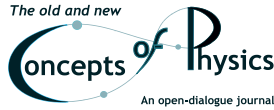


Comment



[www.uni.lodz.pl/concepts](http://www.uni.lodz.pl/concepts)

## Comment on SOME PUZZLES IN QUANTUM MECHANICS

Piotr Kosiński

Department of Physics and Applied Informatics

University of Łódź

Pomorska 149/153, 90-236 Łódź, Poland

e-mail: [pkosinsk@uni.lodz.pl](mailto:pkosinsk@uni.lodz.pl)

The problem of selfenergy (SE) for bounded electrons is well elaborated. This is a part of the general problem of shifting of atomic levels (see, for example, the book by Akhiezer and Berestecky). One simply takes the standard QED and splits the electromagnetic field into classical and quantum parts. The linear problem of Dirac particle in classical em field is solved first and the effect of quantum em field is taken into account perturbatively. This allows for neglecting the selfinteraction contribution to the electron mass by renormalizing it for freely moving electron and taking systematically corrections following from the fact that electron is bounded. The equation proposed by the author is written ad hoc. The proper approach is most clearly seen if one uses the Columb gauge in the formalism sketched above.

Consider now the helium problem. I agree that the many-electron atoms cannot be exhaustively explored without numerical calculations. It is also true that the SE is not complete without boundary

## Comment

conditions. This is, however, rather obvious. One should keep in mind that the quantum mechanical operators, in particular an energy operator, are given as selfadjoint operators related to some formal differential operators and their proper definition needs a careful determination of the domain. This is well known and can be found in Kato, Thirring or Simon & Reed books. As far as helium atom is concerned most of its qualitative properties are well understood. In order to classify its eigenstates one has to find the complete set of commuting observables. In general case this problem is quite interesting. If the classical counterpart of quantum system is integrable and the integrability property survives quantisation the problem is solved automatically; moreover, for generic nonsuperintegrable system the complete set of commuting observables may be smaller than the number of degrees of freedom indicate; in fact it can reduce to the energy itself if there is no degeneracy. For nonintegrable systems the number of commuting observables in complete set is smaller than the number of degrees of freedom.

In the nonintegrable case of, say, parahelium there are nine degrees of freedom and six commuting integrals only (total momentum, energy, total angular momentum and one of its components). The resulting equation is, therefore, three dimensional. It cannot be solved exactly but there are no conceptual problems. These only arise if one wants to quantize helium energy by the methods of old quantum theory; the latter demands complete integrability on classical level which is not the case here.