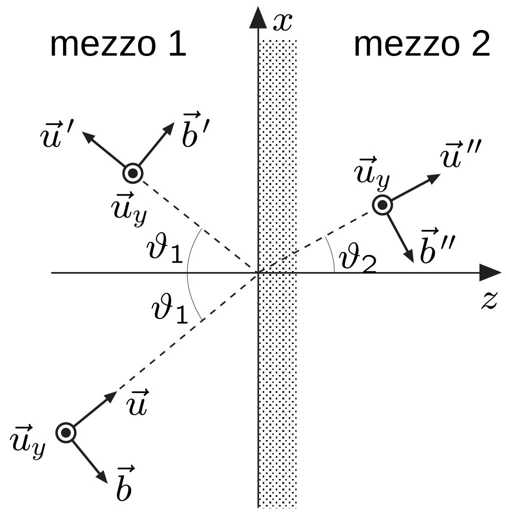
Incidenza obliqua nei casi $n_2 > n_1$ e $n_1 > n_2$, $\vartheta_1 < \vartheta_L$



$$n_1 \sin\vartheta_1 = n_2 \sin\vartheta_2 \qquad \text{Legge di Snell}$$

$$\vec{u} = \vec{u}_x \sin\vartheta_1 + \vec{u}_z \cos\vartheta_1 \qquad \vec{b} = \vec{u} \times \vec{u}_y = -\vec{u}_x \cos\vartheta_1 + \vec{u}_z \sin\vartheta_1$$

$$\vec{E} = (\,F_\perp\,\vec{u}_y + F_\|\,\vec{b}\,)\,e^{-j\beta_1\vec{u}\cdot\vec{r}}$$

$$\eta_0\,\vec{H} = n_1\,(\,F_\perp\,\vec{b} - F_\|\,\vec{u}_y\,)\,e^{-j\beta_1\vec{u}\cdot\vec{r}}$$

$$\vec{u}\,' = \vec{u}_x \sin\vartheta_1 - \vec{u}_z \cos\vartheta_1 \qquad \vec{b}\,' = \vec{u}\,' \times \vec{u}_y = \vec{u}_x \cos\vartheta_1 + \vec{u}_z \sin\vartheta_1$$

$$\vec{E}\,' = (\,F'_\perp\,\vec{u}_y + F'_\|\,\vec{b}\,'\,)\,e^{-j\beta_1\vec{u}\,'\cdot\vec{r}}$$

$$\eta_0\,\vec{H}\,' = n_1\,(\,F'_\perp\,\vec{b}\,' - F'_\|\,\vec{u}_y\,)\,e^{-j\beta_1\vec{u}\,'\cdot\vec{r}}$$

$$\vec{u}\,'' = \vec{u}_x \sin\vartheta_2 + \vec{u}_z \cos\vartheta_2 \qquad \vec{b}\,'' = \vec{u}\,'' \times \vec{u}_y = -\vec{u}_x \cos\vartheta_2 + \vec{u}_z \sin\vartheta_2$$

$$\vec{E}\,'' = (\,F''_\perp\,\vec{u}_y + F''_\|\,\vec{b}\,''\,)\,e^{-j\beta_2\vec{u}\,''\cdot\vec{r}}$$

$$\eta_0\,\vec{H}\,'' = n_2\,(\,F''_\perp\,\vec{b}\,'' - F''_\|\,\vec{u}_y\,)\,e^{-j\beta_2\vec{u}\,''\cdot\vec{r}}$$

formule di Fresnel

$$\Gamma_\perp = \frac{F'_\perp}{F_\perp} = \frac{n_1 \cos\vartheta_1 - n_2 \cos\vartheta_2}{n_1 \cos\vartheta_1 + n_2 \cos\vartheta_2}$$

$$T_\perp = \frac{F''_\perp}{F_\perp} = \frac{2\, n_1 \cos\vartheta_1}{n_1 \cos\vartheta_1 + n_2 \cos\vartheta_2}$$

$$\Gamma_\parallel = \frac{F'_\parallel}{F_\parallel} = \frac{n_2 \cos\vartheta_1 - n_1 \cos\vartheta_2}{n_2 \cos\vartheta_1 + n_1 \cos\vartheta_2}$$

$$T_\parallel = \frac{F''_\parallel}{F_\parallel} = \frac{2\, n_1 \cos\vartheta_1}{n_2 \cos\vartheta_1 + n_1 \cos\vartheta_2}$$

Incidenza obliqua nel caso $n_1 > n_2$, $\vartheta_1 > \vartheta_L$

$$\vec{u} = \vec{u}_x \sin\vartheta_1 + \vec{u}_z \cos\vartheta_1$$

$$\vec{E} = (F_\perp \vec{u}_y + F_\parallel \vec{b})\, e^{-j\beta_1 \vec{u}\cdot\vec{r}}$$

$$\eta_0 \vec{H} = n_1 (F_\perp \vec{b} - F_\parallel \vec{u}_y)\, e^{-j\beta_1 \vec{u}\cdot\vec{r}}$$

$$\vec{b} = \vec{u} \times \vec{u}_y = -\vec{u}_x \cos\vartheta_1 + \vec{u}_z \sin\vartheta_1$$

$$\vec{u}\,' = \vec{u}_x \sin\vartheta_1 - \vec{u}_z \cos\vartheta_1$$

$$\vec{E}\,' = (F'_\perp \vec{u}_y + F'_\parallel \vec{b}\,')\, e^{-j\beta_1 \vec{u}\,'\cdot\vec{r}}$$

$$\eta_0 \vec{H}\,' = n_1 (F'_\perp \vec{b}\,' - F'_\parallel \vec{u}_y)\, e^{-j\beta_1 \vec{u}\,'\cdot\vec{r}}$$

$$\vec{b}\,' = \vec{u}\,' \times \vec{u}_y = \vec{u}_x \cos\vartheta_1 + \vec{u}_z \sin\vartheta_1$$

$$\vec{\gamma} = \vec{\alpha} + j\vec{\beta}$$

$$\vec{E}\,'' = \left(F''_\perp \vec{u}_y + F''_\parallel \vec{p}_\parallel \right) e^{-\vec{\gamma}\cdot\vec{r}}$$

$$\eta_0 \vec{H}\,'' = \left(\frac{|\,\vec{\gamma}\,|\, c}{j\omega} F''_\perp \vec{p}_\parallel - \frac{j\omega\, n_2^2}{|\,\vec{\gamma}\,|\, c} F''_\parallel \vec{u}_y \right) e^{-\vec{\gamma}\cdot\vec{r}}$$

$$\vec{\beta} = \frac{\omega}{c} n_1 \sin\vartheta_1 \, \vec{u}_x \qquad \vec{\alpha} = \alpha\, \vec{u}_z$$

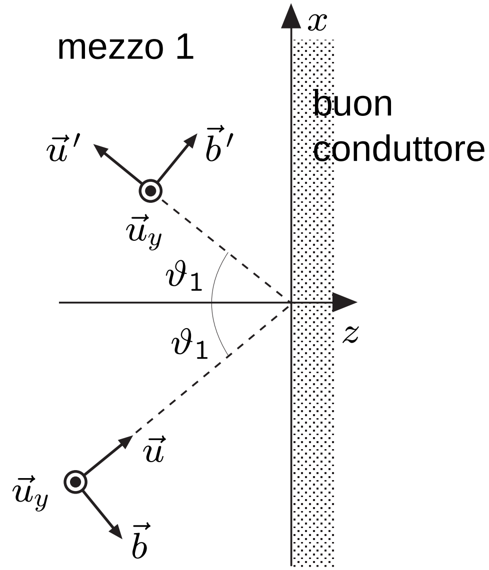
$$\Gamma_\perp = \frac{F_\perp'}{F_\perp} = \frac{\cos\vartheta_1 + j\sqrt{\sin^2\vartheta_1 - \sin^2\vartheta_L}}{\cos\vartheta_1 - j\sqrt{\sin^2\vartheta_1 - \sin^2\vartheta_L}}$$

$$T_\perp = \frac{F_\perp''}{F_\perp} = \frac{2\cos\vartheta_1}{\cos\vartheta_1 - j\sqrt{\sin^2\vartheta_1 - \sin^2\vartheta_L}}$$

$$\Gamma_\| = \frac{F_\|'}{F_\|} = \frac{\sin^2\vartheta_L\cos\vartheta_1 + j\sqrt{\sin^2\vartheta_1 - \sin^2\vartheta_L}}{\sin^2\vartheta_L\cos\vartheta_1 - j\sqrt{\sin^2\vartheta_1 - \sin^2\vartheta_L}}$$

$$T_\| = \frac{F_\|''}{F_\|} = \frac{2j\cos\vartheta_1\sqrt{2\sin^2\vartheta_1 - \sin^2\vartheta_L}}{\sin^2\vartheta_L\cos\vartheta_1 - j\sqrt{\sin^2\vartheta_1 - \sin^2\vartheta_L}}$$

Incidenza obliqua su un buon conduttore



$$\vec{u}_z \times \vec{E} = R_s(1+j)\vec{H}_T$$ condizione di Leontovič

$$\begin{aligned}
\vec{u} &= \vec{u}_x \sin\vartheta_1 + \vec{u}_z \cos\vartheta_1 \\
\vec{E} &= (\,F_\perp\,\vec{u}_y + F_{||}\,\vec{b}\,)\,e^{-j\beta_1\vec{u}\cdot\vec{r}} \\
\eta_0\,\vec{H} &= n_1\,(\,F_\perp\,\vec{b} - F_{||}\,\vec{u}_y\,)\,e^{-j\beta_1\vec{u}\cdot\vec{r}}
\end{aligned}$$

$$\vec{b} = \vec{u} \times \vec{u}_y = -\vec{u}_x \cos\vartheta_1 + \vec{u}_z \sin\vartheta_1$$

$$\begin{aligned}
\vec{u}\,' &= \vec{u}_x \sin\vartheta_1 - \vec{u}_z \cos\vartheta_1 \\
\vec{E}\,' &= (\,F'_\perp\,\vec{u}_y + F'_{||}\,\vec{b}\,'\,)\,e^{-j\beta_1\vec{u}\,'\cdot\vec{r}} \\
\eta_0\,\vec{H}\,' &= n_1\,(\,F'_\perp\,\vec{b}\,' - F'_{||}\,\vec{u}_y\,)\,e^{-j\beta_1\vec{u}\,'\cdot\vec{r}}
\end{aligned}$$

$$\vec{b}\,' = \vec{u}\,' \times \vec{u}_y = \vec{u}_x \cos\vartheta_1 + \vec{u}_z \sin\vartheta_1$$

$$\Gamma_\perp = \frac{F'_\perp}{F_\perp} = \frac{R_s(1+j)\cos\vartheta_1 - \eta_1}{R_s(1+j)\cos\vartheta_1 + \eta_1}$$

$$\Gamma_\parallel = \frac{F'_\parallel}{F_\parallel} = \frac{\eta_1\cos\vartheta_1 - R_s(1+j)}{\eta_1\cos\vartheta_1 + R_s(1+j)}$$

Incidenza normale (mezzi qualsiasi)

$$\vec{E} = F\, e^{-\gamma_1 z}\, \vec{p} \qquad \gamma_1 = \alpha_1 + j\beta_1$$

$$\vec{H} = \frac{F}{\eta_1}\, e^{-\gamma_1 z}\, \vec{u}_z \times \vec{p}$$

$$W = \text{Re}\left(\frac{1}{\eta_1^*}\right) \frac{|\,F\,|^2}{2}\, e^{-2\alpha_1 z}$$

$$\vec{E}\,' = F\,'\, e^{\gamma_1 z}\, \vec{p}$$

$$\vec{H}\,' = -\frac{F\,'}{\eta_1}\, e^{\gamma_1 z}\, \vec{u}_z \times \vec{p}$$

$$W\,' = \text{Re}\left(\frac{1}{\eta_1^*}\right) \frac{|\,F\,'\,|^2}{2}\, e^{2\alpha_1 z}$$

$$\vec{E}\,'' = F\,''\, e^{-\gamma_2 z}\, \vec{p} \qquad \gamma_2 = \alpha_2 + j\beta_2$$

$$\vec{H}\,'' = \frac{F\,''}{\eta_2}\, e^{-\gamma_2 z}\, \vec{u}_z \times \vec{p}$$

$$W\,'' = \text{Re}\left(\frac{1}{\eta_2^*}\right) \frac{|\,F\,''\,|^2}{2}\, e^{-2\alpha_2 z}$$

Incidenza normale su uno strato di spessore d (mezzi qualsiasi)

$$\vec{E} = F\, e^{-\gamma_1 z}\, \vec{p} \qquad \gamma_1 = \alpha_1 + j\beta_1$$

$$\vec{H} = \frac{F}{\eta_1}\, e^{-\gamma_1 z}\, \vec{u}_z \times \vec{p} \qquad W = \mathrm{Re}\left(\frac{1}{\eta_1^*}\right) \frac{|\,F\,|^2}{2}\, e^{-2\alpha_1 z}$$

$$\vec{E}' = F'\, e^{\gamma_1 z}\, \vec{p}$$

$$\vec{H}' = -\frac{F'}{\eta_1}\, e^{\gamma_1 z}\, \vec{u}_z \times \vec{p} \qquad W' = \mathrm{Re}\left(\frac{1}{\eta_1^*}\right) \frac{|\,F'\,|^2}{2}\, e^{2\alpha_1 z}$$

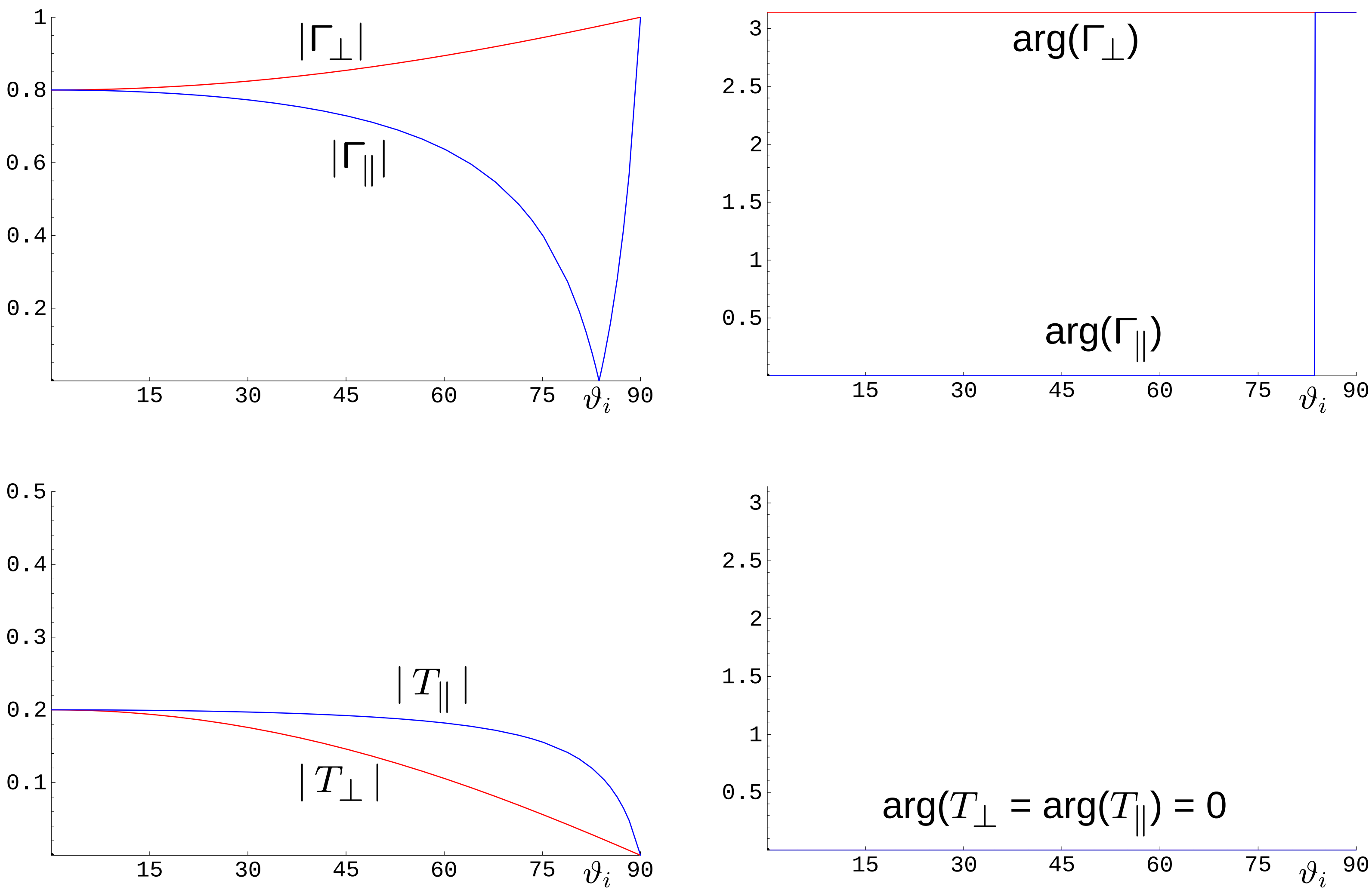
$$\vec{E}'' = F''\, e^{-\gamma_2 (z-d)}\, \vec{p} \qquad \gamma_2 = \alpha_2 + j\beta_2$$

$$\vec{H}'' = \frac{F''}{\eta_2}\, e^{-\gamma_2 (z-d)}\, \vec{u}_z \times \vec{p} \qquad W'' = \mathrm{Re}\left(\frac{1}{\eta_2^*}\right) \frac{|\,F''\,|^2}{2}\, e^{-2\alpha_2 (z-d)}$$

$$\vec{E}_s = \left(A\, e^{-\gamma z} + B\, e^{\gamma z}\right) \vec{p} \qquad \gamma = \alpha + j\beta$$

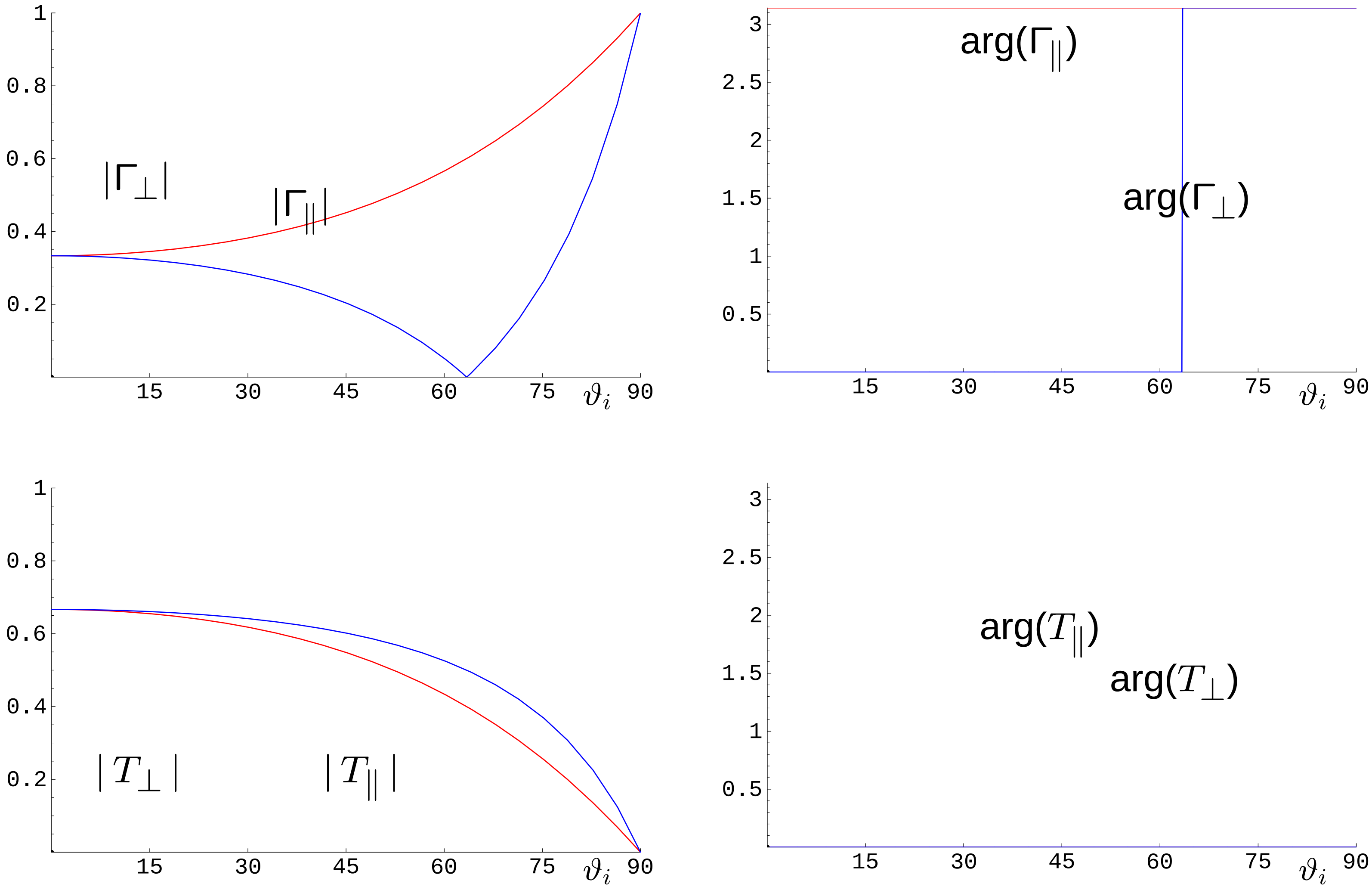
$$\vec{H}_s = \frac{A\, e^{-\gamma z} - B\, e^{\gamma z}}{\eta}\; \vec{u}_z \times \vec{p}$$

$n_1 = 1$, $n_2 = 9$



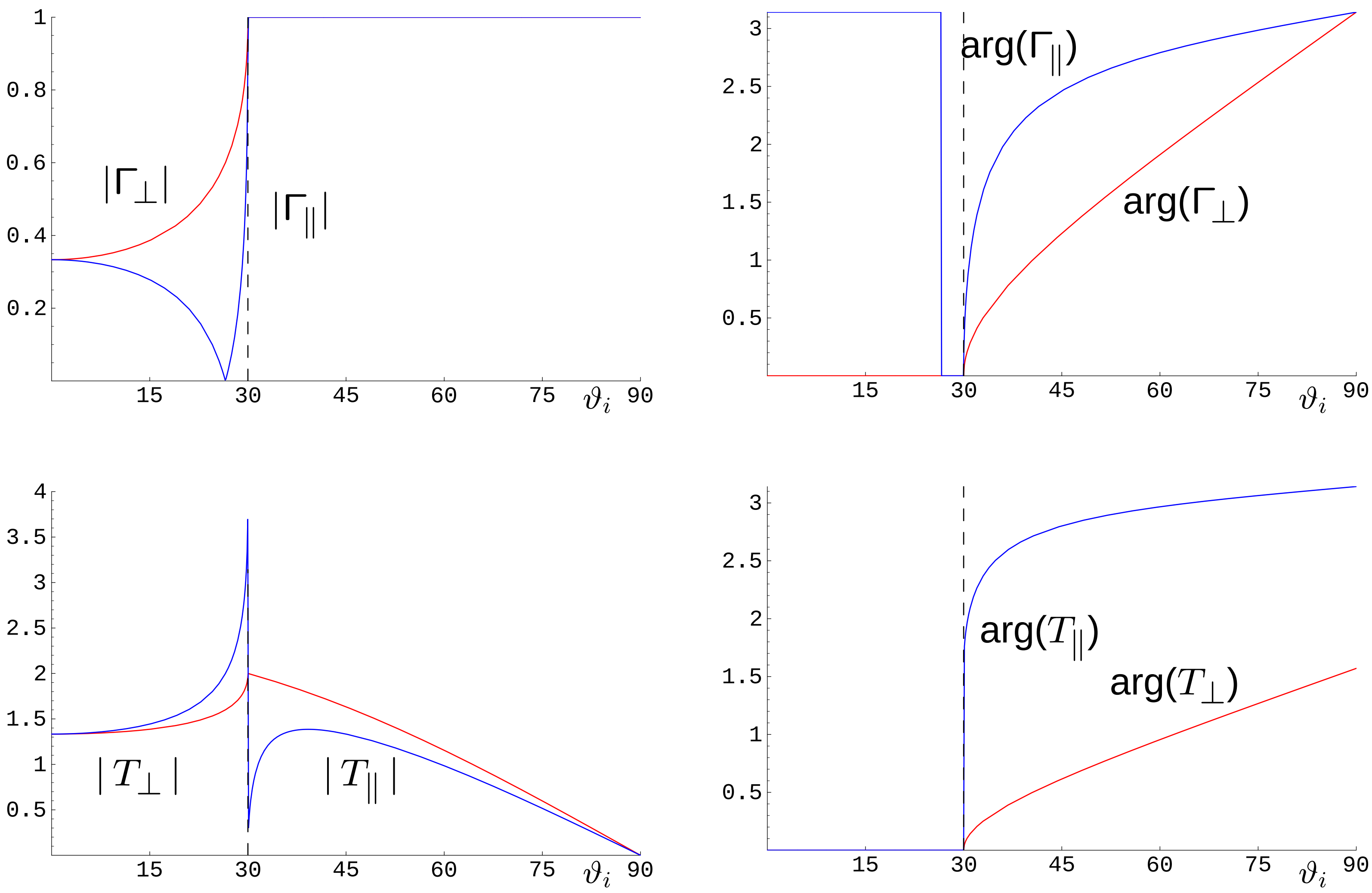
1
0.8
0.6
0.4
0.2
|Γ⊥|
|Γ||
15
30
45
60
75
ϑi
90
3
2.5
2
1.5
1
0.5
arg(Γ⊥)
arg(Γ||)
15
30
45
60
75
ϑi
90
0.5
0.4
0.3
0.2
0.1
|T||
|T⊥|
15
30
45
60
75
ϑi
90
3
2.5
2
1.5
1
0.5
arg(T⊥ = arg(T||) = 0
15
30
45
60
75
ϑi
90

$n_1 = 1 , n_2 = 2$



1
0.8
0.6
0.4
0.2
$|\Gamma_\perp|$
$|\Gamma_\parallel|$
15
30
45
60
75
ϑ_i
90
3
2.5
2
1.5
1
0.5
$\arg(\Gamma_\parallel)$
$\arg(\Gamma_\perp)$
$|T_\perp|$
$|T_\parallel|$
$\arg(T_\parallel)$
$\arg(T_\perp)$

$n_1 = 2\ ,\ n_2 = 1$



$|\Gamma_\perp|$
$|\Gamma_\parallel|$
$\arg(\Gamma_\parallel)$
$\arg(\Gamma_\perp)$
$|T_\perp|$
$|T_\parallel|$
$\arg(T_\parallel)$
$\arg(T_\perp)$
ϑ_i