Non-Perturbation Method on Quantum Electrodynamics
(Atomic Shwinger-Dyson Method)

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We proposed Relativistic Quantum Electrodynamics in matters under strong external fields obeying to Finite Schwinger Dyson Formalism. The original Schwinger-Dyson formalism (SD formalism) is generalized for the application to atoms, molecules and electron matters under external fields. Because the generalized formalism has some important differences from original SD formalism widely used in elementary particle physics, it is called Atomic Schwinger-Dyson (ASD) formalism. First, we introduce the well-known Lagrangian density of quantum electrodynamics (QED), and we consider the classical field and quantum one under the existence of external fields. Then the electromagnetic field of ASD is separated into two parts, which are a mean field (classical field, Coulomb's field, and parts of External classical fields) and a fluctuation filed (quantum field). By paying special attention to the treatment of the condensed photon fields, the coupled Dyson equations of electron and photon are derived based on a functional propagator method. The exact formal solutions of those equations, electron propagator G(p) and photon propagator D_{ab} can be expressed with using the retarded potential, vertex function Γ(p,q) photon self-energy t Q_{ab} and electron self-energy Σ(p). The large photon self-energy invalidates the perturbation approach, and especially the photon self-energy, which is a ring diagram, represents medium effects from particle-hole excitations or particle-antiparticle effects while the photon propagates in various matters. Thus, ASD is truly non-perturbation method and a soluble exact formalism**.** At second, we proposed how to decompose ASD forms into real physical elements, since the electron propagators are composed of electron, positron and of hole. In finite systems, the total electron self-energy Σ(p), which had a classical part t3^C(p) and a quantum part Σ^Q(p), was written down with a one point function <φ(p)> and various propagators. In order to obtain the photon representation we introduced the Lorentze boost and projection operator, and we succeeded to rewrote the electron and baryon density into the integral expressions. Next stage, we proposed the Integral Particle-Hole-Antiparticle Representation (IPHA) and a calculating algorithm for Atomic Schwinger-Dyson method in this paper. The systematic algorithm of ASD method gives us the relativistic and improved radiative correction for molecular structure of matters under the external fields. ASD has anything to do with some famous approximation, (i.e., Hartree method, Hartree Fock method, perturbation method, and Random Phase Approximation), and include those approximations as a part of ASD method. We notice that the self-energy Σ(p), of electron in ASD includes both the quantum component and the classical component (classical external field and Coulomb's field). We emphasize that ASD can be perfectly written down with three terms, i.e., scalar partΣ_S(p), 4-dimensional vector partsΣ_j(p). The any other terms(higher tensor part, 4-dimensional vector parts Σ_j(p). The any other terms (higher tensor part, ever appear in ASD formalism which makes perfectly the closed self-consistent system. As long as one considers the self-energy of electron and vacuum polarization of photon, the predictions of ASD are always free from divergence. ASD belongs to a well-defined class of field theories in which all ultraviolet divergences are removed after fixing small number of physical parameters. The ASD is renormalizable quantum field theory which is accompanied with both the classical field and quantum field.

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