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Short note

Comments on "Wave diffraction by a soft/hard strip: Modified theory of physical optics solution"

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ABSTRACT

Modified theory of physical optics (MTPO) solution for a soft/hard strip is analyzed. It is shown that this solution is incorrect because the MTPO Green function does not satisfy boundary conditions. Defects of MTPO in calculations of fringe waves are also noticed.

The above paper [1] is about wave diffraction by a soft/hard strip. Its author claims that he has developed a novel Green function for the soft/hard-plane problem and applied modified theory of physical optics (MTPO) integral to derive field expressions. However, this paper is misleading in the following aspects below:

1. The paper [1] contains *some critical but not founded* manipulations. These are
   (a) the transition from the half-plane in (18) and (19) to the finite strip in (20) and (21) by the use of the enforced replacement of coordinates ρ, ϕ by R, β. Without this manipulation, one could not get the Green functions in (26) and (27).
   (b) Eqs. (18) and (19) are the results of separation of (16) into two specific parts. However, such a separation is not unique: (16) also can be separated into other parts via representing $\sin(3\phi/4)$ in terms of $\sin(\phi/4)$. The other parts may lead to other Green functions. The choice of (18) and (19) is not discussed and not founded.

   These two examples of not founded artificial operations are typical features of MTPO.
2. The Green function G_{sh} constructed in the paper satisfies the Helmholtz Equation. However, it does not satisfy the boundary conditions (BCs) in (2) and (3). According to (28)–(30), this function is defined as

$$G_{sh}(R,\beta) = p(\beta,\phi_0)\frac{e^{-jkr}}{\sqrt{kR}} \tag{C.1}$$

with

$$p(\beta,\phi_0) = \left[\sin\frac{\pi-\beta}{4}\left(1+2\cos\frac{\phi_0}{2}\right)+\sin\frac{3(\pi-\beta)}{4}\right]\sin\frac{\phi_0}{4}. \tag{C.2}$$

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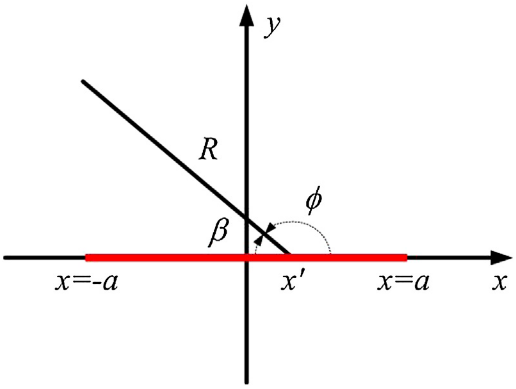

Fig. 1. The geometry of the strip.

Consider the BCs for this function on the strip at the points $y=\pm 0$ and $|x|<a$ where $R=|x-x'|\gg\lambda$, and the angle β takes the values ± 0, $+\pi-0$, $-\pi+0$ (see Fig. 1).

According to BC in (2), the function G_{sh} and therefore $p(\beta,\phi_0)$ must be zero on the soft face of the strip where $y=+0$. However, one can see that $p(0,\phi_0)\neq 0$ at the strip points with $\beta=0$ where $x<x'$. Thus, the function G_{sh} does not satisfy BC at these points. It satisfies BC only at the points $x>x'$ where $p(\pi,\phi_0)=0$.

Now the BC in (3) on the bottom side $y=-0$ of the strip is checked. This BC requires that $\partial p(\beta,\phi_0)/\partial\beta=0$. It follows from (C.2) that

$$\frac{\partial p(\beta,\phi_0)}{\partial\beta}=-\frac{1}{4}\left[\cos\frac{\pi-\beta}{4}\left(1+2\cos\frac{\phi_0}{2}\right)+3\cos\frac{3(\pi-\beta)}{4}\right]\sin\frac{\phi_0}{4} \tag{C.3}$$

It is seen that this function is not zero for $\beta=-0$ where $x<x'$. G_{sh} does not satisfy BC in (3) here. It satisfies (3) only for $\beta=-\pi+0$ where $x>x'$. Thus, G_{sh} of [1] does not satisfy BC on some parts of both sides of the strip.

3. Two important consequences follow from this observation;
   (a) the Green function related to the edge point $x'=-a$ satisfies BC.
   (b) but the Green function related to the edge point $x'=+a$ does not satisfy BC with $\beta=0$ and therefore it is incorrect. This conclusion is also confirmed by (40) and (42). According to them the wave diffracted at the edge 1 ($x=+a$) is defined as

$$\begin{aligned} u_d(1) &= u_{dr1}+u_{dt1} \\ &= \frac{u_0 e^{-j\pi/4}}{2\sqrt{\pi}}\left(\frac{\cos\dfrac{\pi-\beta_{e1}-\phi_0}{4}}{\sin\dfrac{\beta_{e1}+\phi_0}{2}}-\frac{\cos\dfrac{\pi-\beta_{e1}+\phi_0}{4}}{\sin\dfrac{\beta_{e1}-\phi_0}{2}}\right)\frac{e^{jk(a\cos\phi_0-R_{e1})}}{\sqrt{kR_{e1}}} \end{aligned} \tag{C.4}$$

   It is obvious that this wave does not satisfy BC in (2) on the strip: it is not zero for $\beta_{e1}=0$. Thus, this MTPO paper is incorrect.
4. The whole Section 3 deals with the construction of the functions in (26) and (27). However, they are not used for calculations. Instead, a simple approximation of the Hankel function $H_0^{(2)}(kR)$ is used in (29).
5. In connection with this observation, the previous MTPO publications [2–7] on the fringe waves were also incorrect as shown in our comments [8]. Those and present comments reveal the essence of MTPO. It does not provide some general clearly defined rules how to solve diffraction problems. Instead, it consists of not predicted and not founded manipulations.
6. The author makes selective references to the physical theory of diffraction (PTD). He notices some shortcomings of the old/initial form of PTD (Ref. [2] in [1]) but does not refer to its modern form [9] that is free from those shortcomings.

It should be noted that we were aware of Umul's MTPO right after we presented exact and asymptotic forms of fringe waves in our paper [10] and realized some physical inconsistencies and incorrectness of MTPO from the figures presented in [7]. Fig. 2 (reproduced by us from [7]) presents asymptotic and exact MTPO fields around the tip of a 2D wedge for near ($r=\lambda$) and far ($r=20\lambda$) field radial distances. ***It is obvious that, if asymptotic and exact results are correct then they must agree at far fields when radial distance goes to infinity.*** In practical diffraction problems, 20λ radial distance is quite close to infinity. From this physical point of view – without going into details of mathematical expressions – one can easily realize that there is something wrong with MTPO exact and asymptotic forms (actually, as we showed in [8], MTPO exact form is incorrect, but its asymptotic form is correct).

We then showed incorrectness of MTPO in [8] both mathematically and numerically for several wedges with different wedge angles. The plots in Figs. 3 and 4 (from [8]) compare correct PTD and incorrect MTPO fringe waves.