Wess-Zumino quantum mechanics and its relationship with quantum optics

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Abstract

By an appropriate representation of the fermionic variables in the Wess-Zumino quantum mechanics, we show it entails a non-linear generalization of the Jaynes-Cumming (JC) model in quantum optics. Actually, we show that the constraints corresponding to the canonical quantization of the fermionic variables define a real eight-dimensional manifold and that one point in it realizes the JC model. As is well known, the Jaynes-Cummings model describes the interaction between a single two-level atom and a single-mode radiation field and it is experimentally realizable in Cavity-QED systems, whereas the Wess-Zumino quantum mechanics is obtained by dimensional reduction from the four dimensional $N = 1$ supersymmetric Wess-Zumino model. This latter describes the evolution of a complex scalar field and a fermionic (spin-1/2) field in four dimensions. Thus, the mapping built up in this work relates two apparently distinct realms, i.e., supersymmetric quantum field theory and quantum optics, and so it allows the use of superspace techniques in quantum optics, for instance, the superfield path integral formalism.

Keywords: Superspace, Wess-Zumino quantum mechanics, Jaynes-Cumming model, Cavity-QED systems, non-linear quantum optics, supersymmetric optics.

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