24. Seminar Radijske Komunikacije

Postopki računalniške simulacije anten s praktičnimi zgledi

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Seznam prosojnic: Postopki računalniške simulacije anten s praktičnimi zgledi

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Časovni prostor

Ampère $\quad \operatorname{rot} \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$

Faraday $\quad \operatorname{rot} \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

Gauss $\quad \operatorname{div} \vec{D} = \rho$

Preprosta snov

$\vec{D} = \epsilon \vec{E}$

$\vec{B} = \mu \vec{H}$

$\operatorname{rot} \vec{H} = \vec{J} + \epsilon \frac{\partial \vec{E}}{\partial t}$

$\operatorname{rot} \vec{E} = -\mu \frac{\partial \vec{H}}{\partial t}$

$\operatorname{div} \vec{E} = \frac{\rho}{\epsilon}$

Frekvenčni prostor $\quad \frac{\partial}{\partial t} \rightarrow j\omega$

Ampère $\quad \operatorname{rot} \vec{H} = \vec{J} + j\omega\epsilon \vec{E}$

Faraday $\quad \operatorname{rot} \vec{E} = -j\omega\mu \vec{H}$

Gauss $\quad \operatorname{div} \vec{E} = \frac{\rho}{\epsilon}$

Diferencialna oblika v elektrodinamiki!

1 − Maxwellove enačbe v časovnem in frekvenčnem prostoru

Smerni odvod

$$\operatorname{grad} T=\nabla T=\vec{1}_{q1}\frac{1}{h_1}\frac{\partial T}{\partial q_1}+\vec{1}_{q2}\frac{1}{h_2}\frac{\partial T}{\partial q_2}+\vec{1}_{q3}\frac{1}{h_3}\frac{\partial T}{\partial q_3}$$

Izvornost

$$\operatorname{div}\vec{F}=\frac{1}{h_1h_2h_3}\left[\frac{\partial(h_2h_3F_1)}{\partial q_1}+\frac{\partial(h_1h_3F_2)}{\partial q_2}+\frac{\partial(h_1h_2F_3)}{\partial q_3}\right]$$

Vrtinčenje

$$\operatorname{rot}\vec{F}=\frac{1}{h_1h_2h_3}\begin{vmatrix} h_1\vec{1}_{q1} & h_2\vec{1}_{q2} & h_3\vec{1}_{q3} \\ \dfrac{\partial}{\partial q_1} & \dfrac{\partial}{\partial q_2} & \dfrac{\partial}{\partial q_3} \\ h_1F_1 & h_2F_2 & h_3F_3 \end{vmatrix}$$

Koordinate

$$q_1, q_2, q_3$$

Faktorji skale

$$(Lamé)$$

$$h_1, h_2, h_3$$

$$\textit{Antenska naloga: izvori } \vec{J}, \rho \rightarrow \textit{ polja } \vec{E}, \vec{H}$$

$$\textit{Gostota prevodniškega toka } \vec{J}\,[\mathrm{A/m^2}]$$

$$\textit{Gostota elektrine } \rho\,[\mathrm{As/m^3}]$$

$$\textit{Laplace } \Delta\vec{F} = \mathrm{grad}(\mathrm{div}\,\vec{F}) - \mathrm{rot}(\mathrm{rot}\,\vec{F})$$

$$\textit{Valovna enačba za } \vec{E}\,[\mathrm{V/m}]$$

$$\Delta\vec{E} + \omega^2\mu\epsilon\vec{E} = j\omega\mu\vec{J} + \frac{1}{\epsilon}\mathrm{grad}\,\rho$$

$$\textit{Valovna enačba za } \vec{H}\,[\mathrm{A/m}]$$

$$\Delta\vec{H} + \omega^2\mu\epsilon\vec{H} = -\mathrm{rot}\,\vec{J}$$

Uporabno v prostoru brez izvorov

$\vec{J} = 0 \quad \rho = 0$

oziroma v izgubni snovi

$\vec{J} = \gamma\vec{E}$

Skalarni potencial $V\,[\mathrm{V}]$

Vektorski potencial $\vec{\mathrm{A}}\,[\mathrm{Vs/m}]$

Izračun polja:

$$\vec{E} = -j\omega\vec{A} - \mathrm{grad}\,V$$

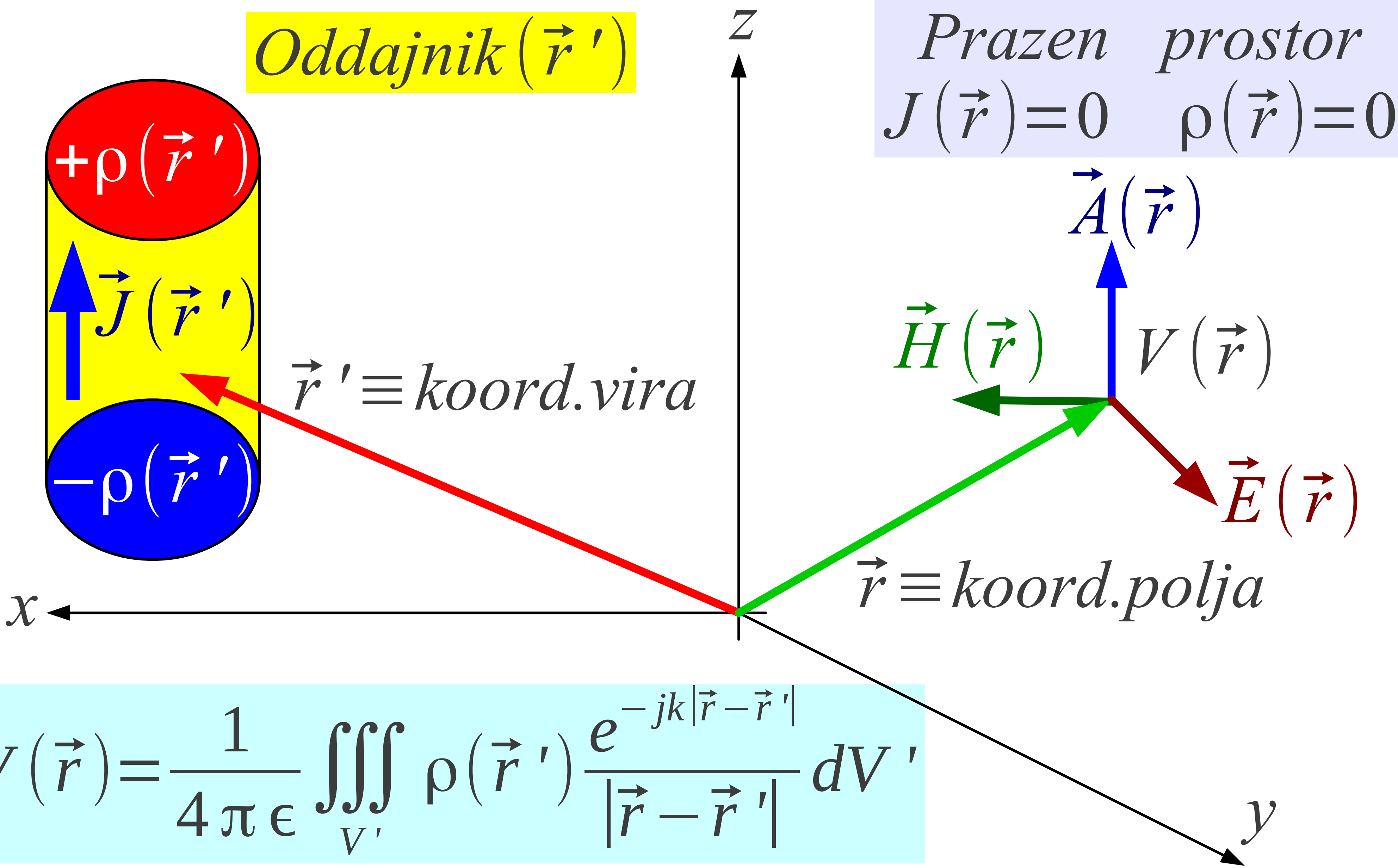
$$\vec{B} = \mathrm{rot}\,\vec{A} \qquad \vec{H} = \frac{1}{\mu}\,\mathrm{rot}\,\vec{A}$$

Lorenzova izbira: $\mathrm{div}\,\vec{A} = -j\omega\mu\epsilon V$

$$\Delta\vec{A} + \omega^2\mu\epsilon\vec{A} = -\mu\vec{J}$$

$$\Delta V + \omega^2\mu\epsilon V = -\frac{\rho}{\epsilon}$$

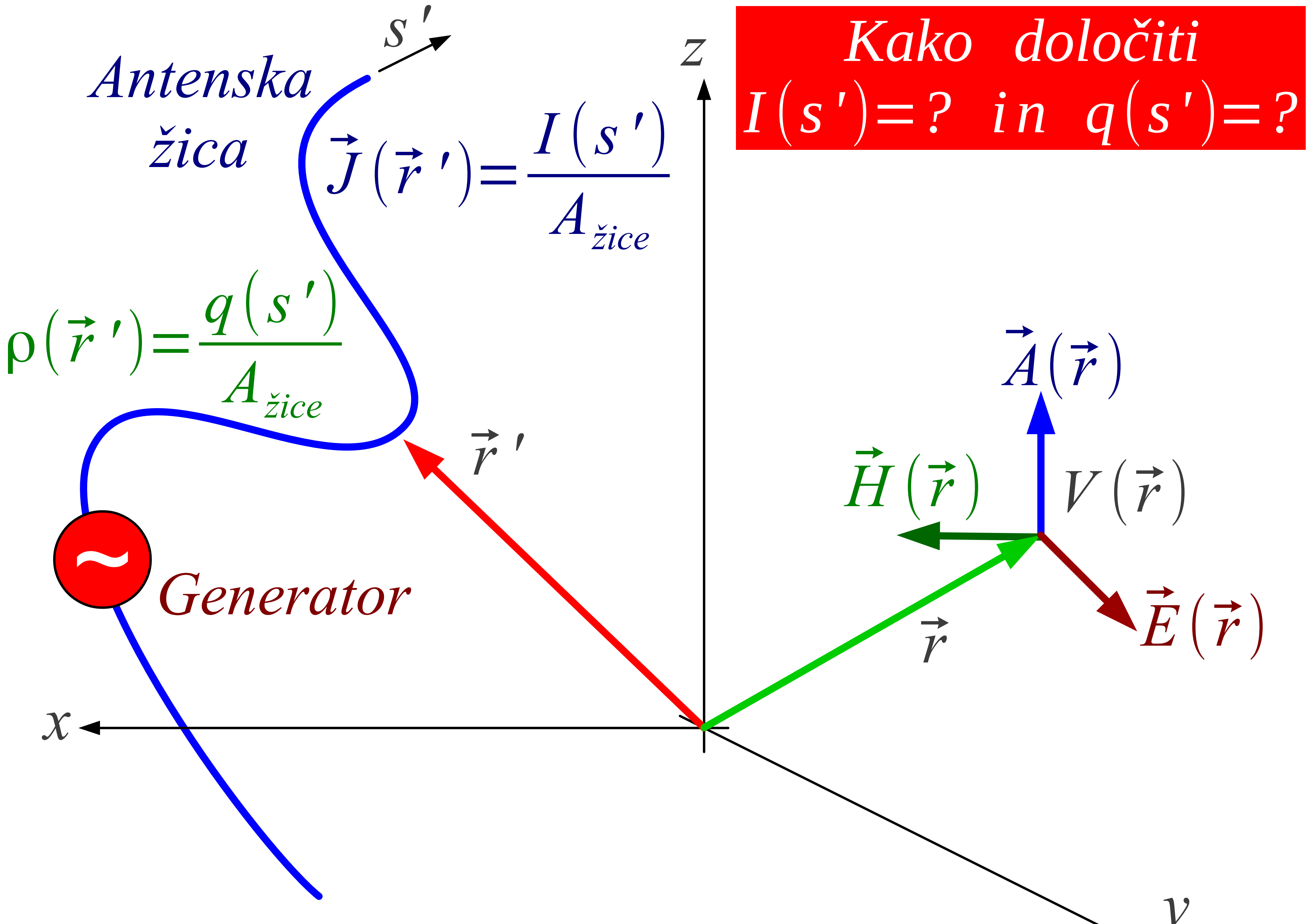
Valovni enačbi za potenciala imata analitsko rešitev!



$$V(\vec{r}) = \frac{1}{4\pi\epsilon} \iiint_{V'} \rho(\vec{r}\,') \frac{e^{-jk|\vec{r}-\vec{r}\,'|}}{|\vec{r}-\vec{r}\,'|} dV'$$

$$\vec{A}(\vec{r}) = \frac{\mu}{4\pi} \iiint_{V'} \vec{J}(\vec{r}\,') \frac{e^{-jk|\vec{r}-\vec{r}\,'|}}{|\vec{r}-\vec{r}\,'|} dV'$$

5 − Zakasnjeni potenciali



6 − Preprosta antenska naloga