Some recent results in the theory of stochastic electrodynamics (SED) are presented. First it is seen that introduction of the SED hypothesis of a real zeropoint field into the thermodynamical description of the equilibrium radiation field in terms of a Maxwell-Boltzmann distribution, leads to Planck's formula and concomitant quantum properties, thus showing that SED is not a classical theory. A new version of SED is then used to study the stationary orbits of the bound particle; under certain explicitly stated conditions it is possible to recover the quantum equations of motion. It is argued that these stationary motions can be interpreted as limit cycles of the mechanical part of the system. The results strongly suggest that quantum mechanics provides an approximate asymptotic description of nature; the kind of approximations involved are briefly discussed.

Key words: Planck's law, zeropoint field, stochastic electrodynamics, Heisenberg equations, limit cycles

1. INTRODUCTION

On this occasion we want to present some recent results of stochastic electrodynamics (SED), the theory built upon the assumption that quantum properties arise as a consequence of the zeropoint radiation field (zpf). Due to lack of space the presentation will be very sketchy; we invite the interested reader to find the omitted details in Refs. [1,2]. The first part of the paper is devoted to the oldest quantum problem, namely Planck's law, whereas in the second part we direct our attention to the mechanics of the SED system. Although the two parts belong to the same theory they are very different in nature. In dealing with the problem of the statistical properties of the field in equilibrium with matter, we will apply ideas that are well known; the solution we are offering could long ago have been found by any of the proponents of SED and thus counted as another one of the...
problems that SED has tackled with success—which is characteristic of the linear problems.

As is well known, SED has been able to solve (or at least to offer understandable physical explanations to) a good series of quantum problems, from the simple harmonic oscillator [3], the van der Waals forces [4], the atomic lifetimes and the Lamb shift, both in vacuum and within cavities [5], to those typical effects of quantum optics that have been studied in stochastic optics [6]. However, the passage from the linear problems to the atomic ones revealed to be far more than a simple matter of technicalities, to the extent that it has been expressed more than once that SED simply is not the correct theory of matter—with as much conviction as it has been said that the failure lies not in the essence of SED, but in the approximations and methods used. Some pertinent references and reviews are [7], [8], and [9].

Some of us still believe that SED contains already the essential ingredients to explain the nonrelativistic quantum behaviour of matter, and that the addition of new ones will allow perhaps a more precise and detailed account of the quantum facts, without inducing a deep conceptual change of the basic scheme. In support of this statement we argue as follows. In usual SED it is assumed that the motion of the atomic system should be obtained as a perturbation of the classical solution. However, the zpf and radiation reaction play an essential role, to the extent that in the stationary states, which are reached after a transient, dissipative process, the average rates of energy absorbed from the field and radiated by the particle coincide; the field controls the existence of such states. This situation can hardly be describable by perturbative methods. It is possible to think, as we shall discuss in the second part of the paper, that there exist limit cycles towards which the atomic electrons fall, giving rise to these stationary states of motion. Further, the fact that the random force on the particle comes from a field seems to be crucial. Indeed, in developing its motion the atomic electron continuously changes the frequencies of the (average) orbital motion due to the nonlinearities of the system. Now, we consider the field as consisting of a set of oscillators, which are physically real and not merely a mathematical artifact; thus, at every moment the orbiting electrons are subject to external excitations to which they resonate. The strong response to such perturbations means fast changes in the orbital motion, except when the system is in one of the stationary states.

In the second part of the paper we sketch an attempt to test these ideas. We show that it is indeed possible to extract a quantum behaviour for the atomic electron subject to the zpf by introducing a couple of demands within the spirit of the above discussion. In this sense, the derivation of Planck's law from the single extra requirement of the existence of the zpf on top of classical elements gives strong support to the conjecture that