Polarizacija

Desnosučnost

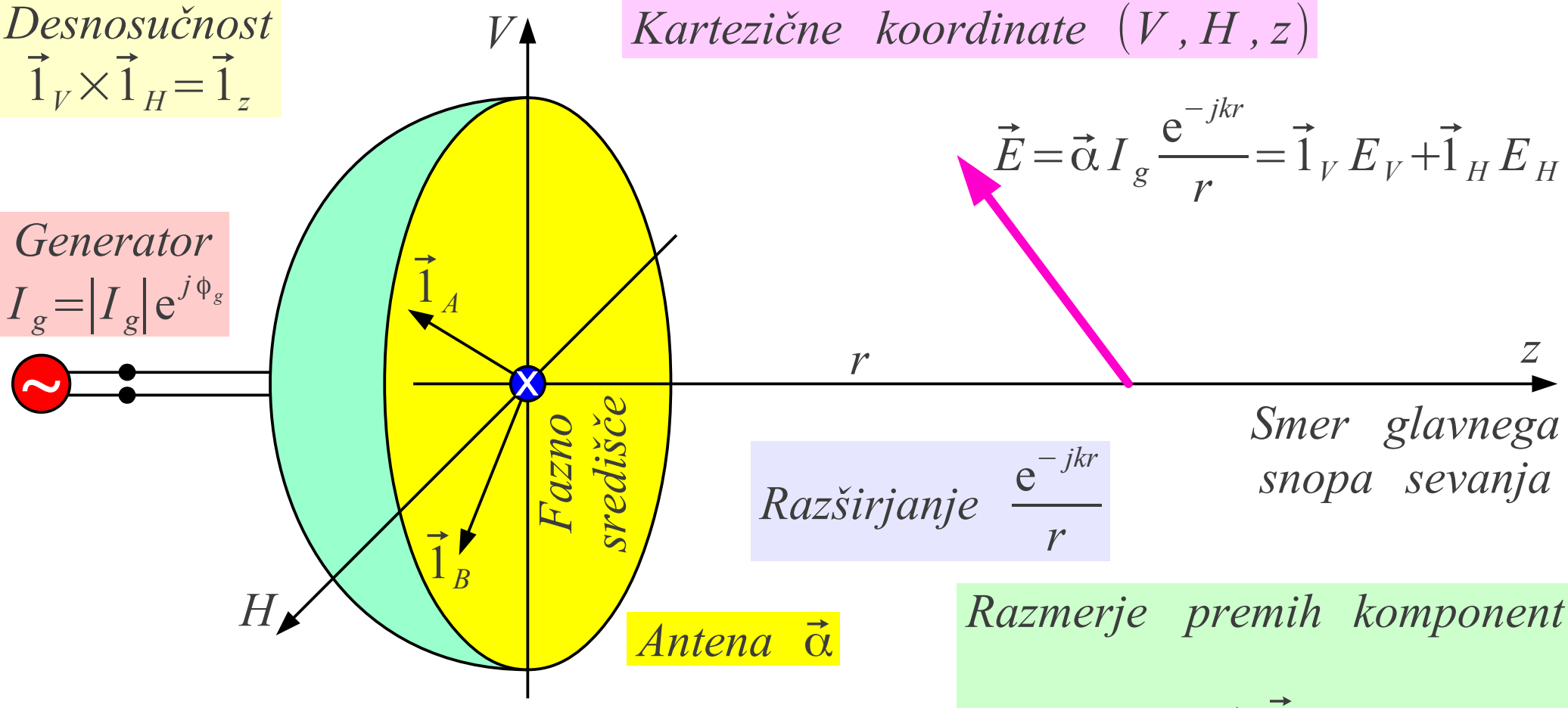
$$\vec{1}_V \times \vec{1}_H = \vec{1}_z$$

Kartezične koordinate (V, H, z)

$$\vec{E} = \vec{\alpha}\, I_g \frac{e^{-jkr}}{r} = \vec{1}_V E_V + \vec{1}_H E_H$$

Generator

$$I_g = |I_g| e^{j\phi_g}$$



Razširjanje $\frac{e^{-jkr}}{r}$

Smer glavnega snopa sevanja

Antena $\vec{\alpha}$

Razmerje premih komponent

$$\frac{E_V}{E_H} = \frac{\vec{\alpha}\cdot\vec{1}_V}{\vec{\alpha}\cdot\vec{1}_H} = \frac{\alpha_V}{\alpha_H}$$

Premo – polarizirani komponenti

$$E_V = \vec{E}\cdot\vec{1}_V = \vec{\alpha}\cdot\vec{1}_V |I_g| e^{j\phi_g} \frac{e^{-jkr}}{r}$$

$$E_H = \vec{E}\cdot\vec{1}_H = \vec{\alpha}\cdot\vec{1}_H |I_g| e^{j\phi_g} \frac{e^{-jkr}}{r}$$

Poševna prema smernika

$$\vec{1}_A = \vec{1}_{(45°)} = \frac{\vec{1}_V + \vec{1}_H}{\sqrt{2}}$$

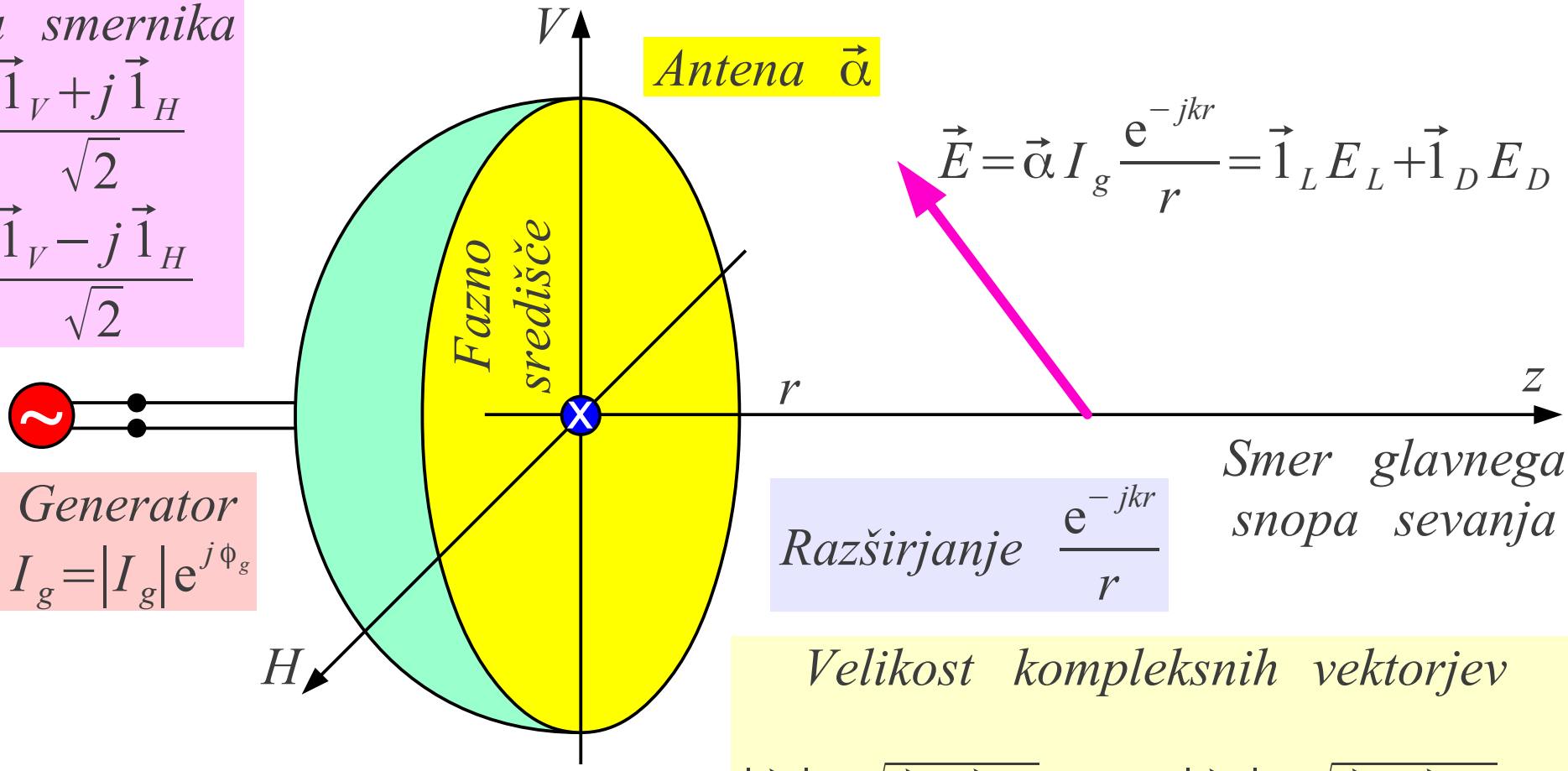
$$\vec{1}_B = \vec{1}_{(135°)} = \frac{\vec{1}_H - \vec{1}_V}{\sqrt{2}}$$

Koordinatni sistem za polarizacijo antene

Krožna smernika

$$\vec{1}_L = \frac{\vec{1}_V + j\,\vec{1}_H}{\sqrt{2}}$$

$$\vec{1}_D = \frac{\vec{1}_V - j\,\vec{1}_H}{\sqrt{2}}$$



Antena $\vec{\alpha}$

$$\vec{E} = \vec{\alpha}\, I_g \frac{e^{-jkr}}{r} = \vec{1}_L E_L + \vec{1}_D E_D$$

Generator

$$I_g = |I_g| e^{j\phi_g}$$

Razširjanje $\frac{e^{-jkr}}{r}$

Smer glavnega snopa sevanja

Velikost kompleksnih vektorjev

$$|\vec{1}_L| = \sqrt{\vec{1}_L \cdot \vec{1}_L^{\,*}} = 1 \qquad |\vec{1}_D| = \sqrt{\vec{1}_D \cdot \vec{1}_D^{\,*}} = 1$$

Pravokotnost $\vec{1}_D \cdot \vec{1}_L^{\,*} = \vec{1}_L \cdot \vec{1}_D^{\,*} = 0$

Krožno – polarizirane komponente

$$E_L = \vec{E} \cdot \vec{1}_L^{\,*} = \vec{\alpha} \cdot \vec{1}_L^{\,*} |I_g| e^{j\phi_g} \frac{e^{-jkr}}{r}$$

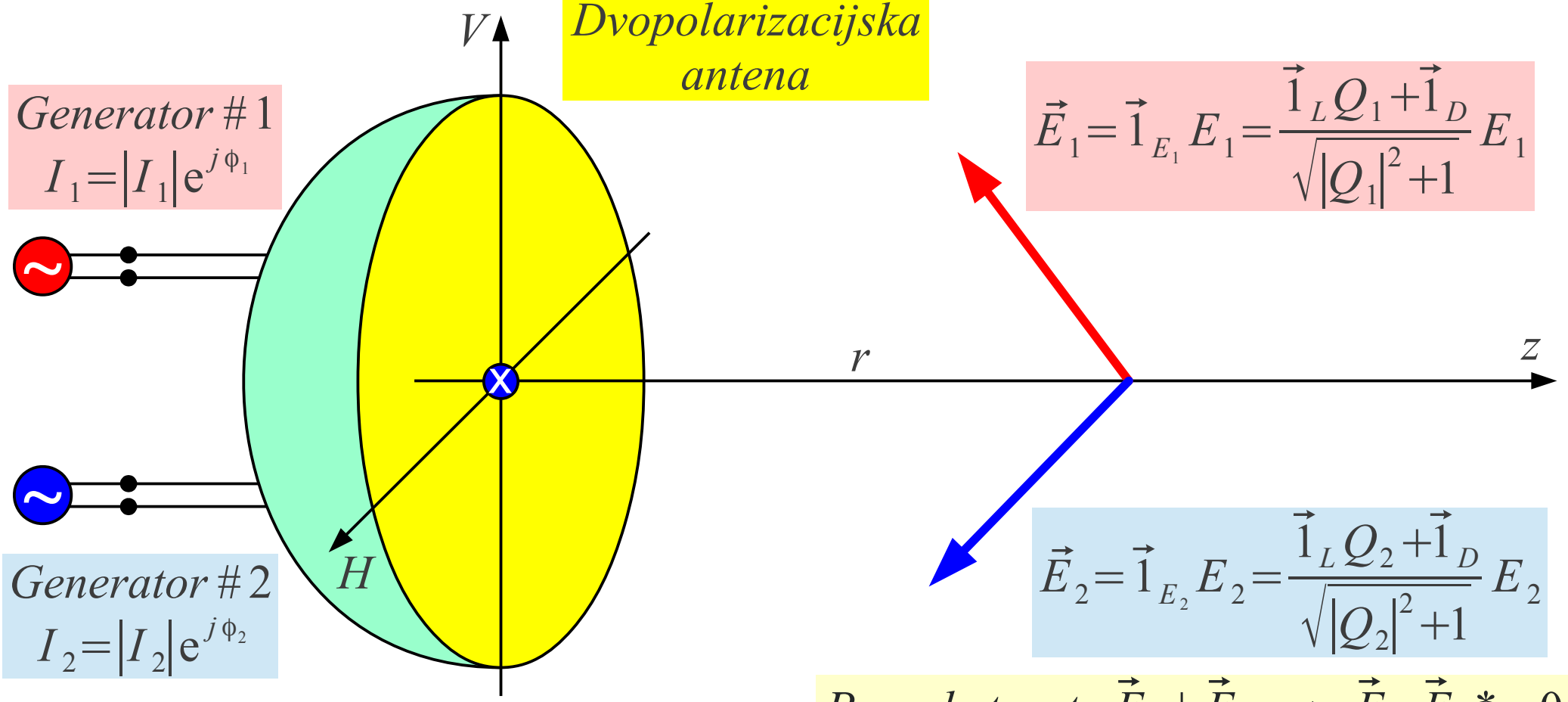
$$E_D = \vec{E} \cdot \vec{1}_D^{\,*} = \vec{\alpha} \cdot \vec{1}_D^{\,*} |I_g| e^{j\phi_g} \frac{e^{-jkr}}{r}$$

Razmerje krožnih komponent

$$Q = \frac{E_L}{E_D} = \frac{\vec{\alpha} \cdot \vec{1}_L^{\,*}}{\vec{\alpha} \cdot \vec{1}_D^{\,*}}$$

Krožni smerniki in komponente

Dvopolarizacijska antena



Generator #1

$I_1 = |I_1| e^{j\phi_1}$

Generator #2

$I_2 = |I_2| e^{j\phi_2}$

$$\vec{E}_1 = \vec{1}_{E_1} E_1 = \frac{\vec{1}_L Q_1 + \vec{1}_D}{\sqrt{|Q_1|^2 + 1}} E_1$$

$$\vec{E}_2 = \vec{1}_{E_2} E_2 = \frac{\vec{1}_L Q_2 + \vec{1}_D}{\sqrt{|Q_2|^2 + 1}} E_2$$

$Q = 0 \equiv desna - krožna \quad polarizacija$

$|Q| < 1 \equiv desna - eliptična \quad polarizacija$

$|Q| = 1 \equiv prema \quad polarizacija$

$|Q| > 1 \equiv leva - eliptična \quad polarizacija$

$Q \to \infty \equiv leva - krožna \; polarizacija$

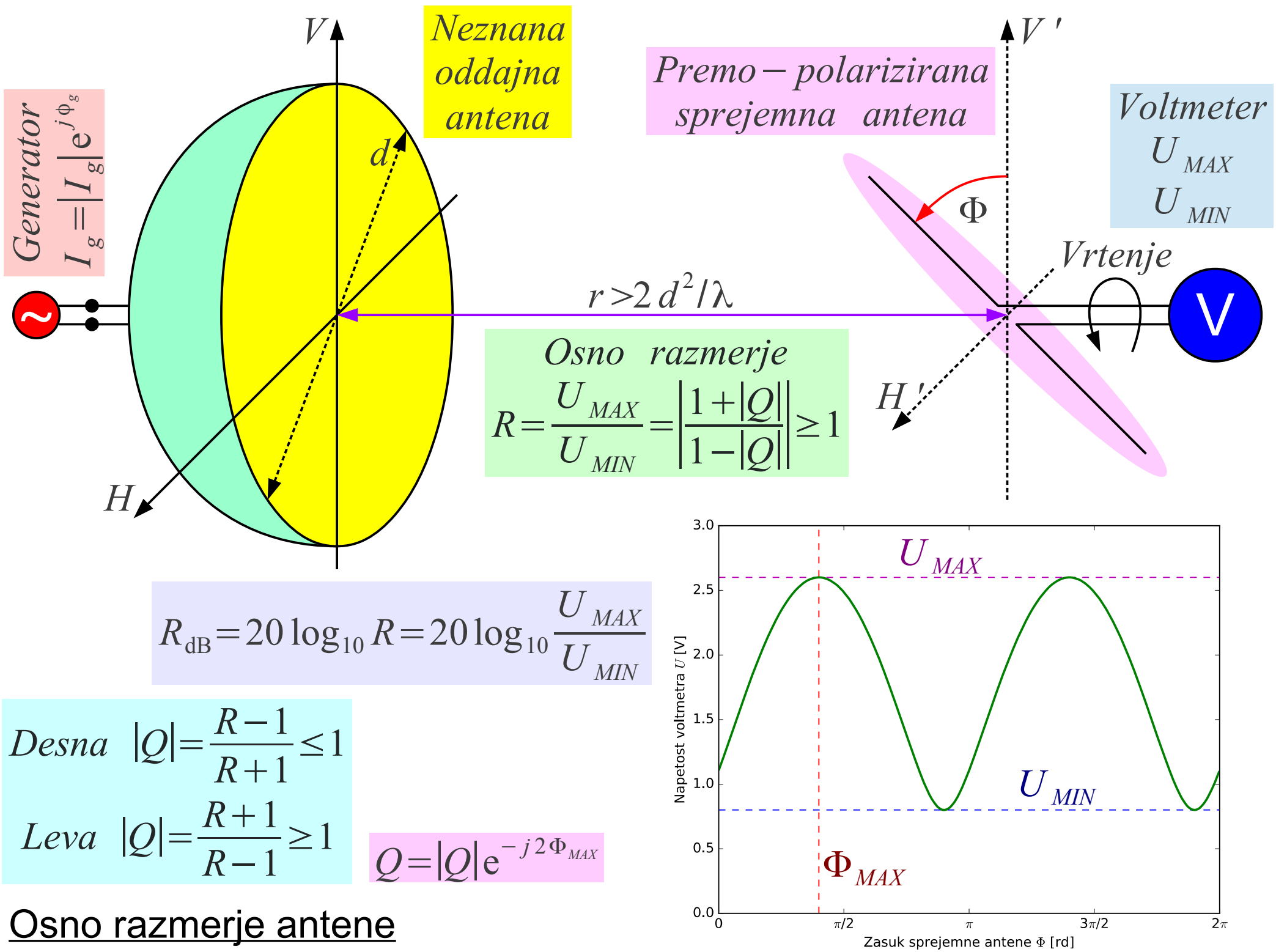
Pravokotnost $\vec{E}_1 \perp \vec{E}_2 \rightarrow \vec{E}_1 \cdot \vec{E}_2^* = 0$

$$\left(\vec{1}_L Q_1 + \vec{1}_D\right) \cdot \left(\vec{1}_L Q_2 + \vec{1}_D\right)^* = 0$$

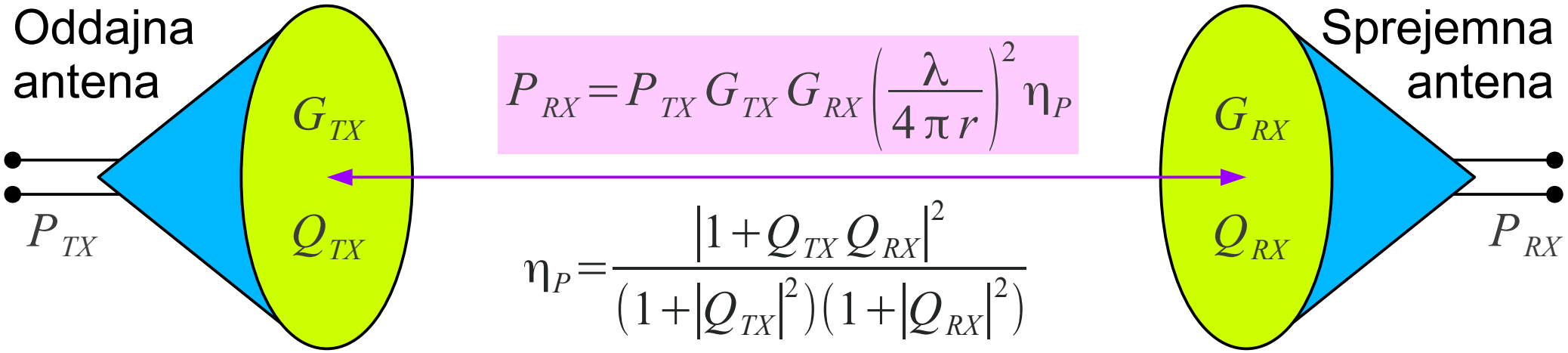
$$Q_1 Q_2^* + 1 = 0$$

$$Q_1 = -\frac{1}{Q_2^*} \qquad Q_2 = -\frac{1}{Q_1^*}$$

Razmerje krožnih komponent



Osno razmerje antene



Polarizacija TX		Q_{TX}	R_{TX}	Faktor skladnosti η_P (polarizacija RX)					
				VP	HP	RHCP	LHCP	$P_{45°}$	$P_{135°}$
VP	$\vec{1}_V$	1	∞	1	0	1/2	1/2	1/2	1/2
HP	$\vec{1}_H$	-1	∞	0	1	1/2	1/2	1/2	1/2
RHCP	$\vec{1}_D = (\vec{1}_V - j\,\vec{1}_H)/\sqrt{2}$	0	1	1/2	1/2	1	0	1/2	1/2
LHCP	$\vec{1}_L = (\vec{1}_V + j\,\vec{1}_H)/\sqrt{2}$	∞	1	1/2	1/2	0	1	1/2	1/2
$P_{45°}$	$\vec{1}_A = (\vec{1}_V + \vec{1}_H)/\sqrt{2}$	$-j$	∞	1/2	1/2	1/2	1/2	0	1
$P_{135°}$	$\vec{1}_B = (\vec{1}_H - \vec{1}_V)/\sqrt{2}$	j	∞	1/2	1/2	1/2	1/2	1	0

Faktor skladnosti polarizacije

George Gabriel Stokes 1852

$$s_0 = P_V + P_H = P_A + P_B = P_L + P_D$$

$$s_1 = P_V - P_H = m\, s_0 \frac{2\,\mathrm{Re}[Q]}{|Q|^2+1}$$

$$s_2 = P_A - P_B = m\, s_0 \frac{-2\,\mathrm{Im}[Q]}{|Q|^2+1}$$

$$s_3 = P_L - P_D = m\, s_0 \frac{|Q|^2-1}{|Q|^2+1}$$

Hitri opazovalec

$B_{opazovalca} \gg B_{signala}$

$$s_0 = \sqrt{s_1^2 + s_2^2 + s_3^2} \qquad m = 1$$

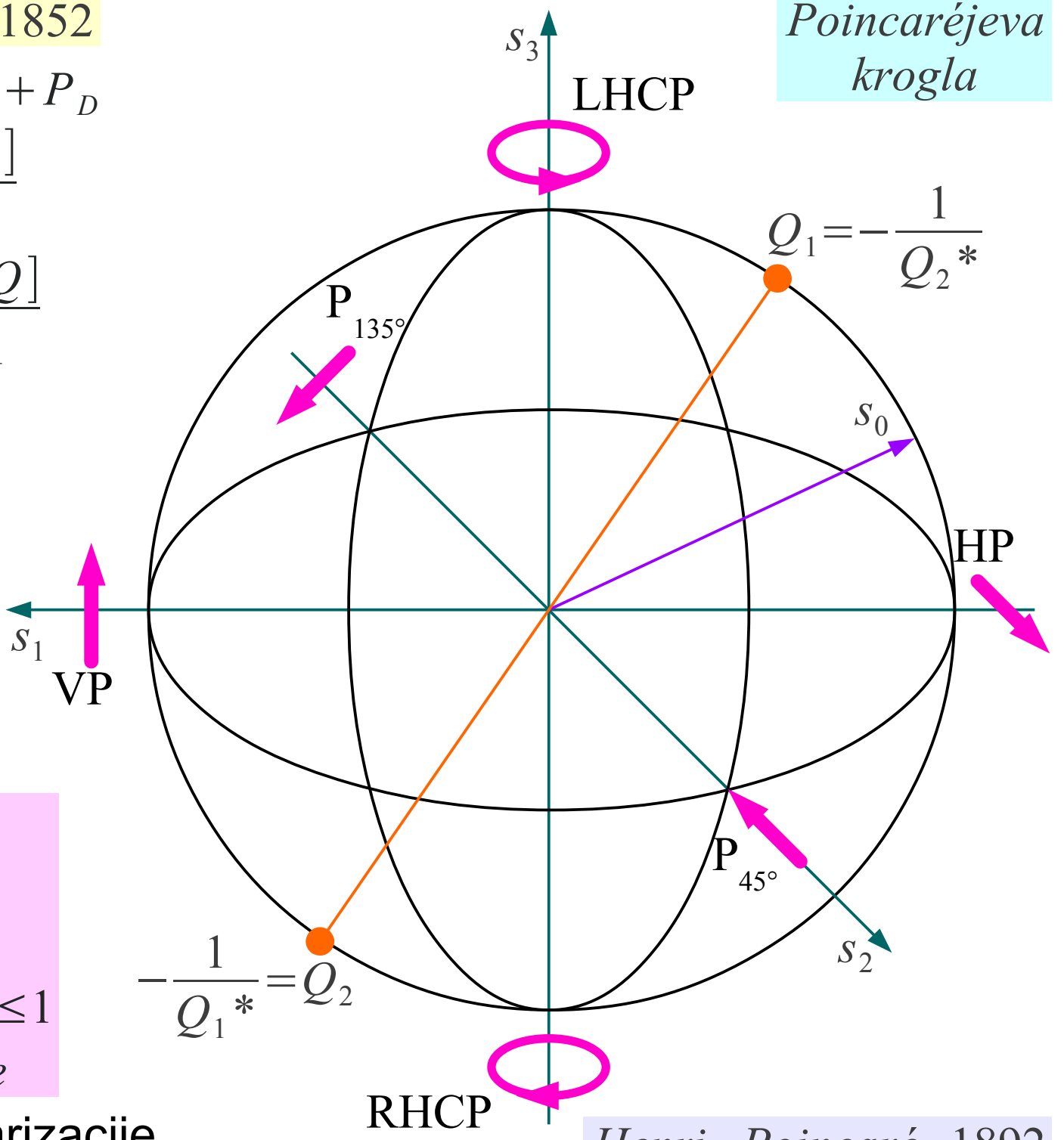
Počasni opazovalec

$B_{opazovalca} \ll B_{signala}$

$$m\, s_0 = \sqrt{s_1^2 + s_2^2 + s_3^2} \qquad 0 \le m \le 1$$

$m \equiv$ *stopnja polarizacije*

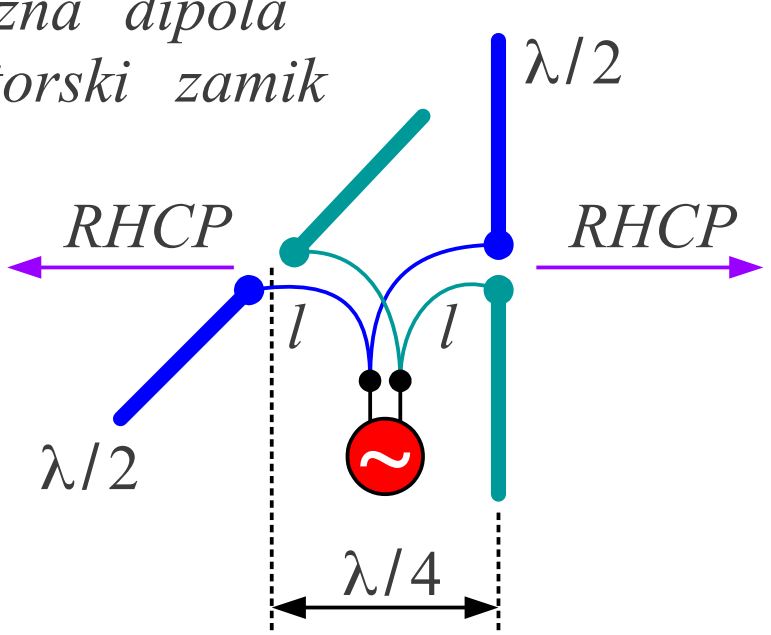
Poincaréjeva krogla



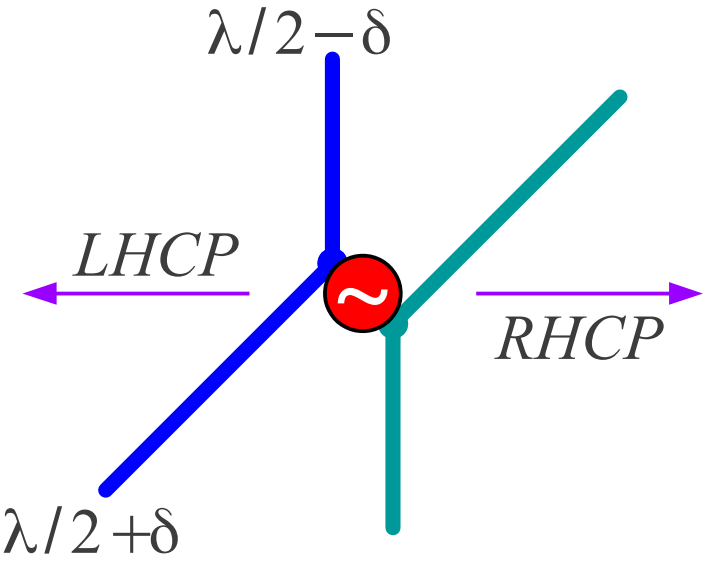
Henri Poincaré 1892

Stokesovi parametri polarizacije

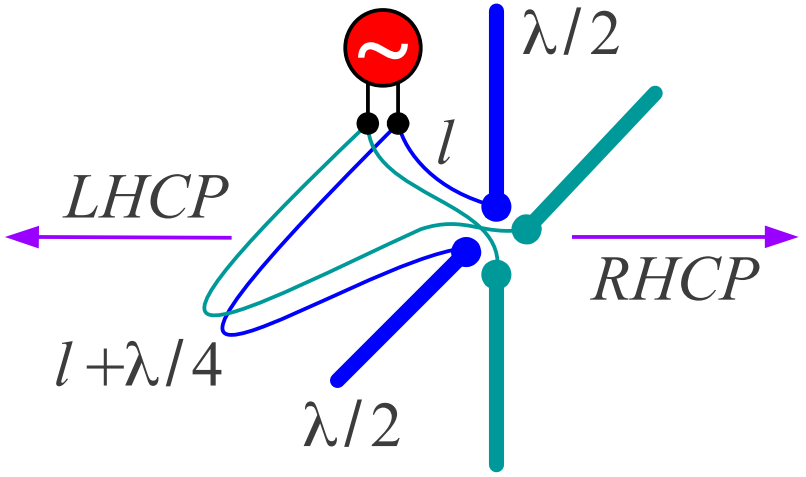
Križna dipola
prostorski zamik



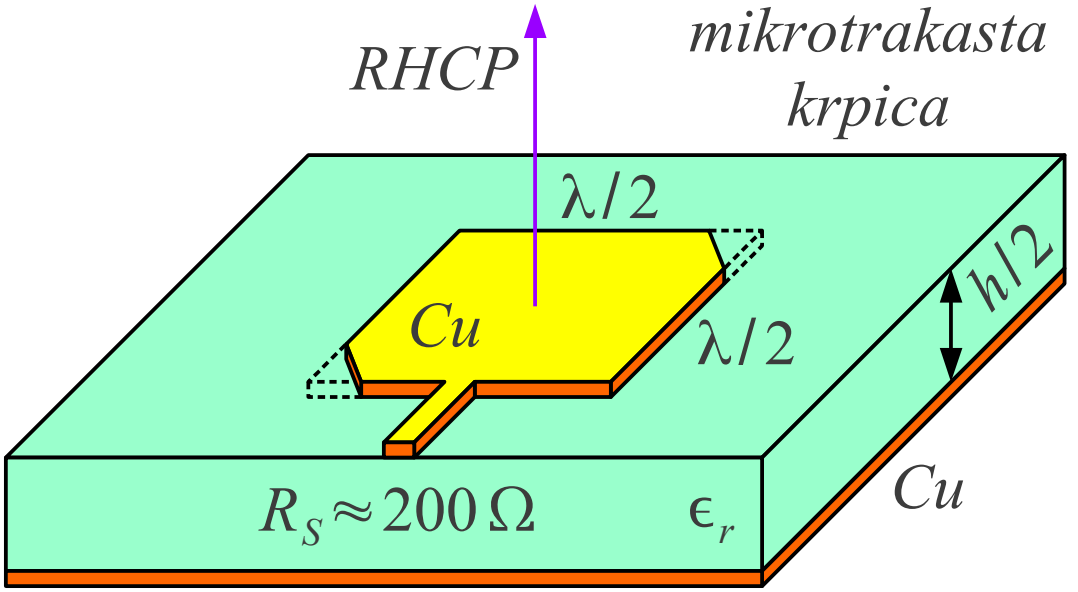
Križna dipola
različnih dolžin



Križna dipola
kvadraturno napajanje

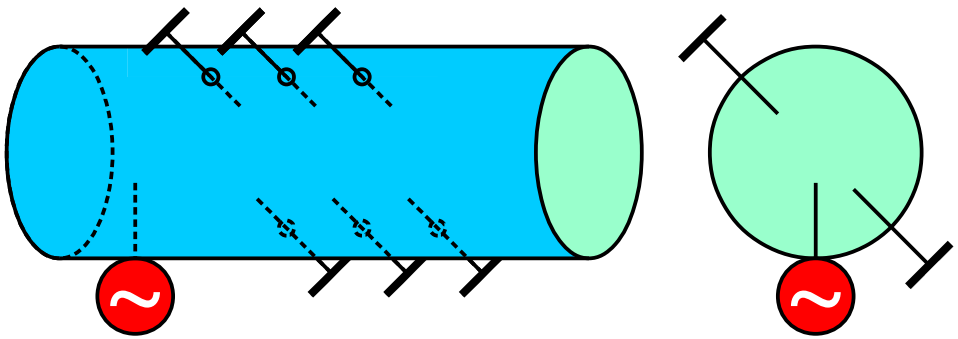


Obrezana
mikrotrakasta
krpica



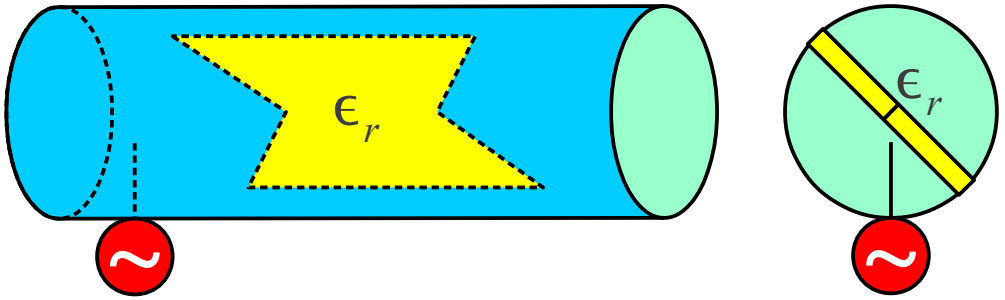
Krožno-polarizirani dipoli

Lonček RHCP



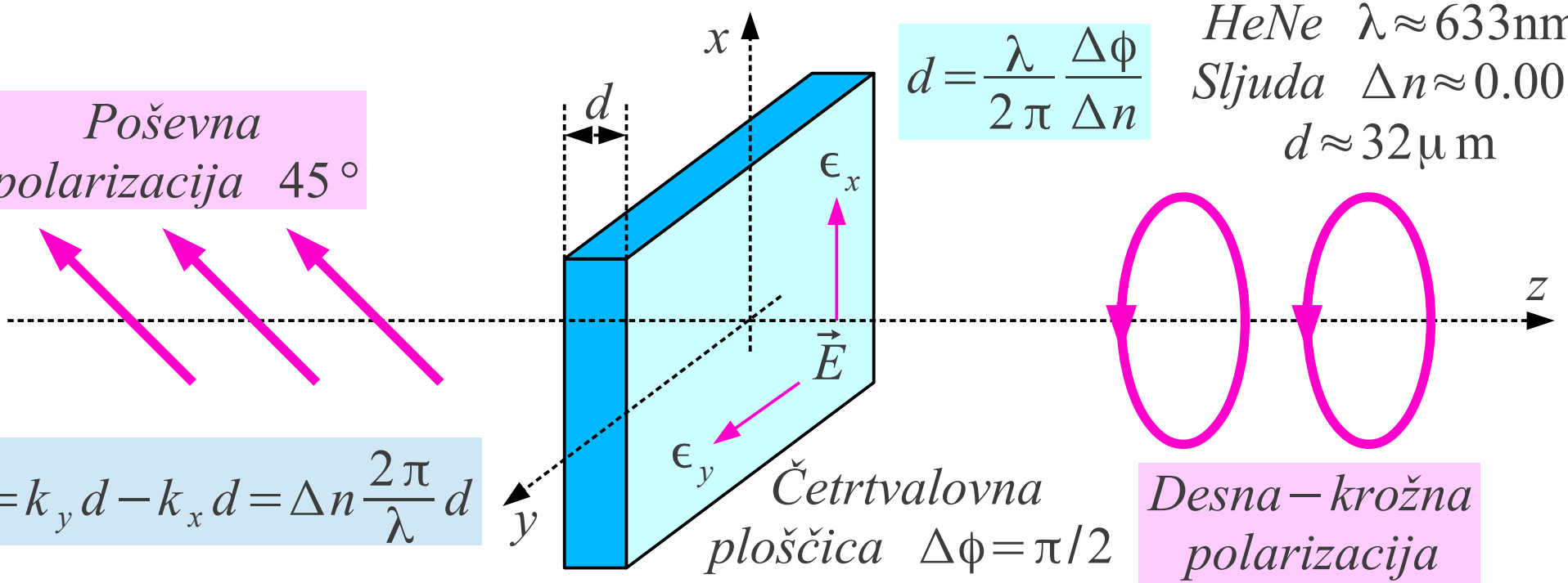
Uglaševalni vijaki pod 45°

Lonček RHCP



Dielektrična ploščica pod 45°

Poševna polarizacija 45°



$$d = \frac{\lambda}{2\pi}\frac{\Delta\phi}{\Delta n}$$

HeNe $\lambda \approx 633\text{nm}$

Sljuda $\Delta n \approx 0.005$

$d \approx 32\mu\text{m}$

$$\Delta\phi = k_y d - k_x d = \Delta n \frac{2\pi}{\lambda} d$$

Četrtvalovna ploščica $\Delta\phi = \pi/2$

Desna–krožna polarizacija RHCP

Krožna polarizacija preko dvolomnosti

Arhimedova spirala $\rho = \alpha \phi$

$$dl = \rho \, d\phi = \alpha \phi \, d\phi$$

$$l_1 = \int_0^{\phi} \alpha \phi \, d\phi = \frac{\alpha \phi^2}{2}$$

$$l_2 = \int_{\pi}^{\phi+\pi} \alpha \phi \, d\phi =$$

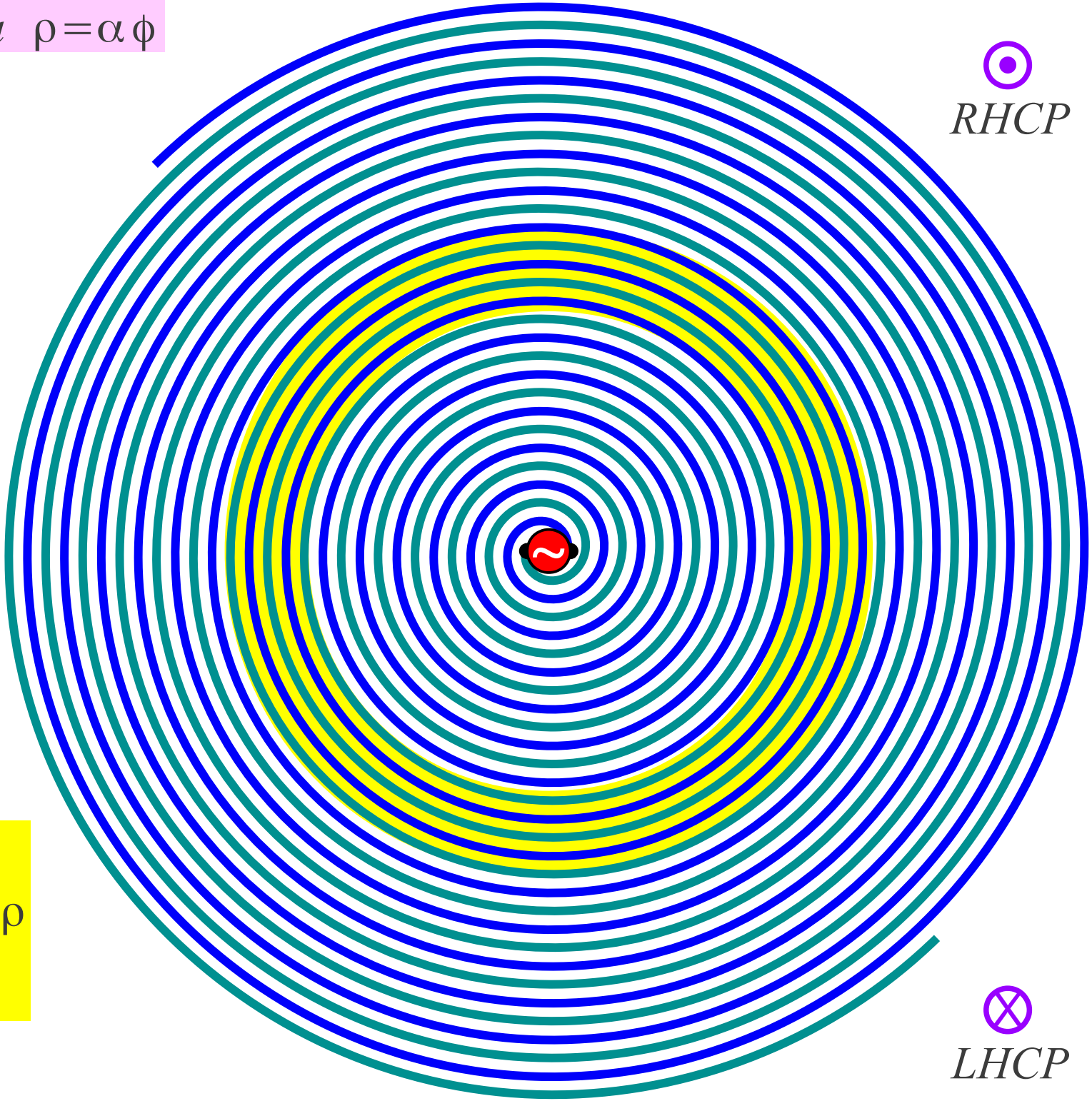
$$= \alpha \left[\frac{(\phi+\pi)^2}{2} - \frac{\pi^2}{2} \right]$$

$$l_2 = \alpha \frac{\phi^2}{2} + \alpha \pi \phi$$

Aktivni kolobar

$$\frac{\lambda}{2} \approx l_2 - l_1 = \alpha \pi \phi = \pi \rho$$

$$\lambda \approx 2 \pi \rho$$



Dvokraka spirala

$l_2 = \lambda + \delta$

$\phi = -\pi/4$

Rezonančna štirižična vijačnica

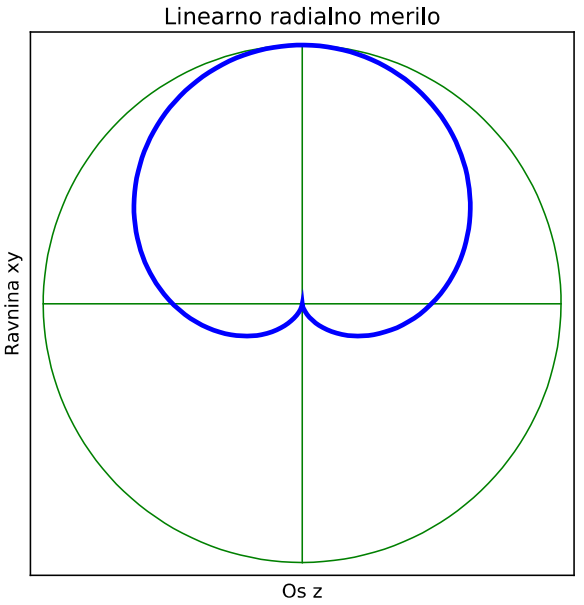
0.5 ovoja !

RHCP nasprotna = leva vijačnica !

$l_1 = \lambda - \delta$

$\phi = +\pi/4$

$F(\Theta, \Phi) \approx 1 + \cos\Theta$

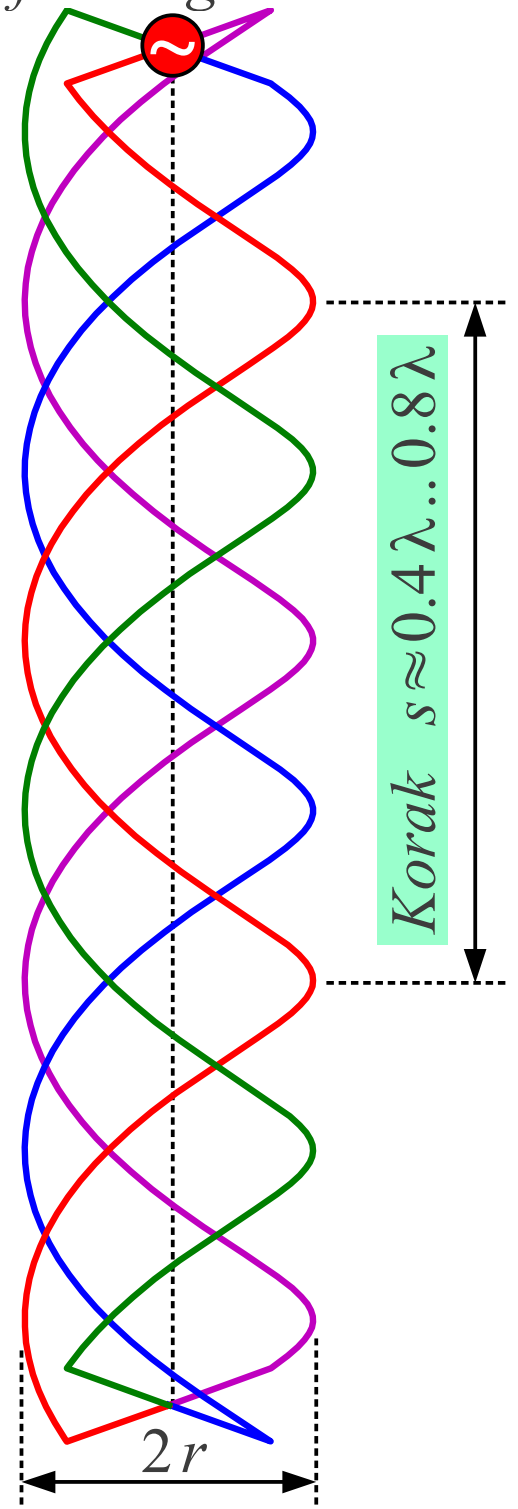


Charles C. Kilgus 1968

RHCP štirižična vijačnica 2 ovoja

Polmer vijačnice $r \approx 0.02\lambda .. 0.12\lambda$

Štirifazni generator



Štirižična vijačna antena z vzvratnim sevanjem