ENHANCEMENT OF HIGH-FREQUENCY FIELD IN NEAR-REAL METAL MIXTURE

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Abstract

The a.c. electric field distribution is studied in a composite, containing n metal layers. The possibility that 2D two-component systems can have non-continuous absorption in the absence of local absorption was evidenced. We study the second and higher moments of electric field and show that they diverge with the decrease of local absorption. The 3D system near the percolation threshold is also discussed. The observation of giant electric field enhancements in a not discovered in 2D is explained.

Introduction

Recently the effect of giant a.c. field enhancements in a 2D composite, containing local plasmons, was discovered. This was done on computer simulations on a system, containing discrete emissive elements, capacitors and inductors, together with a measurement of the electric field in a 2D composite containing a metal-insulator mixture with different conductivities. The strong electric fields can be explained by the presence of global losses in the insulator region, while the true random losses are small, while a second local accumulation of electron magnetic energy is not negligible. The electrostatic local energy accumulators are formed by random local. C circuits or using the solid state physics language, by local modes on m odal.

The observation of strong field enhancements can be explained by poor convergence of a.c. permittivity of the medium. This opposes to the usual convergence of a.c. conductivity of random system. The first field from the insulator phase is small, but it is noticeable in the second. The purpose of the present study is to theoretically explain the observed a.c. field enhancement in a 2D insulator of exactly measurable n real metals of random n by Dykhne and in a 2D composite, containing local plasmons. We shall show that the electric field enhancement in a 2D composite is due to the local plasmon modes remaining long-lived. Such a system exhibits the divergency of higher moments in a 2D composite.

The problem of 2D statistically equivalent two-phase mixture was not studied by Dykhne. The effective electric permittivity in such a medium obeys the following equation

\[ \varepsilon_{eff} = \frac{\varepsilon_1 + \varepsilon_2}{2} \]  

(1)

where \( \varepsilon_1 \) and \( \varepsilon_2 \) are the local permittivities of both n media. Let's consider the case of two n metals so that on the n frequency boundaries n media are near-lossless;

\[ \varepsilon_{12} = 1 \]  

(2)

For n real metal n = 2

\[ \varepsilon_{eff} = \frac{\varepsilon_1 + \varepsilon_2}{2} \]  

(3)

Such system may be considered, for example, as an in-line lattice, built from capacitors and inductors with in pedances \( L = C \) and \( L = \frac{1}{C} \), where C and L are the capacitance, self-inductance and resistivity of energy, m in equal ratio.

Within the region \( \varepsilon_1 < \varepsilon_2 \) both n permittivities are real, while, in \( \varepsilon_1 > \varepsilon_2 \) they are imaginary. Nevertheless, if the local rate of absorption is small, the system as a whole absorbs energy, but it should be chosen in accordance with the condition of energy absorption. The imaginary part with the energy conservation law is involved in Larmor damping | the absorption of the whole n medium m the excitation of local plasmons. That gives losses of a macroscopic medium while the n microscopic layers are losses. Hence the energy should be absorbed by the whole medium without heating and should be accumulated by planes on its way to convert the heat by real conductivity.

\[ \frac{\text{energy}}{\varepsilon_{eff} = \varepsilon_1 \varepsilon_2} \]  

where \( \varepsilon_{eff} \) is the effective permittivity of the composite materials.

Dykhne M edium

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(4)

In the case of Dykhne medium, we can nd the exact formula for \( \varepsilon_{eff} = \varepsilon_1 \varepsilon_2 \). From the energy conservation law we have

\[ \frac{\text{energy}}{\varepsilon_{eff} = \varepsilon_1 \varepsilon_2} \]  

where \( \varepsilon_{eff} \) is the effective permittivity of the composite materials.

The equations (1) and (2) mean that averaging is done in the 2D medium, corresponding to

\[ \frac{\text{energy}}{\varepsilon_{eff} = \varepsilon_1 \varepsilon_2} \]  

The equation (1) may be generalized to the a.c. case including complex capacitance and vector components of the field (Appendix:)

\[ \frac{\text{energy}}{\varepsilon_{eff} = \varepsilon_1 \varepsilon_2} \]  

The subscripts 1 and 2 mean that averaging is done in the 2D medium, corresponding to

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Realistically if the ed ictuations exceed the average ed it is not reasonable to consider the polarization p as a preassigned quantity and should change it together with electric ed . Hence we play role of limit E by size for the formula (1) and K = E
.

The density of excitations in D ykhne ed can be estimated as a density of "hot spots" and has a power-law dependence of probability of two distant sites belonging to the same ed cluster. It is independent on electric parameters. In the present work we studied the moments of electric field in the system the effective properties do not have definite limits and they are not self-averaging. For example, this is reflecting in the frequency dependence of correlation radius in the system. The system spectrum does not contain singular lines. This is easy to understand if to consider the boson system like the quantum particle (photon) propagation in the inhomogeneous disordered media. In fact, the spectrum of quasiparticle spectrum consists from distinct lines and the spatial distribution of wave function amplitude is fractal. The divergence of squared modulus of wave function leads to the localization of photons. In the term of fractals model this is the localization of ed in resonating circuits. The moments of electric field in the system the e. f. properties do not have definite limits and they are not self-averaging. For example, this is reflecting in the frequency dependence of correlation radius in the system. The system spectrum does not contain singular lines. This is easy to understand if to consider the boson system like the quantum particle (photon) propagation in the inhomogeneous disordered media. In fact, the spectrum of quasiparticle spectrum consists from distinct lines and the spatial distribution of wave function amplitude is fractal. The divergence of squared modulus of wave function leads to the localization of photons. In the term of fractals model this is the localization of ed in resonating circuits.

The last equation coincides with the consequence of e. f. in 2D case with the same asymptotics.

**Conclusions**

In the present work we studied the moments of electric ed in the D ykhne ed with low absorption. We exactly found the second moment and showed that the moments diverges and b E1 diverges and is lim ited if the absorption grows. We could not find higherm onents but proved the relation between moments of ed 
2 and the momenta.

The divergence is conditioned by the density signs of media perm itti vi ties responsible for the existence of local plasm ons. The divergence of ed is not specific for 2D 2-componens but only for the same media limited by the constant conditi ons.

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