ON THE NONLOCAL SYMMETRIES OF THE MAXWELL EQUATIONS AND THE CONSERVATION LAWS

I.Yu. Krivsky, V.M. Simulik

Institute of Electron Physics, Nat. Acad. Sci. of Ukraine
(*21, Universytets'ka Str., Uzhgorod 88000;*
e-mail: sim@iep.uzhgorod.ua)

S u m m a r y

We have found two new unitary representations, relative to which the free Maxwell equations are invariant and which are determined by nonlocal generators of the universal covering Poincare group. It is shown that both representations, like a local one, describe a field with mass $m = 0$ and spin $s = 1$ (helicity $h = \mp 1$). We have proposed a Lagrangian in terms of the intensities $(\vec{E}, \vec{H}) = \vec{\mathcal{E}} \equiv \vec{E} - i\vec{H}$ of an electromagnetic field, which gives the physically adequate correspondence "symmetry generator – conservation law" using the usual method based on the Noether theorem. In this way, not appealing to potentials, we have obtained the standard series of 15 Poincare $(P_\mu, J_{\mu\nu})^{\rm loc}$ and conformal (D, K_μ) conservation laws as a result of the local conformal $C(1,3)$-symmetry of the free Maxwell equations and two sets $(P_\mu, J_{\mu\nu})^{\rm I,II}$ of basic dynamical variables — the consequences of the mentioned nonlocal symmetries, and $(P_\mu, J_{\mu\nu})^{\rm I} = (P_\mu, J_{\mu\nu})^{\rm loc}$. The quantities $P_\mu, J_{\mu\nu}$ are presented in terms of momentum-helicity amplitudes, and it is shown that the collection $(P_\mu, J_{\mu\nu})^{\rm I}$ requires the Bose-quantization of the field $\vec{\mathcal{E}}$, whereas the collection $(P_\mu, J_{\mu\nu})^{\rm II}$ requires the Fermi-quantization of this field. The last one is referred to a hypothetical massless particle with helicity $h = \mp 1$ obeyed the Fermi—Dirac statistics. Both types of quantization use the Fock space with a definite metric and satisfy the principle of microcausality. We propose to call the hypothetical particle under consideration as a Fermi-photon (F-photon).