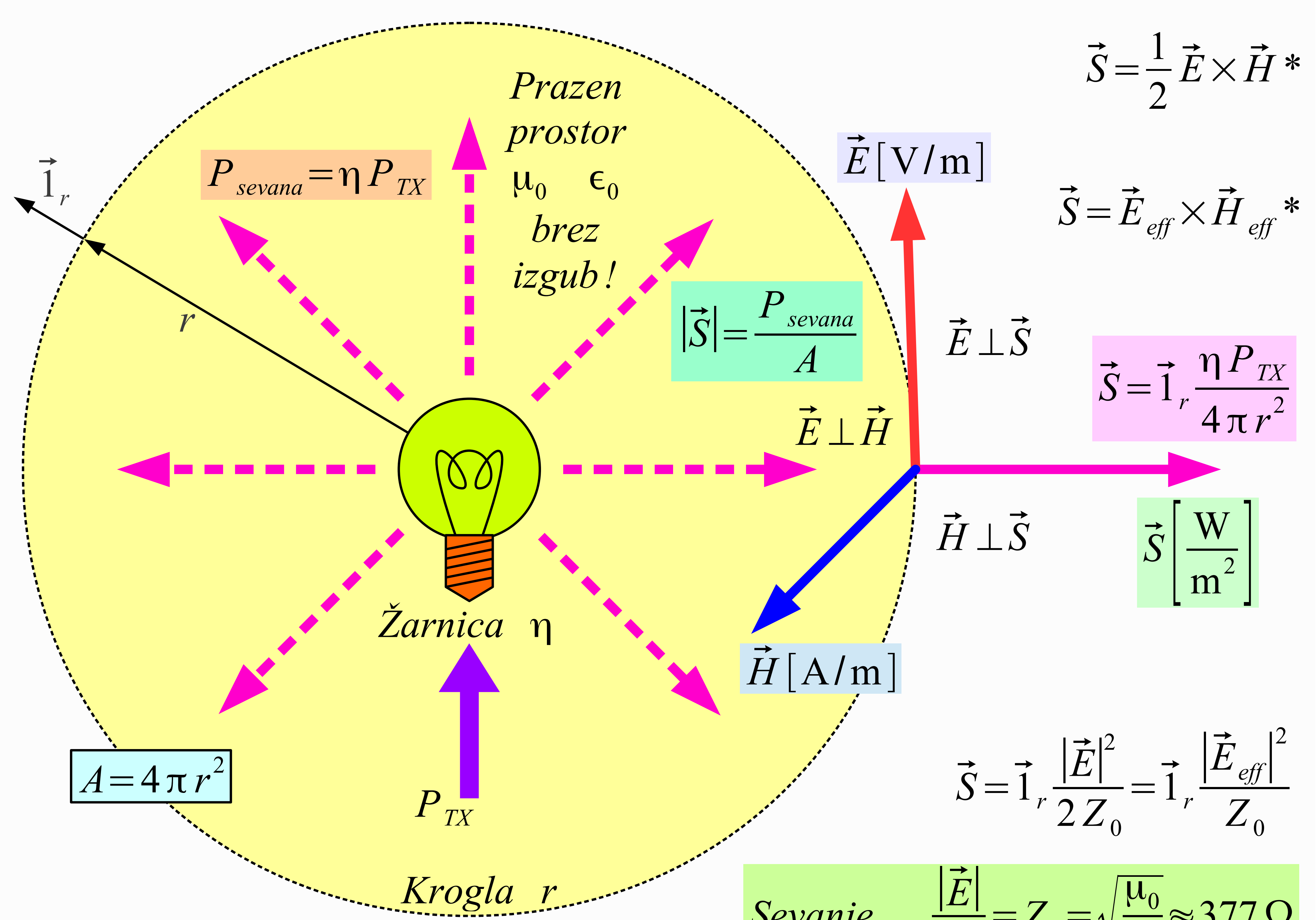
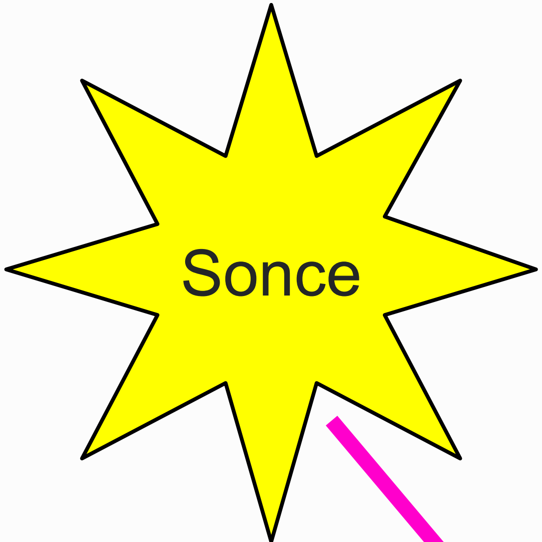
Zveza



Sevanje neusmerjenega vira



Učinek sevanja	*Gostota pretoka moči* $\lvert\vec{S}\rvert$		*Jakost polja* $\lvert\vec{E}_{eff}\rvert$
Sončna svetloba	$1\,\mathrm{kW/m^2}$	$100\,\mathrm{mW/cm^2}$	$614\,\mathrm{V_{eff}/m}$
Zaznaven učinek	$100\,\mathrm{W/m^2}$	$10\,\mathrm{mW/cm^2}$	$194\,\mathrm{V_{eff}/m}$
Varna meja	$10\,\mathrm{W/m^2}$	$1\,\mathrm{mW/cm^2}$	$61\,\mathrm{V_{eff}/m}$
Zakonska omejitev	$0.1\,\mathrm{W/m^2}$	$10\,\mu\mathrm{W/cm^2}$	$6\,\mathrm{V_{eff}/m}$

Prazen prostor
$\mu_0 \quad \epsilon_0$
brez izgub!

$$\lvert\vec{E}\rvert = \sqrt{2 Z_0 \lvert\vec{S}\rvert} \qquad \lvert\vec{E}_{eff}\rvert = \sqrt{Z_0 \lvert\vec{S}\rvert}$$

$\lvert\vec{S}\rvert \approx 1\,\mathrm{kW/m^2}$
(na površini Zemlje)

$f < 750\,\mathrm{THz} \equiv$ *neionizirajoče sevanje*

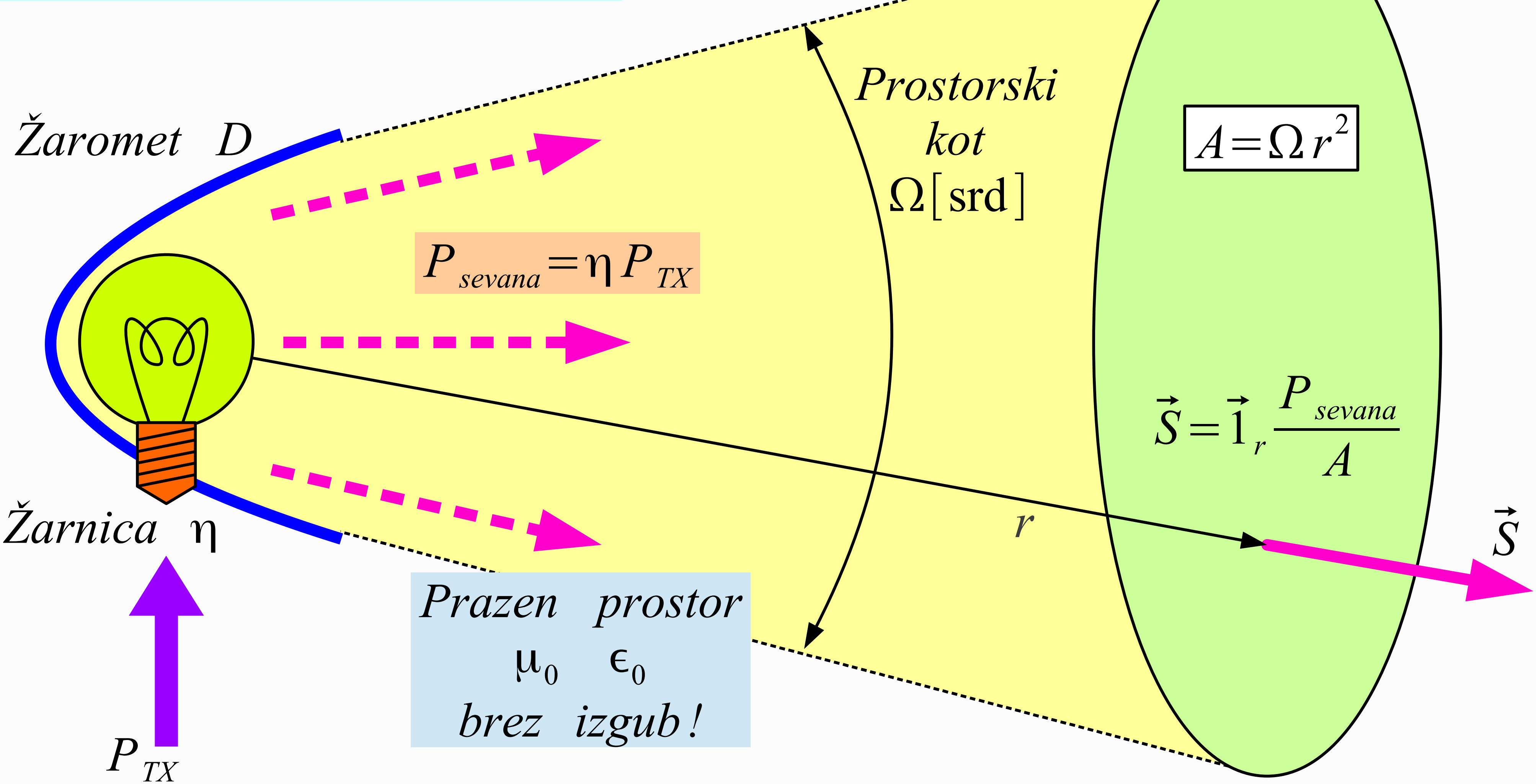
$A_{maček} \approx 0.05\,\mathrm{m^2}$

$$P_{RX} = \vec{S}\cdot\vec{1}_n A_{maček}\left(1-|\Gamma|^2\right)$$

$P_{RX} \approx 50\,\mathrm{W}$

Toplotni učinki sevanja

Smernost (Directivity) $D = \frac{4\pi}{\Omega}$



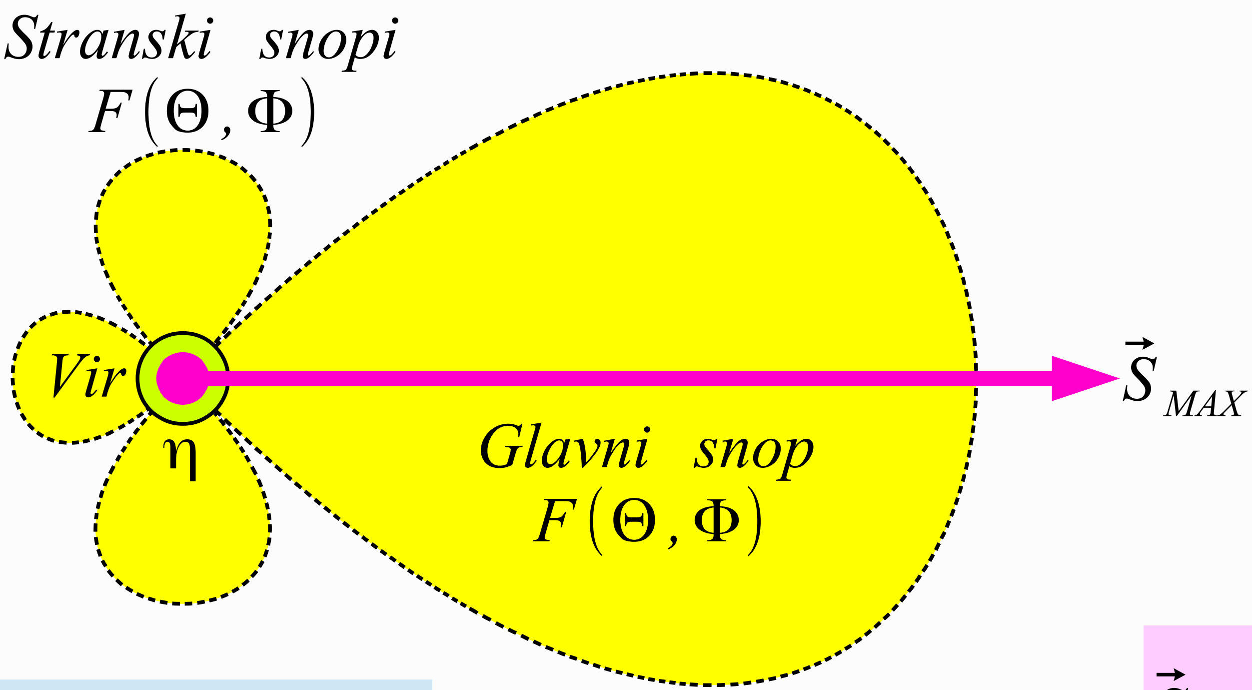
$$EIRP = D\,P_{sevana} = G\,P_{TX}$$

Dobitek (Gain) $G = \eta D$

$$\vec{S} = \vec{1}_r \frac{\eta P_{TX}}{\Omega r^2} = \vec{1}_r \frac{\eta D P_{TX}}{4\pi r^2} = \vec{1}_r \frac{G P_{TX}}{4\pi r^2}$$

<u>Sevanje usmerjenega izvora</u>

Smernost oddajne antene



$$\vec{E}(\vec{r}) = \vec{1}_E\,\alpha\, I\,\frac{e^{-jkr}}{r}\,F(\Theta,\Phi)$$

$$F(\Theta,\Phi) \equiv smerni \quad diagram$$

$$\vec{S} = \vec{1}_r\,\frac{|\vec{E}|^2}{2Z_0}$$

$$\vec{S}(\vec{r}) = \vec{1}_r\,\frac{|\alpha I|^2}{2Z_0 r^2}\,|F(\Theta,\Phi)|^2$$

$$\vec{S}_{MAX} = \vec{1}_r\,\frac{|\alpha I|^2}{2Z_0 r^2}\,|F(\Theta_{MAX},\Phi_{MAX})|^2$$

Prazen prostor

$\mu_0 \quad \epsilon_0$

brez izgub!

$$P_{sevana} = \oiint_{4\pi} \vec{S}(\vec{r})\cdot\vec{1}_r\, r^2\, d\Omega = \frac{|\alpha I|^2}{2Z_0}\oiint_{4\pi} |F(\Theta,\Phi)|^2\, d\Omega$$

$$D = \frac{|\vec{S}_{MAX}|}{\left(\dfrac{P_{sevana}}{4\pi r^2}\right)} = \frac{\dfrac{|\alpha I|^2}{2Z_0 r^2}|F(\Theta_{MAX},\Phi_{MAX})|^2}{\dfrac{1}{4\pi r^2}\dfrac{|\alpha I|^2}{2Z_0}\oiint_{4\pi}|F(\Theta,\Phi)|^2\, d\Omega}$$

$$D = \frac{4\pi\,|F(\Theta_{MAX},\Phi_{MAX})|^2}{\oiint_{4\pi}|F(\Theta,\Phi)|^2\, d\Omega}$$

$$d\Omega = \sin\Theta\, d\Theta\, d\Phi$$

Smerni diagram (kompleksna skalarna funkcija): $F(\Theta,\Phi)$

$$F(\Theta,\Phi)=A(\Theta,\Phi)\,\mathrm{e}^{j\phi(\Theta,\Phi)}$$

Amplitudni smerni diagram: $A(\Theta,\Phi)=\pm|F(\Theta,\Phi)|$ *(običajno +)*

Fazni smerni diagram: $\phi(\Theta,\Phi)=\arctan\dfrac{\mathrm{Im}[F(\Theta,\Phi)]}{\mathrm{Re}[F(\Theta,\Phi)]}$ *(kvadrant?)*

Normirani smerni diagram: $F_N(\Theta,\Phi)=\dfrac{F(\Theta,\Phi)}{F(\Theta_{MAX},\Phi_{MAX})}$

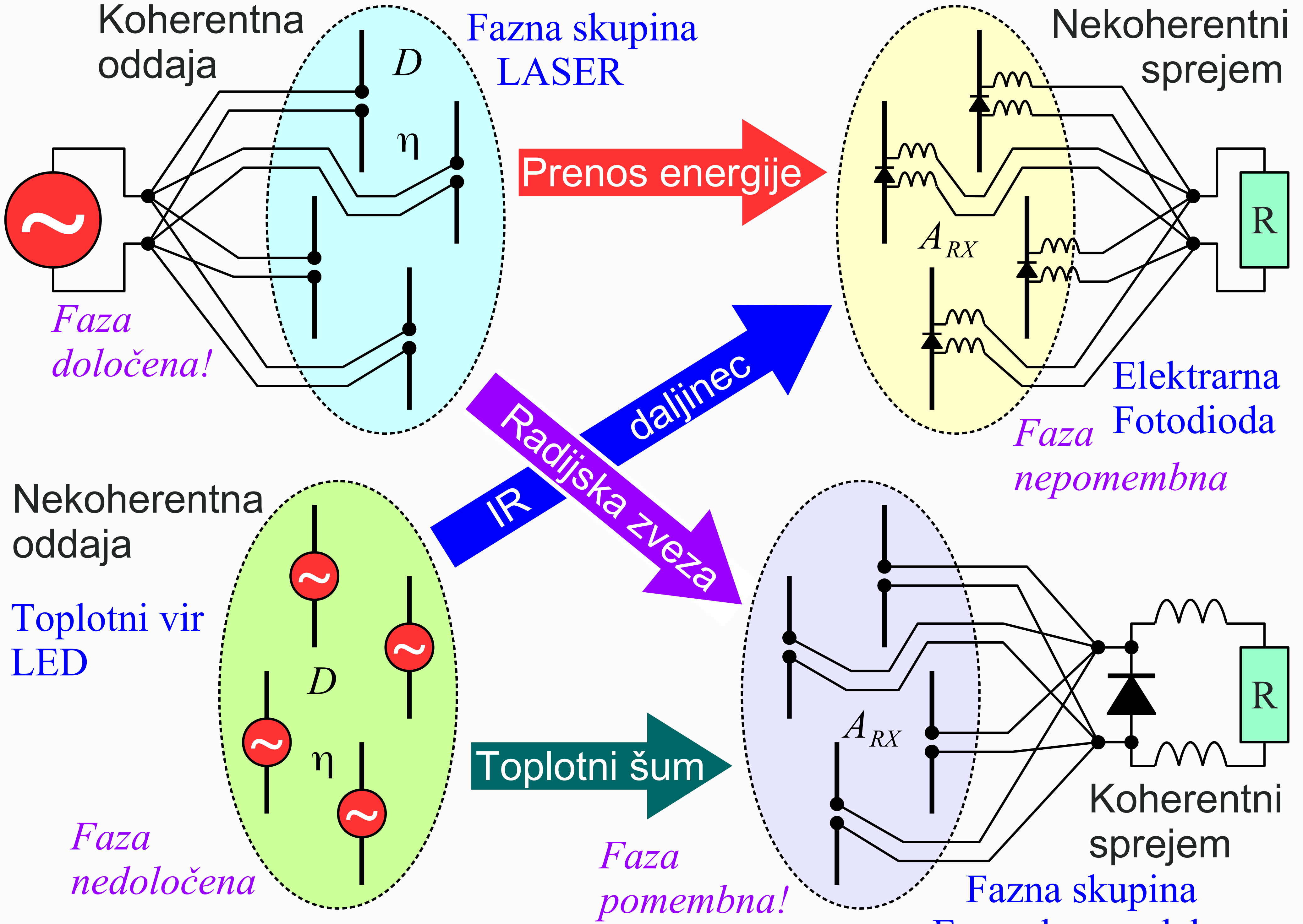
Močnostni smerni diagram: $|F(\Theta,\Phi)|^2$

Logaritemski smerni diagram: $F_{\mathrm{dB}}(\Theta,\Phi)=20\log_{10}\left|\dfrac{F(\Theta,\Phi)}{F(\Theta_{MAX},\Phi_{MAX})}\right|$

Zgled:
$F(\Theta,\Phi)=\sin(\Theta)$

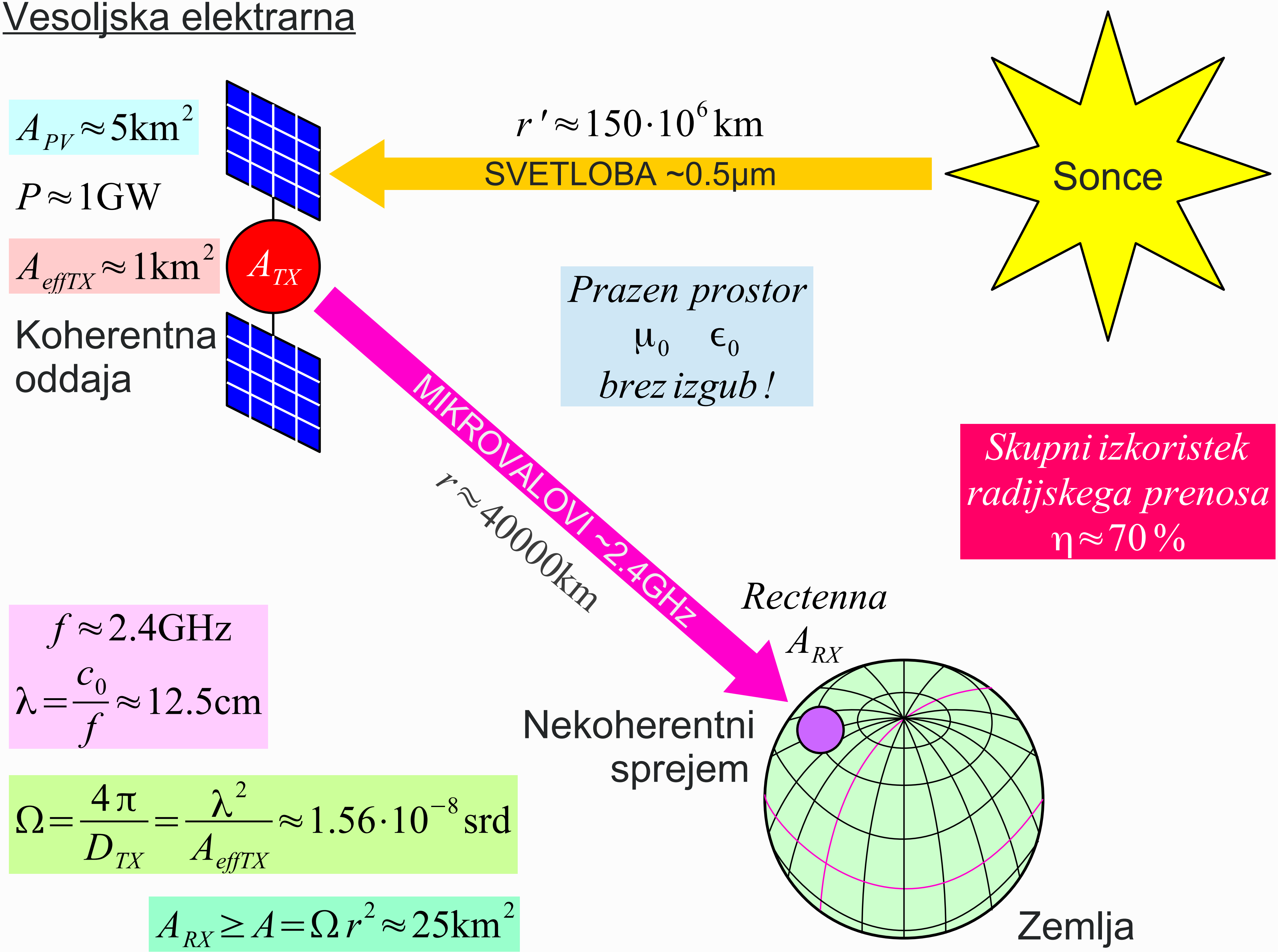
$$D=\frac{4\pi|F(\Theta_{MAX},\Phi_{MAX})|^2}{\oiint\limits_{4\pi}|F(\Theta,\Phi)|^2\,d\Omega}=\frac{4\pi|\sin\Theta_{MAX}|^2}{\int\limits_0^{\pi}\int\limits_0^{2\pi}|\sin\Theta|^2\sin\Theta\,d\Theta\,d\Phi}=$$

$$=\frac{4\pi|\sin(\pi/2)|^2}{2\pi\int\limits_0^{\pi}(1-\cos^2\Theta)\sin\Theta\,d\Theta}=\frac{2}{\int\limits_{-1}^{1}(1-u^2)\,du}=\frac{2}{4/3}=1.5=1.76\mathrm{dBi}$$

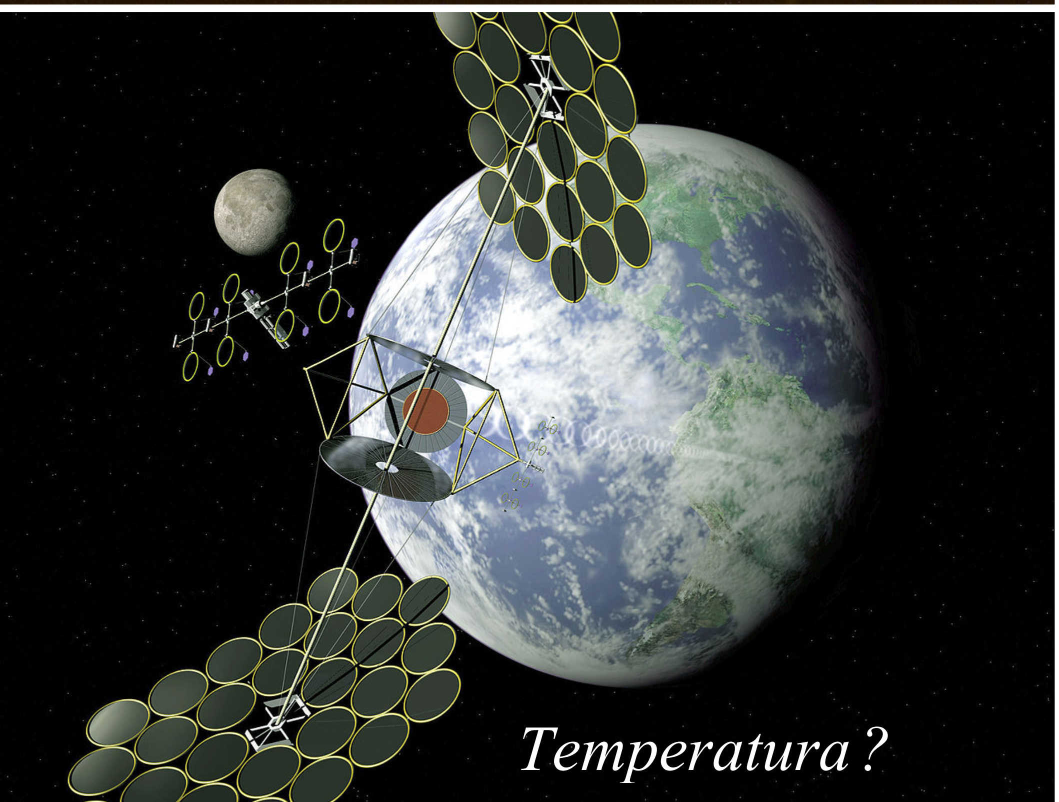


Nekoherentna in koherentna oddaja in sprejem

Vesoljska elektrarna

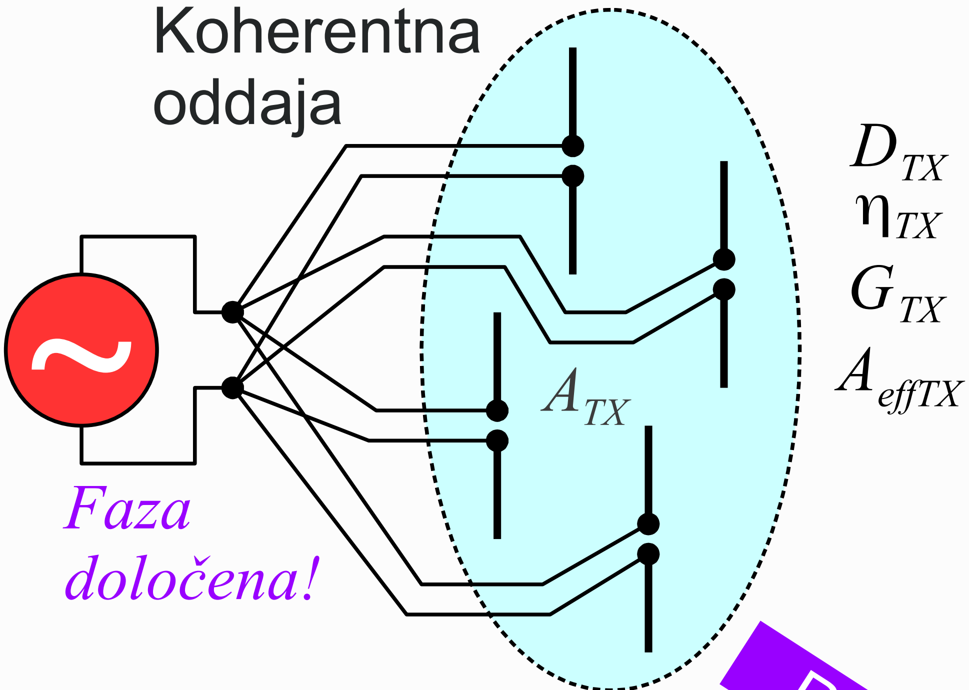



Vrtilna količina ?

Meteorit ?

Temperatura ?

Nočno nebo ?

Efektivna površina koherentne antene



$$A_{effTX}=\frac{\lambda^2}{4\pi}D_{TX}=\frac{\lambda^2}{4\pi}\frac{G_{TX}}{\eta_{TX}}$$

$$A_{eff}=A\cdot\eta_0\equiv \textit{efektivna površina}$$

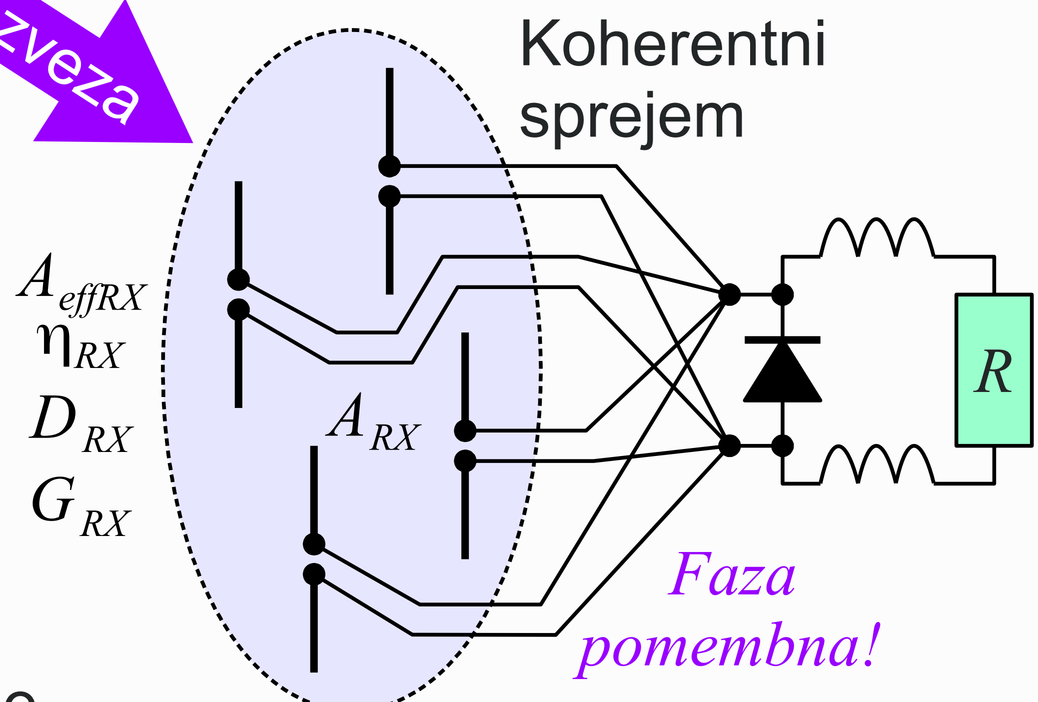
$$\eta_0\equiv \textit{izkoristek osvetlitve}$$

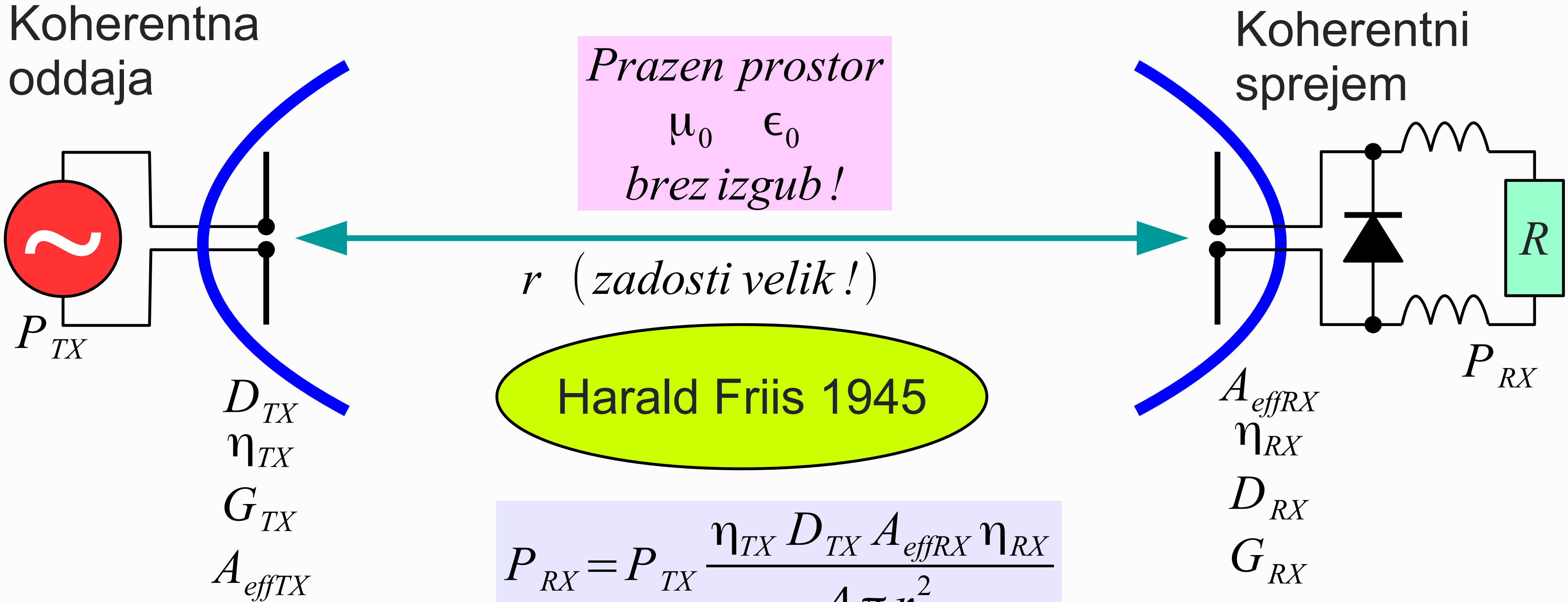
$$\eta_0\approx 50\%\ldots80\%$$

Recipročnost !

$$D_{RX}=\frac{4\pi}{\lambda^2}A_{effRX}$$

$$G_{RX}=\frac{4\pi}{\lambda^2}A_{effRX}\,\eta_{RX}$$





$$P_{RX} = P_{TX} \frac{\eta_{TX} D_{TX} A_{effRX} \eta_{RX}}{4\pi r^2}$$

Zapis z dobitki anten: $$P_{RX} = P_{TX} G_{TX} G_{RX} \left(\frac{\lambda}{4\pi r} \right)^2$$

Recipročnost !

Zapis s površinami anten: $$P_{RX} = P_{TX} \frac{\eta_{TX} A_{effTX} A_{effRX} \eta_{RX}}{\lambda^2 r^2}$$

Friisova enačba za domet koherentne zveze

$$P[\mathrm{dBm}]=10\log_{10}(P/1\mathrm{mW})=P[\mathrm{dBW}]+30\mathrm{dB}$$
$$P[\mathrm{dBW}]=10\log_{10}(P/1\mathrm{W})=P[\mathrm{dBm}]-30\mathrm{dB}$$

dBm ≡ dB glede na 1mW

dBW ≡ dB glede na 1W

$$D[\mathrm{dBi}]=10\log_{10}D$$
$$G[\mathrm{dBi}]=10\log_{10}G$$

dBi ≡ dB glede na neusmerjen (izotropni) vir

$$D[\mathrm{dBd}]=D[\mathrm{dBi}]-2.15\,\mathrm{dB}$$
$$G[\mathrm{dBd}]=G[\mathrm{dBi}]-2.15\,\mathrm{dB}$$

dBd ≡ dB glede na polvalovni dipol

$$P_{RX}[\mathrm{dBm}]=P_{TX}[\mathrm{dBm}]+G_{TX}[\mathrm{dBi}]+G_{RX}[\mathrm{dBi}]+$$
$$+20\log_{10}\lambda[\mathrm{m}]-20\log_{10}r[\mathrm{m}]-21.98\,\mathrm{dB}$$

$$20\log_{10}(4\pi)=21.98\mathrm{dB}$$

Friisova enačba

$$P_{RX}=P_{TX}G_{TX}G_{RX}\left(\frac{\lambda}{4\pi r}\right)^2$$

Slabljenje praznega prostora

$$a[\mathrm{dB}]=20\log_{10}\left(\frac{\lambda}{4\pi r}\right)$$

$$P_{RX}[\mathrm{dBm}]=P_{TX}[\mathrm{dBm}]+G_{TX}[\mathrm{dBi}]+G_{RX}[\mathrm{dBi}]-$$
$$-20\log_{10}f[\mathrm{MHz}]-20\log_{10}r[\mathrm{m}]+27.55\,\mathrm{dB}$$

$$\lambda[\mathrm{m}]\approx 299.7/f[\mathrm{MHz}]\quad(\mathit{zrak}\quad n\approx 1.0003)$$

Logaritemske merske enote

Efektivna dolžina antene

Ena od možnih definicij
efektivna dolžina
ali efektivna višina
ali antenski faktor

$$U_{emf}=\vec{E}_{eff}\cdot\vec{l}_{eff}$$

$U_{emf}[V]\equiv$ *napetost odprtih sponk*

$\vec{E}_{eff}\left[\frac{V}{m}\right]\equiv$ *električna poljska jakost*

$\vec{l}_{eff}[m]\equiv$ *vektor efektivne dolžine*

Gostota moči $|\vec{S}|\left[\frac{W}{m^2}\right]=\frac{|\vec{E}_{eff}|^2}{Z_0}$ $\quad Z_0=\sqrt{\frac{\mu_0}{\epsilon_0}}\approx 377\,\Omega\equiv$ *valovna impedanca*

Moč sprejema $P_{RX}[W]=|\vec{S}|A_{RX}\eta_{RX}$

$A_{effRX}[m^2]\equiv$ *efektivna površina antene*

$\eta_{RX}[\%]\equiv$ *električni izkoristek antene*

Napetost sprejema $U_{eff}[V]=\sqrt{R_S P_{RX}}$ $\quad R_S=\mathrm{Re}[Z]\equiv$ *sevalna upornost antene*

Napetost odprtih sponk $U_{emf}[V]=2U_{eff}[V]$ $\quad emf\equiv$ *electromotive force*

Efektivna dolžina antene $\vec{l}_{eff}[m]=\vec{1}_P 2\sqrt{\frac{R_S A_{effRX}\eta_{RX}}{Z_0}}$ $\quad \vec{1}_P\equiv$ *polarizacija antene*

Obstajajo še drugačne, nezdružljive definicije efektivne dolžine antene!