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QED approach to parity non-conservation effect and dynamical enhancement of weak interaction: Quantum chaos

During the past decade, first of all the optical experiments to detect atomic parity on-conservation (PNC) have progressed to the point where PNC amplitudes can be measured with accuracy on the level of a few percents in certain heavy atoms [1]. To provide an adequate treating these experiments in terms of the standard model for electro-weak interaction, comparison of the measured amplitudes with theoretically defined ones is required. In the quantum many-body systems with dense spectra of excited states weak perturbation can be significantly enhanced. We consider an enhancement of the PNC effects in heavy atoms and neutron-nucleus reactions. Using the PNC effects one can study quantum chaos in many –body systems, nuclear fission , distribution of neutrons in nuclei etc [2,3]. In our paper we systematically apply the formalism of the QED many-body perturbation theory (PT) [2] to precise studying PNC effect in heavy atoms with taking into account the relativistic, nuclear, QED corrections. The key element is in an accurate taking into account the correlation corrections (CC) of the PT second and higher orders (dominating classes: Coulomb interaction screening; interaction «particle-hole» ; mass operator iterations), which is based on using the Feynman diagrammatic technique and Green function (GF) method. The chain of the screening correlation diagrams forms the geometric progression, the mass operator iterations accouting reduces to solution of the corresponding equations. Usually the GF is defined on the basis of the direct summation. More effective procedure is based on the GF definition from solutions of the Dirac equations. Missing non-local exchange interaction, the GF is defined by the corresponding solutions of the Dirac equations: regular in zero and on indefiniteness. The exchange interaction is taken into account by solving the matrix equation: GF=G+G·V·GF. Earlier an efficiency of this approach was shown in the precise calculation of hyperfine structure constants for a number of the atomic systems [4]. Here present numerical illustrations concerning definition of the hyperfine structure intervals, E1-,M1-transitions amplitudes in some heavy systems.

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