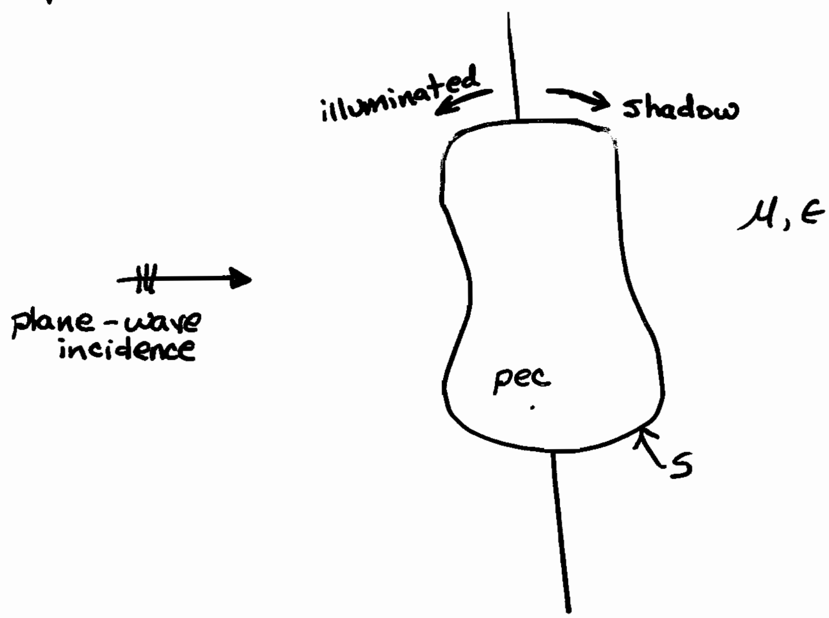
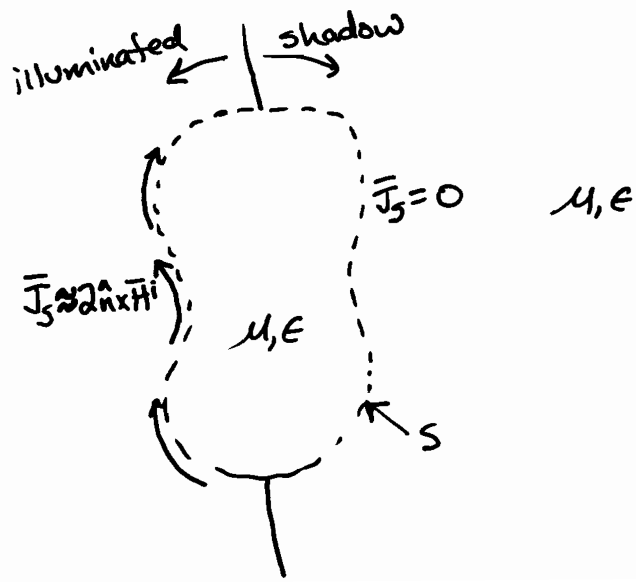
Physical Optics Approximation

For large, smooth pec scatterers it is possible to obtain a <u>rough measure</u> of the scattering with surprisingly little computational effort. This technique is referred to as the <u>Physical Optics</u> (PO) approximation.

Consider a pec scatterer illuminated as shown →



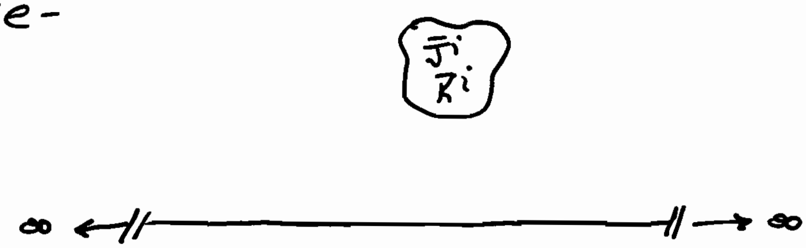
The PO approximation assumes that a known surface current density resides on the equivalent surface as shown, while $\bar{J}_s = 0$ on the shadow side.



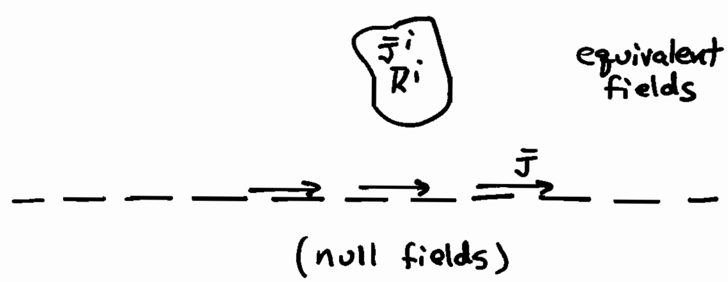
It is important to notice that $\bar{J}_s = 2\,\hat{n}\times\bar{H}^i$ which is known. Therefore, the scattered fields can be found from a source/field relationship.

This approximation can be partially justified by considering each elemental segment of the pec scatterer as an infinite pec plane!

In that case -



can be replaced with the equivalent problem -



where $\bar{J} = 2\,\hat{n}\times\bar{H}^i$ (from image theory)

Representative monostatic RCS curves are shown in the following 2 slides. Notice that the monostatic pattern is polarization independent!

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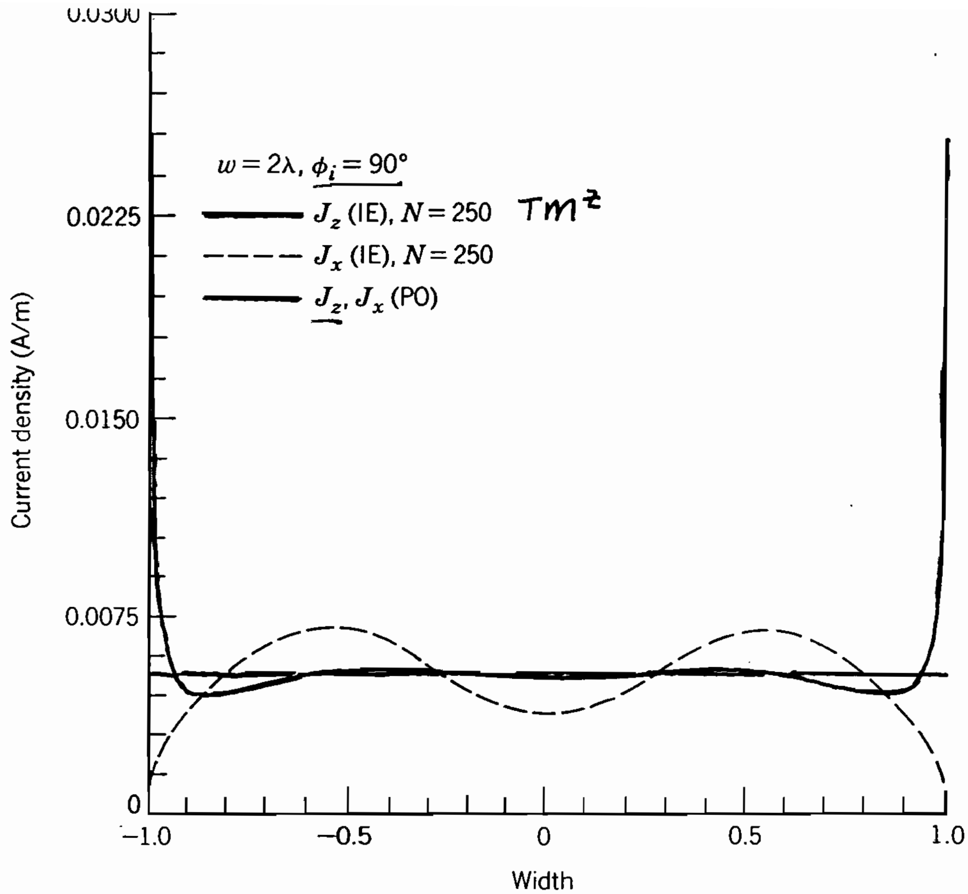


FIGURE 12-15 Current density induced on a finite width strip by a plane wave at normal incidence.

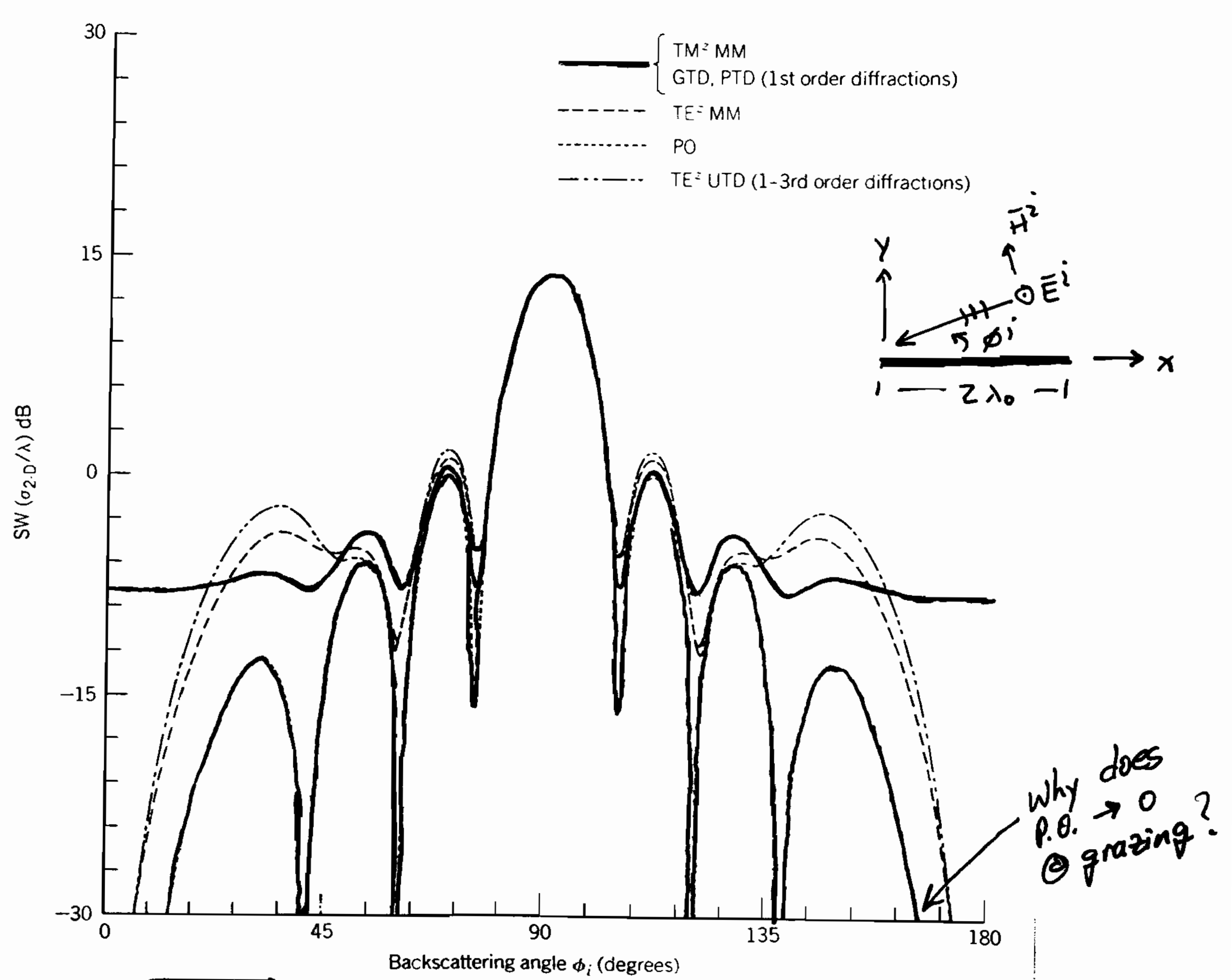


FIGURE 12-16 Monostatic scattering width of a finite width strip ($w = 2\lambda$).

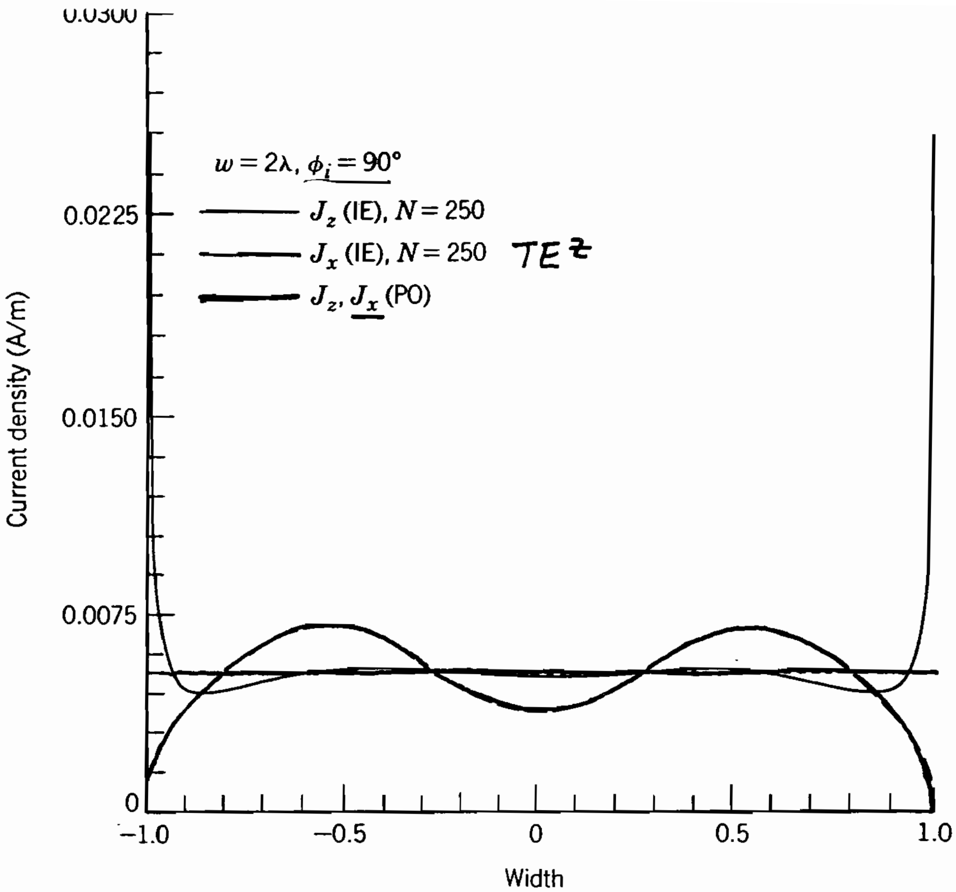
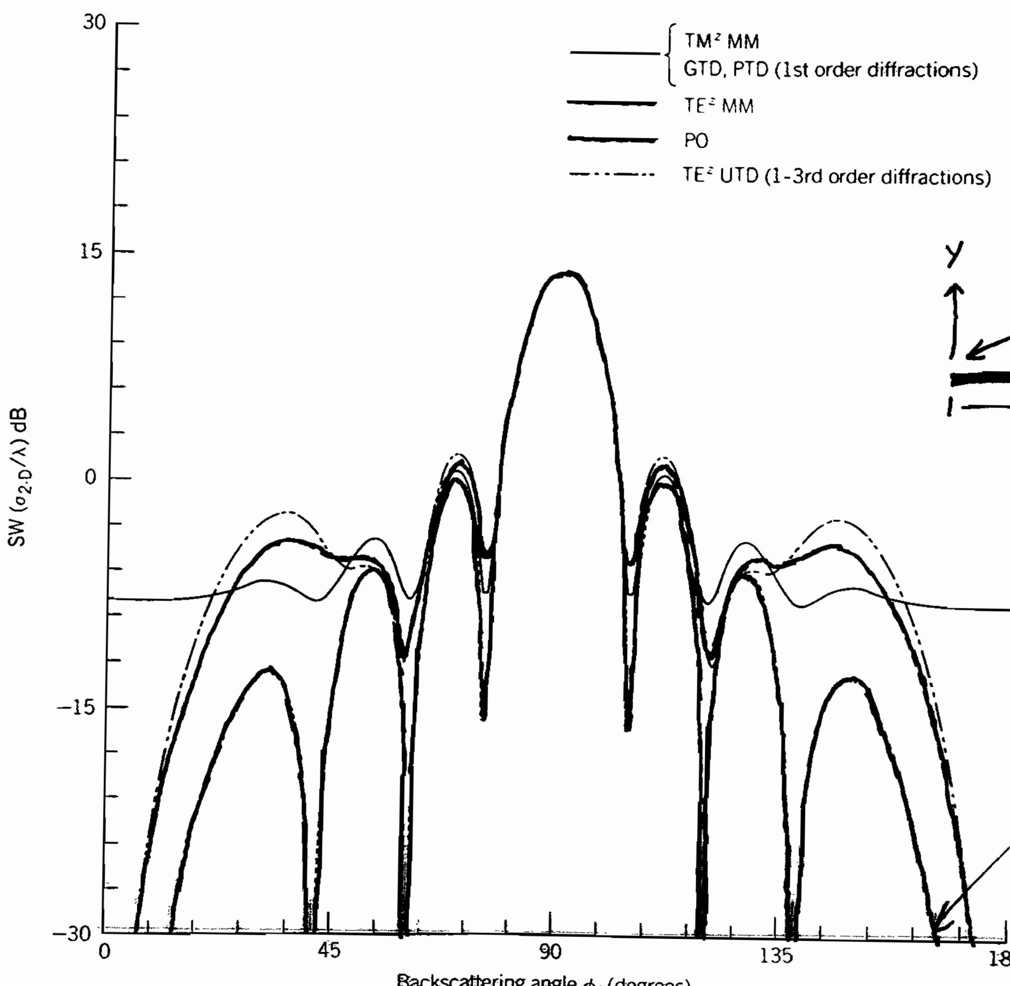
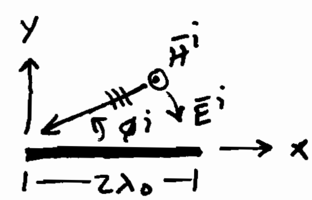


FIGURE 12-15 Current density induced on a finite width strip by a plane wave at normal incidence.

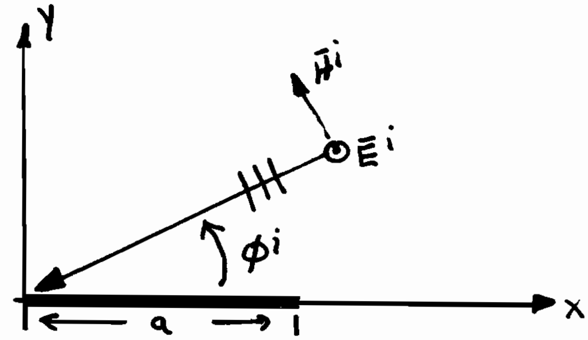




Why does P.O. → 0 @ grazing?

FIGURE 12-16 Monostatic scattering width of a finite width strip ($w = 2\lambda$).

Additional current and bistatic RCS curves are shown on the following slides for TM^z incidence on a pec strip as –



The PO current is thus $\bar{J}^{PO} = \hat{z}\,\frac{2\sin\phi^i}{\eta}\,e^{jk_x^i x}$

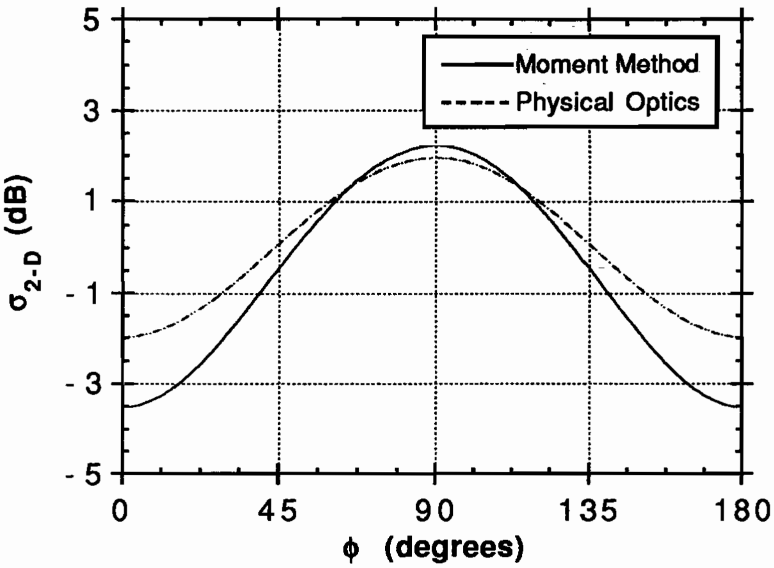
The far scattered fields produced by this current supported only on the strip (remember PO neglects edge effects) is the Fourier transform given as

$$E_\phi^{PO} = -jk\eta\,\hat{\phi}\cdot\bar{A} \sim -\frac{k\sin\phi^i}{2}\sqrt{\frac{j2}{\pi k\rho}}\,e^{-jk\rho}\int_0^a e^{j(k_x^i+k_x)}\,dx$$

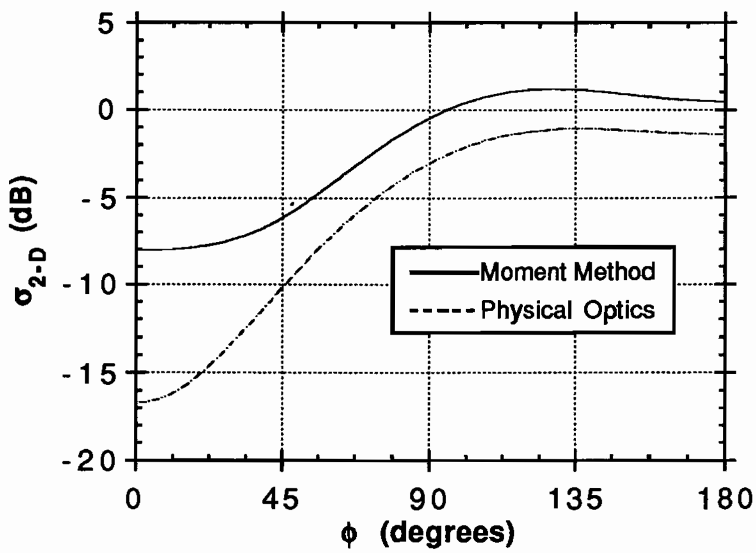
The echo width therefore is

$$\sigma_{2-D}^{PO} = \lim_{\rho\to\infty}\left\{\frac{2\pi\rho\,|\bar{E}^s|^2}{|\bar{E}^i|^2}\right\} = ka^2\sin^2\phi^i\ \mathrm{sinc}^2\left(\frac{k_x^i+k_x}{2}a\right)$$

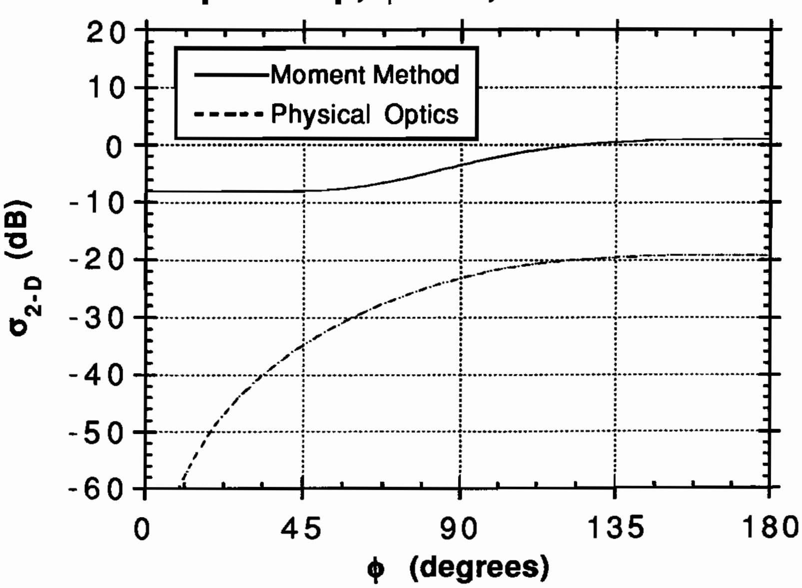
pec strip, ϕ^i = 90°, width = 0.5 λ



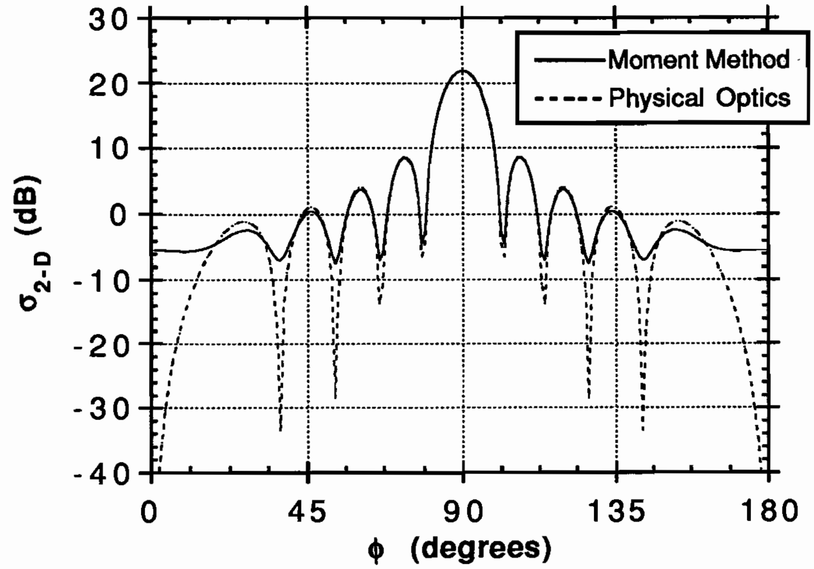
pec strip, ϕ^i = 45°, width = 0.5 λ



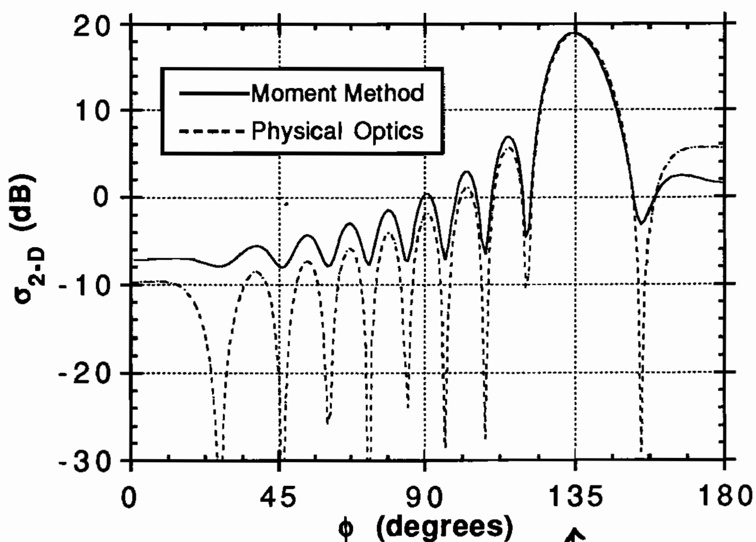
pec strip, ϕ^i = 5°, width = 0.5 λ



pec strip, ϕ^i = 90°, width = 5 λ

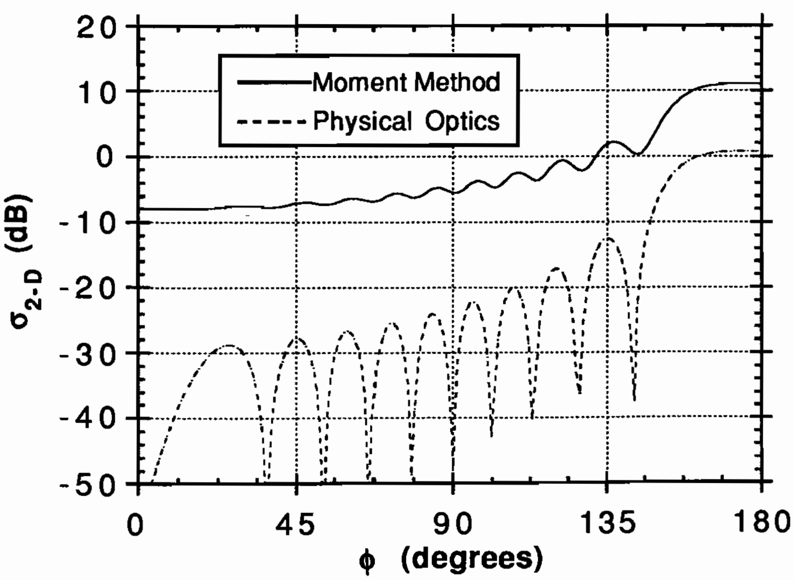


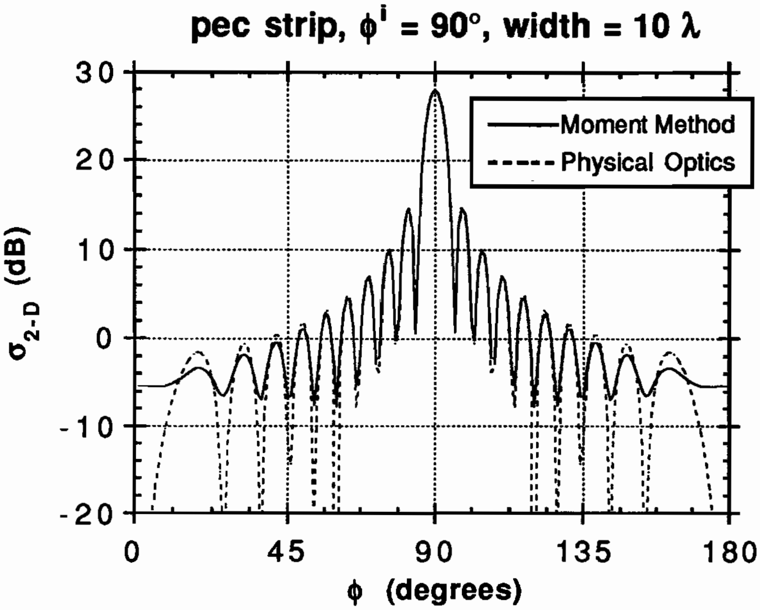
pec strip, ϕ^i = 45°, width = 5 λ

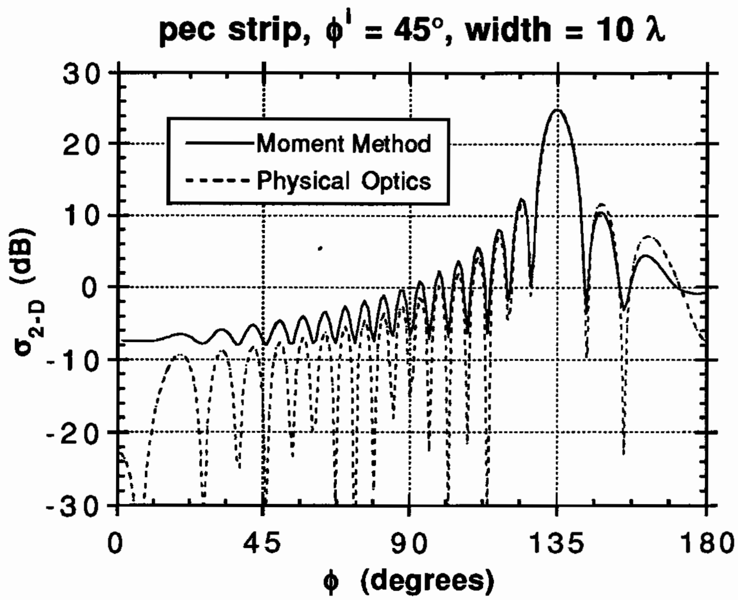


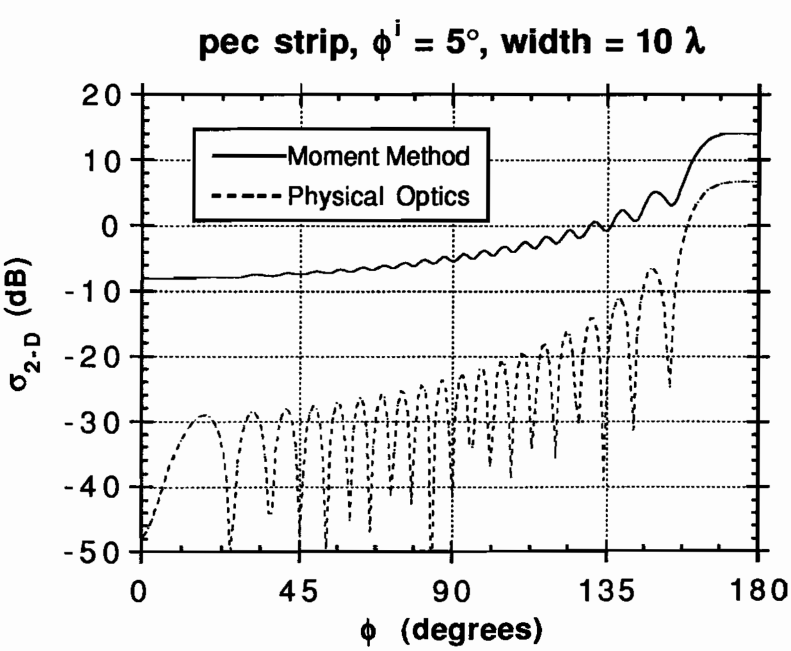
specular

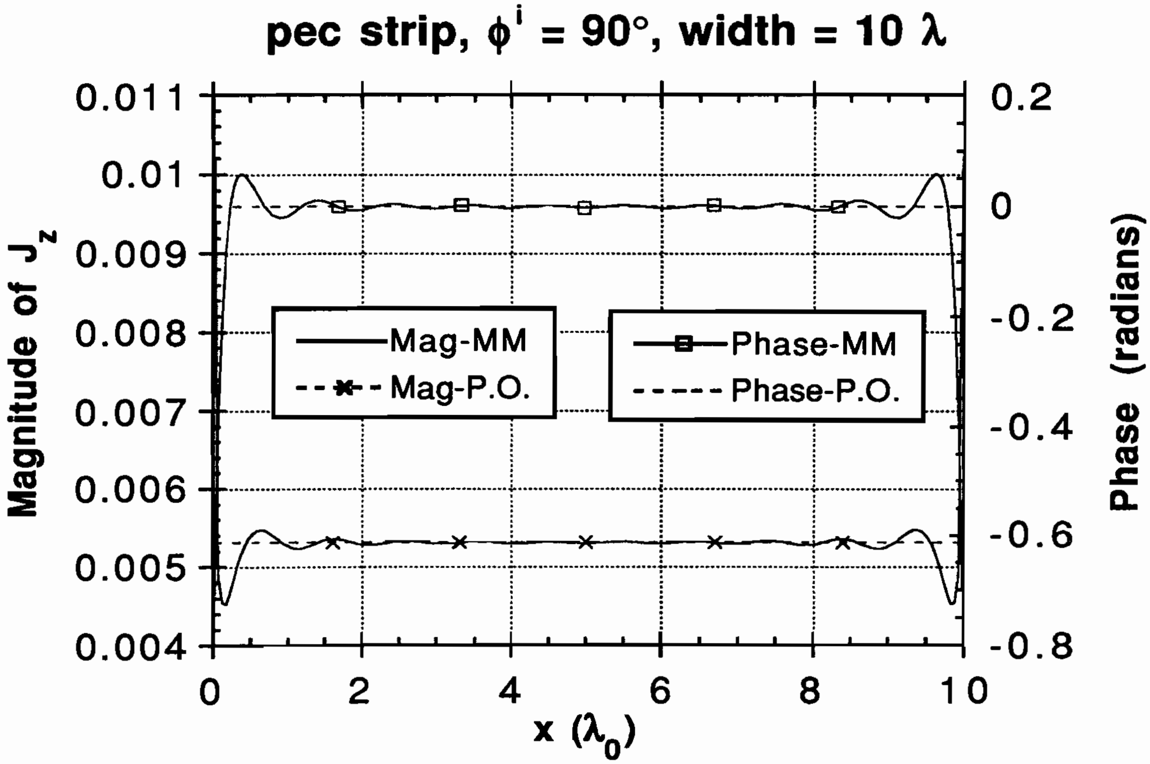
pec strip, ϕ^i = 5°, width = 5 λ

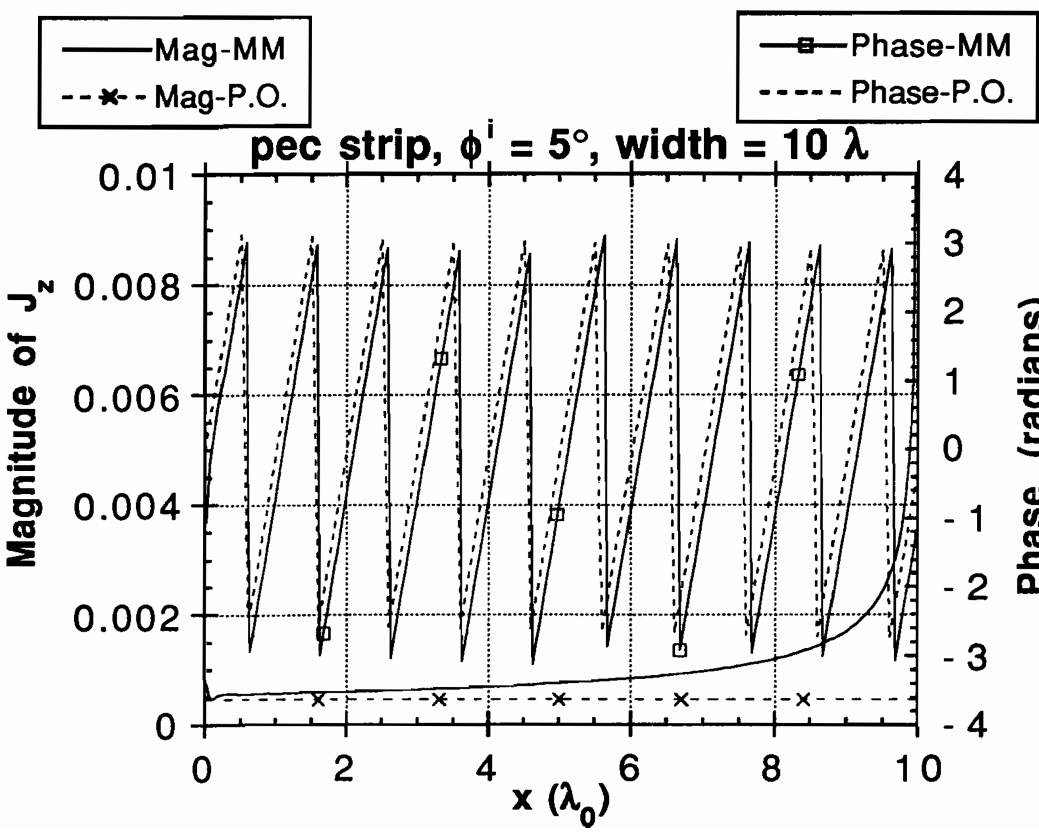



pec strip, ϕ^i = 90°, width = 10 λ
Moment Method
Physical Optics
$\sigma_{2\text{-}D}$ (dB)
30
20
10
0
-10
-20
0
45
90
135
180
ϕ (degrees)


pec strip, ϕ^i = 45°, width = 10 λ
Moment Method
Physical Optics
$\sigma_{2\text{-}D}$ (dB)
30
20
10
0
-10
-20
-30
0
45
90
135
180
ϕ (degrees)


pec strip, ϕ^i = 5°, width = 10 λ
Moment Method
Physical Optics
$\sigma_{2\text{-}D}$ (dB)
20
10
0
-10
-20
-30
-40
-50
0
45
90
135
180
ϕ (degrees)


pec strip, ϕ^i = 90°, width = 10 λ
Mag-MM
Mag-P.O.
Phase-MM
Phase-P.O.
Magnitude of J_z
Phase (radians)
x (λ_0)
0.011
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.2
0
-0.2
-0.4
-0.6
-0.8
0
2
4
6
8
10


Mag-MM
Mag-P.O.
Phase-MM
Phase-P.O.
pec strip, ϕ^i = 5°, width = 10 λ
Magnitude of J_z
Phase (radians)
x (λ_0)
0.01
0.008
0.006
0.004
0.002
0
4
3
2
1
0
- 1
- 2
- 3
- 4
0
2
4
6
8
10