Foundations of Physics, Vol. 34, No. 6, June 2004 (© 2004)

The Electrodynamic 2-Body Problem and the Origin of Quantum Mechanics

C. K. Raju[1]

Received May 9, 2003: revised February 20, 2004

We numerically solve the functional differential equations (FDEs) of 2-particle electrodynamics, using the full electrodynamic force obtained from the retarded Lienard–Wiechert potentials and the Lorentz force law. In contrast, the usual formulation uses only the Coulomb force (scalar potential), reducing the electrodynamic 2-body problem to a system of ordinary differential equations (ODEs). The ODE formulation is mathematically suspect since FDEs and ODEs are known to be incompatible; however, the Coulomb approximation to the full electrodynamic force has been believed to be adequate for physics. We can now test this long-standing belief by comparing the FDE solution with the ODE solution, in the historically interesting case of the classical hydrogen atom. The solutions differ. A key qualitative difference is that the full force involves a 'delay' torque. Our existing code is inadequate to calculate the detailed interaction of the delay torque with radiative damping. However, a symbolic calculation provides conditions under which the delay torque approximately balances (3rd order) radiative damping. Thus, further investigations are required, and it was prematurely concluded that radiative damping makes the classical hydrogen atom unstable. Solutions of FDEs naturally exhibit an infinite spectrum of discrete frequencies. The conclusion is that (a) the Coulomb force is not a valid approximation to the full electrodynamic force, so that (b) the n-body interaction needs to be reformulated in various current contexts such as molecular dynamics.

KEY WORDS: many-body problem; protein dynamics; functional differential equations; relativistic many-body problem; interpretation of quantum mechanics.

[1]Centre for Computer Science, MCRP University, Gyantantra Parisar, 222, M.P. Nagar Zone I, Bhopal 462 011, India; e-mail: c_k_raju@vsnl.net

0015-9018/04/0600-0937/0

1. INTRODUCTION

1.1. Aim

This author had earlier[1] proposed a new model of time evolution in physics using mixed-type functional differential equations (FDEs), with a tilt in the arrow of time. This paper sets aside the notion of a "tilt", and takes up only the FDEs of retarded electrodynamics. The retarded case already explicitly incorporates certain subtle mathematical features of electrodynamics and relativity noticed by Poincaré, but overlooked by Einstein and subsequent researchers. To bring out these subtleties, this paper reports on a numerically computed solution of FDEs of the 2-body problem of classical retarded electrodynamics.[2]

The use of the full (retarded) electrodynamic 2-particle force leads to the formulation of the electrodynamic 2-body problem as a system of FDEs that have *not* actually been solved earlier, numerically or otherwise, despite some sporadic attempts in simplified situations.[3] In the absence of a systematic way to solve these FDEs, a widely used alternative has been to approximate the full electrodynamic 2-particle force by the Coulomb force. This reformulates the electrodynamic 2-body problem as an easier system of ODEs, which can be numerically solved with exactly the same numerical techniques that are used for the ODEs of the classical 2-body problem of Newtonian gravitation. This alternative ODE formulation of the 2-particle electrodynamic interaction is incorporated, for example, in models of protein dynamics[4] underlying current software such as CHARMM, WASSER, AMBER, etc.

This alternative ODE formulation is, however, mathematically suspect, for it is known that solutions of FDEs may exhibit qualitative features impossible for solutions of ODEs. On the other hand, it is believed that, from the viewpoint of physics, the Coulomb force is an adequate approximation to the full electrodynamic force.

We can now put this long-standing belief to test: our numerical solution of the full-force FDEs enables us compare the two solutions in the historically interesting context of the classical hydrogen atom.

1.2. The Full Electrodynamic Force

In classical electrodynamics, the force between moving charges is given by the Lienard–Wiechert potentials combined with the Heaviside–Lorentz force law. The scalar and vector (retarded) Lienard–Wiechert potentials, are given by the expressions[5]