Waves of correlations of electromagnetic field in nonequilibrium emitter medium

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In our paper [1] kinetics of electromagnetic field described by its average quantities $\xi^x_{in}(t)$ ($\xi^x_{1n}(t) \equiv E_n(x,t)$, $\xi^x_{2n}(t) \equiv B_n(x,t)$) and binary correlations $(\xi^x_{in}\xi^{x'}_{i'n'})_t$ has been developed for nonequilibrium medium consisting of two-level emitters. The medium is described by density of emitter energy $\varepsilon(x,t)$. Spatial density of emitters $n(x)$ is assumed to be constant. Spatial orientation of the corresponding dipoles is considered as an isotropic one. Material equation for the current density is given by relation

$$J_n(x) = \int dx'\sigma(x-x',\varepsilon(x))E_n(x') + c\int dx'\chi(x-x',\varepsilon(x))Z_n(x')$$

where the Fourier transformed values $\sigma(k,\varepsilon)$, $\chi(k,\varepsilon)$ are conductivity and magnetic susceptibility which in developed approximation are proportional to $\varepsilon(x)$ ($Z_n(x) \equiv \mathrm{rot}_n B(x)$; we omit here and further time variables). Evolution equation for the energy density is given by formula

$$\partial_t\varepsilon(x) = \int dx'\sigma(x-x',\varepsilon(x))\{(E^x_n E^{x'}_n) + E_n(x)E_n(x')\}+$$

$$+c\int dx'\chi(x-x',\varepsilon(x))\{(E^x_n B^{x'}_n) + E_n(x)B_n(x')\} + R(n(x))$$

in which the last term describes dipole radiation of the emitters. Obtained in [1] time equations for correlations of the field satisfy the Onsager principle. Therefore, material equations for field-current correlations are defined by the above mentioned material coefficients. On the basis of the described equations waves of correlations of the field and energy density of emitters have been investigated. These waves describe periodic exchange by energy between the field and emitters. In the considered approximation usual electromagnetic waves of a small amplitude do not interact with waves of correlations of the field.

[1] S.F. Lyagushyn, A.I. Sokolovsky, Physics of Particles and Nuclei, 41(7) 1035-1038 (2010).