DYNAMICS OF A CHARGED PARTICLE IN ELECTROMAGNETIC FIELD WITH JOULE EFFECT

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Abstract. In this paper, we present a new approach for solving equations of motion for the dynamics of charged particles moving under the action of electromagnetic field along with additional influence of the Joule effect. A new type of solving procedure is implemented here for the equations of motion of the charged particle, determined by the Lorentz force, and additionally taking into account the Joule effect. Meanwhile, the system of equations of motion has been successfully explored with respect to the existence of an analytical way for the presentation of the solution. Last but not least, we obtain the solutions in a form of a spiral-type motion. As a main result of this study, the equations of motion are reduced to a system of two nonlinear ordinary differential equations of first order (with regard to time t) for two unknown functions: 1) w(t) (angular velocity of spiral rotation) and 2) ξ (t) (spiral factor of motion for a charged particle). Moreover, the approximated solutions have been also obtained under appropriate simplifying assumptions.

Keywords: Lorentz force, charged particle, Joule effect.

1. INTRODUCTION, EQUATIONS OF MOTION

The Lorentz force [1] plays a significant, crucial role at describing the dynamics of a charged particle, moving under the action of electro-magnetic field (including dynamics of solar wind near the magnetic shield of the planets); this is an extremely non-linear problem even in non-relativistic case insofar.

It is worth to note that only a few cases of analytical or semi-analytical solutions are known in the history of electro-magnetic theory, including trivial case of zero electric field along with constant magnetic field (which means a circular motion of a particle) as well as elegant Alfven's solution for solar wind in MHD theory [2].

The problem of motion of a charged particle under a Lorentz force has been studied in the past under various versions (*e.g.* Störmer's problem, the magnetic-binary problem, as well as in various models of Celestial Mechanics, Geophysical Sciences, and Plasma Physics) and there is a rich and extended international bibliography. In the current research, we will restrict ourselves in presenting a new analytical technique for solving equations of