Total Internal Reflection —

The kinetic properties viz, Snell's law and applies equally to all polarizations. This phenomenon is called total internal reflection.

When the angle of incidence and angle of refraction becomes $\pi/2$ then,

$$i = i_c = \sin^{-1}\left(\frac{n'}{n}\right). \quad \text{—(1)}$$

where i_c = critical angle.

Now for $i > i_c$, $\sin r > 1$, then —(2)

$$\cos(r) = j\sqrt{\left(\frac{\sin i}{\sin i}\right)^2 - 1}$$

The meaning of these complex quantities becomes clear, when we consider the propagation factor for the refracted wave,

$$e^{j\vec{k}'\vec{x}} = e^{jk'(x\sin r + z\cos r)} \quad \text{—(3)}$$

$$= e^{-k'[(\sin i/\sin i_c) - 1]^{1/2} z} e^{jk'(\sin i/\sin i_c)x}$$

Even though fields exists on the other side of the surface, there is no energy flow through the surface. Hence, the total internal reflection occurs for $i \geq i_c$.

The fact that though there are fields but no energy flow can be verified by calculating time average normal component of the poynting vector just inside of the surface.

$$\vec{S}\cdot\hat{n} = \frac{1}{2} Re[\hat{n}(\vec{E}' \times \vec{H}')^*] \quad \text{—(4)}$$

These are required equations of total internal reflection.