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DIRECT AND INVERSE PROBLEMS OF ELECTROMAGNETIC AND ACOUSTIC WAVE THEORY

DIPED-2000

Tbilisi State University, Georgia
Institute for Applied Problems of Mechanics and Mathematics of NASU, Ukraine

IEEE MTT/ED/AP/EMC Republic of Georgia Chapter
IEEE MTT/ED/AP/CPMT/SSC West Ukraine Chapter

DIPED - 2000

Proceedings of V[th] International Seminar/Workshop
on

DIRECT AND INVERSE PROBLEMS OF ELECTROMAGNETIC AND ACOUSTIC WAVE THEORY

Tbilisi, October 3-6, 2000

Lviv-Tbilisi, 2000

Organized and sponsored by

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in Cooperation with

Tbilisi State University, Tbilisi, Georgia

Institute for Applied Problems of Mechanics and Mathematics of NASU Lviv, Ukraine

in Technical Co-Sponsorship with

IEEE Electron Devices Society

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ЛДКФ „Атлас", Зам. 92-0

Welcome to Tbilisi!

On behalf of the IEEE MTT/ED/AP/EMC Georgia and MTT/ED/AP/CPMT/SSC West Ukraine Chapters, we are delighted with the opportunity to welcome you to Tbilisi, the home of the Vth International Seminar/Workshop **DIPED-2000.** The seminar is scheduled for October 3-6 and will be held in Tbilisi State University, Georgia. It is with open arms and wholehearted enthusiasm that we welcome you to our city!

Tbilisi, the capital of the Georgia, is one of the oldest towns in the world. Between the Greater and Lesser Caucasus ranges lie fertile valleys and – at the intersection of the densely wooded mountain ranges and the Mtkvari River – the city of Tbilisi, founded in 458 AD.

This fortified city in the Mtkvari gorge soon became an important crossroad for both military and trade purposes. The Georgian alphabet and literature date back prior to the spread of Christianity, which was declared the official state religion in 337 AD. This beautiful land has worked like a magnet, attracting numerous conquerors.

In times past, two mighty fortresses – Narikala Citadel (4th century) and the Metechi Castle (5th century) – guarded the entrance to the city. Together with the Metechi Temple and other historic buildings in the old city center, they comprise a 90-hectare architectural protection zone.

A number of the old structures have been converted into cosy cellars, cafes, and restaurants in recent years. After all, Georgia is the land of wine and cognac, of overwhelming hospitality and the quaintest toasts in the world.

Each year, on the last weekend in October, the largest of the many Georgian festivals takes place. "Tbilisoba" is a very special city festival, which unites the celebration of the wine harvest and carnival.

Also famous are the warm spas of Tbilisi with there mineral water springs, sulphur baths, and balneological treatment facilities. The city's name – "tbili" - means "warm".

Today Tbilisi is an important industrial center. Numerous factories for the production of electrical goods and foodstuffs are located here. Georgian tea and tobacco also make a valuable contribution to the local economy

At the very latest, one comes to love this old city after an evening of good food and music with Georgian friends

But one should also not miss the opportunity to let the grandiose nature of the Caucasus perform its magic

We truly hope that you will take time off to stay an extra day or two, and take advantage of the unique attractions and feature, with its breathtaking sites and historical traditions that Tbilisi has to offer to make your stay memorable and certainly enjoyable.

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Diffraction and Scattering

Scattering Electromagnetic and Acoustic Waves

Tbilisi State University, Georgia
Institute for Applied Problems of Mechanics and Mathematics of NASU, Ukraine

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Plenary Session

ON THE THEORY OF HALLEN INTEGRAL EQUATION

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Abstract. A strict approach to solution of the Hallen integral equation for current density of a symmetric active dipole is proposed. It is shown that the nucleus of the equation has a logarithmic characteristic. The solution, which at dipole edges, satisfies the Meiksner's condition of the $\rho 1/2 \to 0$ type (at $\rho \to 0$) was found, that assures uniqueness of the desired solution.

As it is known, the Hallen integral equation for a symmetric dipole has the form [1]:

$$\frac{r_0}{4\pi i\omega\varepsilon_0}\int_{-h/2}^{h/2} I(z')K(|z-z'|)dz' = A\cos kz + B\sin(k|z|) \quad (1)$$

$$(-h/2 \le z \le h/2)$$

where r_0 is the dipole radius; h is the dipole length; ω is the cyclic frequency; $\varepsilon_0=(1/36\pi)\cdot 10^{-9}$, $I(z')$ is the desired current density; A is the unknown coefficient, and B - the specified one; $k=2\pi/\lambda$, λ is the wavelength in vacuum; $k(|Z - Z'|)$ is the nucleus of the integral equation, and

$$K(|z-z'|)=\int_0^{2\pi}\frac{e^{-ikr}}{r}d\psi \quad (2)$$

where

$$r=\sqrt{2r_0^2(1-\cos\psi)+(z-z')^2} \quad (3)$$

It is convenient to reduce equation (1) to the dimensionless form:

$$\int_{-1}^{1}\omega(\xi)K_0(|\eta-\xi|)d\xi = A\cos\beta\xi + B\sin(\beta|\xi|) \quad (4)$$

where $\xi=2z'/h,\quad \eta=2z/h,\quad \omega(\xi)=\frac{r_0}{4\pi i\omega\varepsilon_0}I(z'),\quad \left(z'=\frac{h}{2}\xi\right)$

$$K_0(|\xi-\eta|)=4\int_0^{\pi/2}\frac{e^{-i\beta\sqrt{\gamma^2\sin^2\psi+(\xi-\eta)^2}}}{\sqrt{\gamma^2\sin^2\psi+(\xi-\eta)^2}}d\psi \quad (5)$$

and $\gamma=\frac{4r_0}{h},\quad \beta=\frac{\pi h}{\lambda}$.

The coefficient A in the right part of Eq. (4) should be found from the condition

$$\omega(\pm 1)=0 \quad (6)$$

We have proved that nucleus (5) has a logarithmic characteristic in the following form:

$$K_0(|\xi-\eta|)=K_0^*(|\xi-\eta|)-\frac{4}{\gamma}\ln(|\xi-\eta|) \quad (7)$$

where $K_0^*(|\xi-\eta|)$ is the regular function, $|K_0^*(0)|<\infty$.

Basing on Eq. (7), it is proved that, at γ<<1 (a case of a thin dipole $4r_0/h$<<1), the solution of Eq. (4) has the form:

$$\omega(\xi)=\frac{2}{\pi}\sum_{m=0}^{\infty}\frac{X_{2m}}{\sigma_m}\frac{\cos(2mar\cos\xi)}{\sqrt{1-\xi^2}} \tag{8}$$

(σ_m=1 when m=0 and σ_m=1/2 when $m\neq0$)

The X_{2m} coefficients have the following structure

$$X_0=\frac{\gamma}{2\pi}q(Aa_0+Bb_0) \qquad (q=1/2\ln 2) \tag{9}$$

$$X_{2m}=\frac{\gamma}{2\pi}(Aa_{2m}+Bb_{2m}) \tag{10}$$

where as

$$a_{2m}=\pi(-1)^m J_{2m}(\beta), \quad \beta_{2m}=2(-1)^m\sum_{s=0}^{\infty}\frac{(2s+1)J_{(2s+1)}(\beta)}{(2s+1)^2-4m^2}$$

Substituting Eqs.(9) and (10) into Eq.(8) and using condition (6), we find for the unknown coefficient A

$$A=-BQ, \quad Q=\left(b_0q+2\sum_{m=1}^{\infty}mb_{2m}\right)\Big/\left(a_0q+2\sum_{m=1}^{\infty}ma_{2m}\right)$$

where as

$$\sum_{m=1}^{\infty}ma_{2m}=-\pi\frac{\beta}{4}J_1(\beta), \quad \sum_{m=1}^{\infty}mb_{2m}=-\frac{1}{2}\sum_{s=1}^{\infty}J_{2s+1}(\beta)$$

Finally Eq.(8) is reduced to the following form

$$\omega(\xi)=\frac{4\gamma B}{\pi^2 G}\left\{q\sum_{m=1}^{\infty}mC_{2m}\sin^2(m\arccos\xi)+\sum_{m=1}^{\infty}mD_{2m}\cos\,(2m\arccos\xi)\right\}\frac{1}{\sqrt{1-\xi^2}} \tag{11}$$

where

$$C_{2m}=a_0b_{2m}-b_0a_{2m}, \quad D_{2m}=p_1a_{2m}-p_2b_{2m}$$

$$p_1\sum_{s=1}^{\infty}sb_{2s}, \quad p_2\sum_{s=1}^{\infty}sa_{2s}, \quad G=a_0q+2\sum_{m=1}^{\infty}ma_{2m}$$

At $\xi\to\pm1$, Eq.(11) degenerates into the indeterminate form 0/0. Evaluating it, we convince ourselves that

$$\lim_{\xi\to\pm1}\omega(\xi)=const\cdot\lim_{\xi\to\pm1}\sqrt{1-\xi^2}=0 \tag{12}$$

Hence, the dipole current density $I(z')$ at $z'\to\pm h/2$ decreases as

$$\lim_{z'\to\pm h/2}I(z')=const\cdot\lim_{z'\to\pm h/2}\sqrt{\left(\frac{h}{2}\right)^2-z'^2}=0 \tag{13}$$

Eqs.(12) and (13) are the Meiksner's condition for the case when the dipole is a hollow thin tube with sharp edges. They assure the uniqueness of obtained solution (11).

As the dipole radiation characteristic $F(\theta)$ is proportional to the integral