RELATIVISTIC THEORY IN TERMS OF TWO-COMPONENT SPINORS

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For a theory of electrons only, two-component spinors are sufficient, while four-component spinors (bispinors) are required for a simultaneous description of electrons and positrons. However, the formulation of a relativistic two-component theory for electrons (often called quasi-relativistic theory) meets a lot of obstacles. The rather popular Foldy-Wouthuysen transformation cannot be used as starting point for a two-component formalism, because (in the presence of Coulomb forces) it introduces spurious and even pathologic singularities, that were not present in the original Dirac theory. However, it is, in a surprisingly simple way, namely by a two-step procedure – in the framework of the theory of effective Hamiltonians –, possible to avoid these singularities. On this way a very general quasi-relativistic formulation is possible, that contains e.g., the Douglas-Kroll-Hess (DKH) transformation or the zeroth-order regularized approximation (ZORA), as well as the recently presented 'quasidegenerate direct perturbation theory' (QD-DPT) and ist infinite-order variant as special cases. The question of rigorous upper bounds and its relation to a regularization of the trial functions is discussed. So is the difference between 'variational' and 'variationally stable'. The last part of the lecture is devoted to many-electron systems, where still a few important problems are not fully understood.