the use of entangled states to describe composite systems from 1926 onwards. In his letters he confessed more clearly than in his published writings that this presented an obstacle to his own interpretation of his theory, and it was one of the reasons why he stopped defending it against the statistical interpretation.

Also based on his research notes and correspondence, I show that in contrast to the received view among historians and philosophers of quantum theory, that Schrödinger's 1935 paper was merely responding to the EPR publication, he actually struggled with the essential content of this argument four years earlier. The research notes show that after a talk that Einstein gave in 1931 on his photon box thought experiment, Leo Szilard proposed a simple setup that would achieve the same point that Einstein was making, that it is possible to measure either one of two noncommuting observables on a distant particle without any physical interaction with that particle. This, as Schrödinger also wrote in a letter to Sommerfeld from that time, seems to imply that the distant particle must already possess values for both these observables.

Schrödinger was initially quite skeptical of both Einstein's photon box and of Szilard's mirror experiment. Only when Szilard showed him an explicit wave function to support his thought experiment, Schrödinger realized that entanglement posed a fundamental problem for the understanding of quantum mechanics, not only for his interpretation. The wave function given by Szilard is slightly more general, but essentially the same as the one used in EPR. Since Schrödinger and Einstein were close colleagues and friends in Berlin at this time, it seems eminently likely that Schrödinger must have talked to Einstein about his analyses, and this suggests a likely path how Einstein finally arrived at the simple example exhibited in the EPR experiment. I believe this conclusively shows that Schrödinger's involvement with the EPR argument was not merely a response that was triggered by the publication of the EPR paper. Instead, Schrödinger was actively involved in crafting this argument, even if the logic of the argument is clearly due to Einstein.

Schrödinger however rejected Einstein's conclusion that the thought experiment showed that quantum mechanics was an incomplete theory and that there are objective values to noncommuting observables. Rather, he gave an explicit argument why there could not be any (in modern parlance) non-contextual, i.e. objective, values for these observables.

Since he rejected the statistical interpretation, he was not misled, like both Einstein and the mainstream, to interpret entanglement as a mere case of statistical correlation. This left him to see entanglement as a true paradox that contradicted the very foundations of the belief in an objective world and his remaining hope was that a relativistic generalization of quantum mechanics would not have this problem.

In this light, the many comments from Schrödinger's letters in 1935 that the contents of the EPR paper were already quite familiar to him and discussed at great length back in Berlin ought to be taken more seriously than the historical literature has so far acknowledged. But also, credit for the original formulation of the famous EPR state has to go to a hitherto overlooked actor, Leo Szilard, adding another example to his impressive list of visionary ideas. Nevertheless, Schrödinger remains the one physicist of his time that understood the fundamental importance of entanglement.