Iranian Journal of Physics Research, Vol. 23, No. 2, 2023
DOI: 10.47176/ijpr.23.2.71720

A finite model for electrodynamics by introducing a form factor $f_{HD_2}\left(\ell^2\Box\right)=1+\left(-\ell^2\Box\right)^2$ into the kinetic term of Maxwell theory

M Hashemi and S K Moayedi

Department of Physics, Faculty of Basic Sciences, Arak University, Arak 38156-8-8349, Iran

E-mail:s-moayedi@araku.ac.ir

(Received 12 July 2023 ; in final form 23 August 2023)

Abstract

In this paper, a higher-derivative model for electrodynamics is presented in a $D+1$ dimensional Minkowski space-time by introducing a form factor into the kinetic term of Maxwell theory as $-\frac{1}{4\mu_0}F_{\mu\nu}F^{\mu\nu}\to-\frac{1}{4\mu_0}F_{\mu\nu}f_{HD_2}\left(\ell^2\Box\right)F^{\mu\nu}$, where $\ell>0$ is a characteristic length scale. Our calculations show that for $D\in\{3,4,5\}$ the electrostatic potential of a point charge is finite at the position of the point charge in this higher-derivative modification of Maxwell's theory. For $D=3$ the explicit form of the potential and the electric field of a point charge are obtained analytically in this higher-derivative electrodynamics. According to numerical estimations, the upper bound for the characteristic length scale ℓ is $\ell_{\max}\sim\frac{1}{100}\ell_{electroweak}$, where $\ell_{electroweak}=10^{-18}m$ is the electroweak length scale. Finally, it should be emphasized that for $\ell\ll1$ the results of this paper are compatible with the results of ordinary Maxwell theory.

Keywords: Maxwell electrodynamics, regularization techniques, form factor, characteristic length scale, field theories with higher derivative terms

For full article, refer to the Persian section