Comment

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Comment on DEMONSTRATION OF THE SPIN-STATISTICS CONNECTION IN ELEMENTARY QUANTUM MECHANICS

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The spin-statistics theorem, as well as the PCT theorem, is usually formulated in the framework of the relativistic quantum field theory and subsequently proved using all the machinery of this theory with special emphasis put on the locality principle [1]. In this context the spin-statistics theorem is considered as a consequence of basic axioms underlying the relativistic quantum field theory. Moreover, it is believed to be provable only within the formalism of the relativistic quantum field theory which differs its status from other properties of physical systems usually considered as consequences of relativistic invariance but in fact shown to be correctly described also within consistently formulated Galilean covariant field-theoretical models [2]. As examples of such prejudices one can mention the spin and the gyromagnetic ratio of the electron, or the existence of antiparticles. Being dominated, or even suppressed, by both the formalism of the

relativistic quantum field theory and requirements of its mathematical rigor we used to accept such an approach and in fact we have not paid attention to the fact that the spin-statistics connection is valid for physical systems independently from the choice of their correct description, relativistic or nonrelativistic. But if it is so, there should exist consistent explanations (not necessary "proofs" in a rigorous mathematical sense) of the spin-statistics connection which use notions taken from nonrelativistic quantum physics and, eventually, possible to be formulated in the language of standard quantum mechanics. It is my feeling that J.A.Morgan's work follows such a way of thinking and provides the reader, hopefully also a student who passed a course of elementary quantum mechanics and who is still interested in learning and understanding quantum physics, an example that the spin-statistics connection is deeply built-in into physics and that we should not treat its appearence in the relativistic quantum field theory a mysterous *deus ex machina* event.

As claimed by the author "the most of the paper rely upon concepts and methods taken from elementary quantum mechanics" and I share his opinion. Reading the technical part of the paper reminds how useful can be analysis of the angular momentum, the Clebsch-Gordan coefficients and the parity operation - everything seems to be clear. The situation changes when one comes to the discussion presented in the Section 4. The author links his nonrelativistic considerations to relativistic physics and here I face the impression that this is unnecessary and done, in a sense, by force. For me the concept of changing the particles is purely nonrelativistic and we should restrict ourselves to this statement - relating it to commuting field operators localized in space-like separated regions, even if close to intuition, does not give any profit to the pedagogically oriented paper.

References

[1] See for example: S. Schweber, *An Introduction to Relativistic Quantum Field Theory*, Row, Peterson and Co., Evanston, Ill., Elmsford, N.Y., (1961), Ch. 18; S. Weinberg, *The Quantum Theory of Fields*, Cambridge University Press, (1995), Vol. I, Ch. 5.

[2] J.-M. Levy-Leblond, *Galilei Group and Galilean Invariance*, in *Group Theory and Its Applications*, Vol.2, Ed. E. Loebl, N.Y. (1971), Section VI.D.1.