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An evaluation of surface response function Re {$d_\perp$ (ω)} and y (ω) for r_s = 4 with surface damping r_s = 0.3 ω_p and 0.15 ω_p

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Abstract: *we have evaluated the surface response function $Re\ (d_\perp(\omega)\ and\ y\ (\omega)$ for r_s = 4 with surface damping r_s = 0.3 ω_p and 0.15 ω_p where $\omega_p$is the Plasmon frequency. The hydrodynamic model with additional boundary condition treats optical problems at metal surface. Now the attempts were made to calculate electromagnetic field at metal surface.*

Keywords: *Plasmon frequency, Hydrodynamic model, non local effect*

Introduction: The phenomenological approach attempt to use knowledge of the bulk response. This leeds to the long standing problem of additional boundary condition in phenomenological optics. Then, one develops green's functions for an extended hydrodynamic model. Here, one consider hydrodynamic model with spatial dispersion in both the longitudinal and the transversal response function. One develops the relation between ABC and nonlocal conductivity of the surface problem. For the homogeneous bulk system, the conductivity tensor gives longitudinal and transverse conductivities. The poles of this conductivity determine Eigen solutions of the $\overleftrightarrow{w}\bar{j} = 0$ where $\overleftrightarrow{w}$ is a differential operator containing spatial derivative. To study optical response, one has are another model called the specular reflection model, In this model the conduction electron are specularly reflected at the surface plan. This system responds like one side of a homogenous system with a mirror plane for all properties and also for the existing fields. On a microscopic level this means that the current density $\vec{j}$ and the electric field $\vec{E}$ in the metal halfspace of interest (z > 0) can be considered the as the current density j^{eff} and electric field $\vec{E}^{eff}$ in an effective homogenous system submitted to symmetary conditions of the form

$$\vec{E}^{eff}(z) = \frac{\vec{E}(z)}{\overleftrightarrow{\alpha}\vec{E}(-z)} \begin{matrix} z > 0 \\ z < 0 \end{matrix} (4.a)$$

Where $\vec{a}$ is the specular reflection matrix. With this constraints on the solution of Maxwell equation, the effective homogeneous system responds to bulk conductivity $\overleftrightarrow{\sigma}^{SR}(\bar{r},\overline{r'},\omega)$. Although in specular reflection mode symmetry condition for effective field are formulated which allow to map interface system on effective homogeneous system with surface and volume charge and currents which responds with bulk susceptibilities. The symmetry condition on the other hand, interpreted in terms of the probabilities that an electron interface are transmitted, speculars reflected or diffused reflected. One does not know in which respect this typie of phenomenological interface model can be helpful for an understanding of the physical effects on the interface.

Description of Nonlocal Effects by the Surface Response Functions$\boldsymbol{d_\perp}$ (ω) and $\boldsymbol{d_{||}}$ (ω) <u>Economical Presentation of Experimental Results : $\boldsymbol{d_\perp}$ (ω) , $\boldsymbol{d_{||}}$ (ω)</u>

Nonlocal effects in metal optics lead to rapidly varying longitudinal fields near the surface, but far from the surface only transverse electromagnetic fields survive. This is true even at and above the plasma frequency, since the damping of plasma waves is typically by a factor C/V_F larger than that of the transverse waves. Within the very successful classical Fresnel optics, which considers only transverse fields, all the optical properties of a clean metal surface are determined by the bulk dielectric function of the metal (and the adjacent medium), which is a function of frequency only. It seems desirable to have a similar description of the nonlocal surface effects in terms of one or two general functions which depend only on frequency and allow to calculate all the optical properties, e.g. surface Plasmon dispersion or reflection amplitudes, which may depend also on the angle of incidence of the incoming light, for instance.

FEIBELMAN1-3 has shown from microscopic considerations that this can indeed by achieved in the "long-wavelength"(LWL i.e. if the scale of the spatial variation of the transverse electromagnetic fields is much larger than the width of the surface region, in which deviations from the asymptotic transverse fields are important. With typical metals the conditions for the LWL are met below and if a realistic damping is taken into account, also at and even well above the plasma frequency, and the nonlocal surface effects on the reflection amplitude and other measureable quantities can be expressed in terms of two surface response functions $d_{\perp}$ (ω) and $d_{||}$ (ω), which depend only on the frequency ω. From a microscopic point of view, these surface response functions involve integrals over the surface region, and they cannot be used to calculate the surface fields. But they can be used to calculate the macroscopic response properties of clean surface and also of surfaces covered with thin films, and they can, in turn, be evaluated from experimental results. They offer a general, meaningful and economical way to present experimental and also theoretical results on optical properties of meal surfaces.

A very transparent method to derive the surface parameters $d_{\perp}$ (ω) and $d_{||}$ (ω) which also clarifies their physical meaning, has been proposed by APELL[4] and is presented in a slightly generalized form the idea is old[5-2] and has already been introduced by PLEETH and BAEGELE[8] in the present context : One extrapolates the asymptotic transverse fields towards the surface and derives boundary conditions for these fields by an integration of Maxwell's equations in the surface region. These boundary conditions contain certain moments of the deviations of the exact fields from the extrapolated fields i.e. of the "surface solutions" discussed by MUKHOPADHYAY and LUNDQVIST9, and yield exact expression for e.g. the reflection coefficient in terms of the moments. One show that these expressions reduce in the LWL to Feibelman's results and to equivalent expressions given by BAGCHI et al.[10].

One considers the simple local three layer model, which has been discussed by McINTYPRE and ASPNES11 and its frequently used to express the surface parameters $d_{\perp}$ (ω) and $d_{||}$ (ω) in terms of the thickness d of the surface layer and the dielectric constants of surface layer and metal substrate, provided the surface layer has a reduced symmetry ($\varepsilon^{s}_{xx} = \varepsilon^{s}_{yy} \neq \varepsilon^{s}_{zz}$). But it is not possible to determine these optical constants and the thickness d of the surface layer uniquely from the values of $d_{\perp}$ (ω) and $d_{||}$ (ω) or from optical measurements, as has been emphasized by PLIETH and NAEGLE[8]. Moreover, the nonlocal calculation of shows that it does in general not increase the insight into the physics of the problem, if one expresses the surface response functions $d_{\perp}$ (ω) and $d_{||}$ (ω) in terms of parameters of a local model, even if this is formally possible. A simple example is illustrative: The decay length of plasma waves (for $\omega < \omega_p$) and thereby, the effective width of the surface region depends on the frequency. To simulate this effect in a local three layer model one needs a surface layer with an artificial frequency dependence of either the layer thickness or the dielectric functions. Further more, it turns out that only within the LWL nonlocal effects can be simulated by a local three layer model so that there is no good reason to express experimental data in terms of dielectric functions of such a model.

One considers within the hydrodynamic approximation a three layer model is which both the surface layer and the bulk metal can sustain longitudinal fields, within the LWL one present explicit analytical results for $d_{\perp}$ (ω),$d_{||}$ (ω) and for the ellipsometry parameters, which contain previous results of ABELES and LOPEZRIOS as special cases and may be useful for the interpretation of experimental data on metal films absorbed on metallic substrates. One discuss surface plasmons in terms of the response functions $d_{\perp}$ (ω),$d_{||}$ (ω), Especially the treatment of "multipole" surface plasmons yields some understanding of the frequency dependence of $d_{\perp}$ (ω).

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