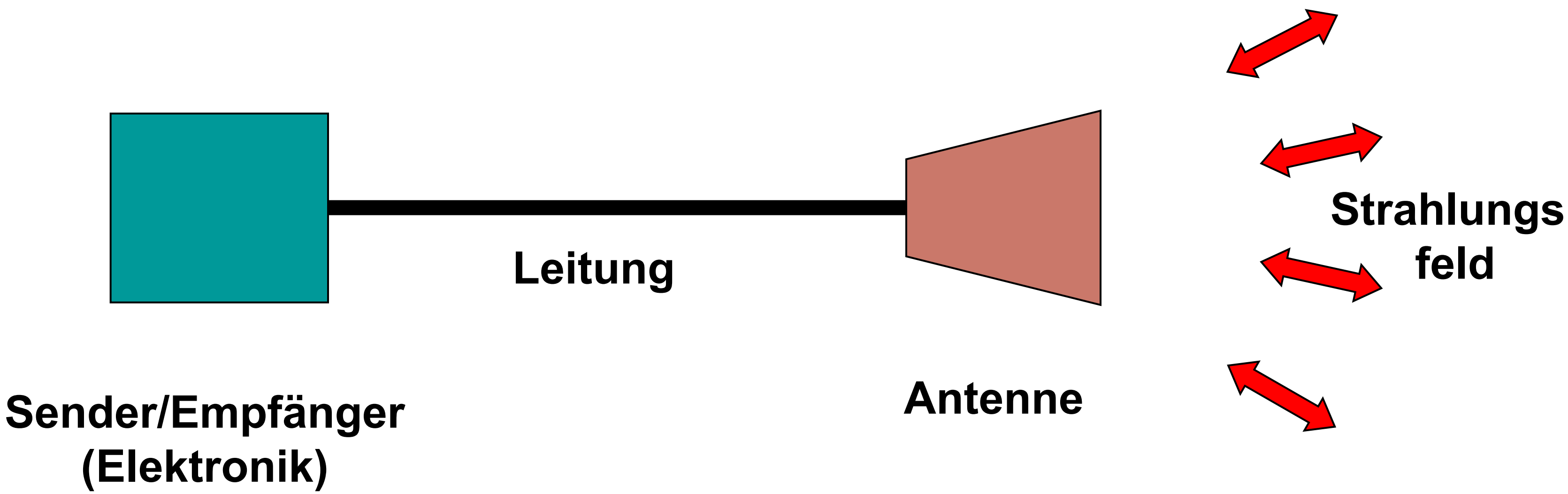
Übersicht

- Aufgabe der Antenne
- Physikalisches Grundprinzip
- Praktische Ausführungsformen
- Beschreibung der Funktion einer Antenne
- Beispiel kurze Dipol-Antenne

Antennen

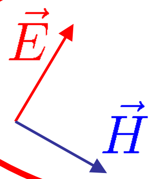
Es geht darum, elektromagnetische Energie in den freien Raum zu bringen bzw. von dort einzufangen.



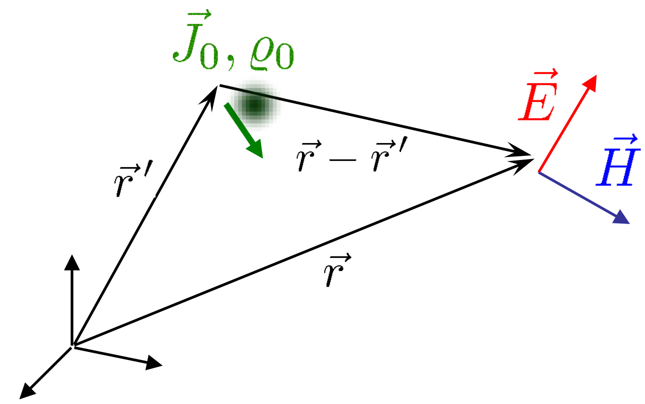
Transformation Leitungswellen ⟺ freie Wellen

Ströme & Ladungen erzeugen freie Wellen

Ebene Welle



$$\frac{\underline{\vec{E}} \cdot \underline{\vec{E}}}{\underline{\vec{H}} \cdot \underline{\vec{H}}} = Z_{\mathrm{w}}^2 = \frac{\mu}{\varepsilon}$$



$$\vec{H}(\vec{r}, t) = \frac{1}{4\pi} \iiint\limits_{\mathrm{V}'} \frac{\mathrm{rot}' \, \vec{J}_0(\vec{r}\,', t')}{|\vec{r} - \vec{r}\,'|} dV'$$

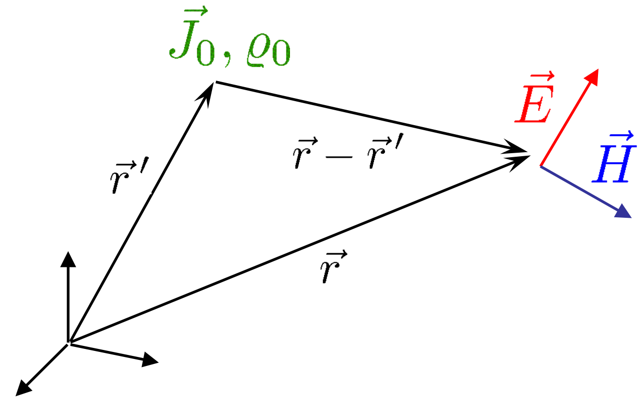
$$t' = t - \sqrt{\mu\varepsilon}|\vec{r} - \vec{r}\,'|$$

$$\vec{E}(\vec{r}, t) = \frac{-1}{4\pi\varepsilon} \iiint\limits_{\mathrm{V}'} \frac{\mu\varepsilon \frac{\partial}{\partial t'} \vec{J}_0(\vec{r}\,', t') + \mathrm{grad}' \, \varrho_0(\vec{r}\,', t')}{|\vec{r} - \vec{r}\,'|} dV'$$

Ströme & Ladungen erzeugen freie Wellen

$$\vec{H}(\vec{r},t) = \frac{1}{4\pi} \iiint\limits_{V'} \frac{\mathrm{rot}'\, \vec{J}_0(\vec{r}\,',t')}{|\vec{r}-\vec{r}\,'|} dV'$$

$$\vec{E}(\vec{r},t) = \frac{-1}{4\pi\varepsilon} \iiint\limits_{V'} \frac{\mu\varepsilon \frac{\partial}{\partial t'} \vec{J}_0(\vec{r}\,',t') + \mathrm{grad}'\, \varrho_0(\vec{r}\,',t')}{|\vec{r}-\vec{r}\,'|} dV'$$



$$\vec{A}(\vec{r},t) = \frac{\mu}{4\pi} \iiint\limits_{V'} \frac{\vec{J}_0(\vec{r}\,',t')}{|\vec{r}-\vec{r}\,'|} dV'$$

$$\varphi(\vec{r},t) = \frac{1}{4\pi\varepsilon} \iiint\limits_{V'} \frac{\varrho_0(\vec{r}\,',t')}{|\vec{r}-\vec{r}\,'|} dV'$$

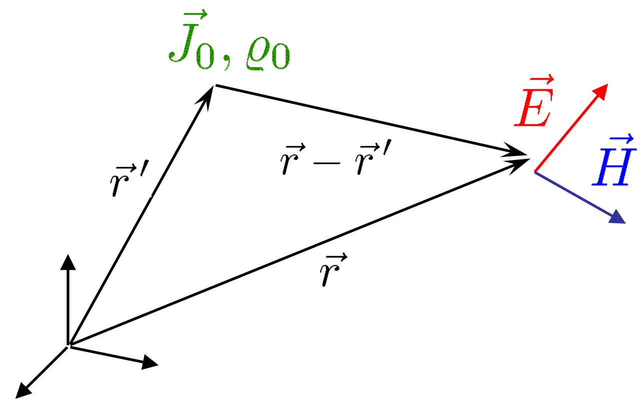
$$t' = t - \sqrt{\mu\varepsilon}|\vec{r}-\vec{r}\,'|$$

$$\vec{E} = -\,\mathrm{grad}\,\varphi - \frac{\partial \vec{A}}{\partial t}$$

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

Im Aufpunkt!

Ströme & Ladungen erzeugen freie Wellen



Fragen:

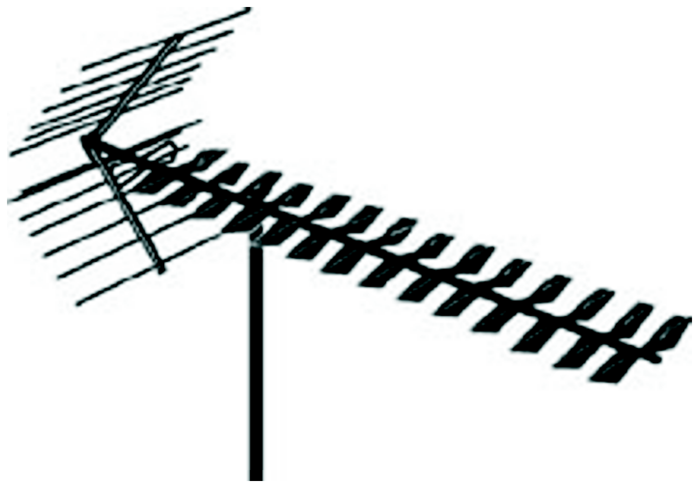
- Wie kann in eine gewünschte Richtung gestrahlt werden?
- Wie bringt man Ströme/Ladungen dazu, zur richtigen Zeit am richtigen Ort zu sein?

$$\vec{H}(\vec{r}, t) = \frac{1}{4\pi} \iiint\limits_{V'} \frac{\operatorname{rot}' \vec{J}_0(\vec{r}\,', t')}{|\vec{r} - \vec{r}\,'|} dV'$$

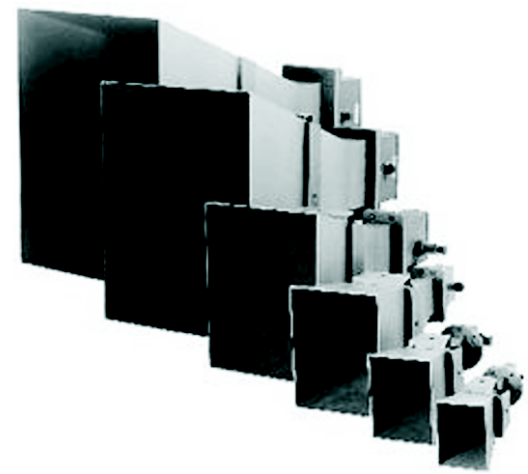
$$\vec{E}(\vec{r}, t) = \frac{-1}{4\pi\varepsilon} \iiint\limits_{V'} \frac{\mu\varepsilon \frac{\partial}{\partial t'} \vec{J}_0(\vec{r}\,', t') + \operatorname{grad}' \varrho_0(\vec{r}\,', t')}{|\vec{r} - \vec{r}\,'|} dV'$$

Gebräuchliche Antennen

Schleifenantenne



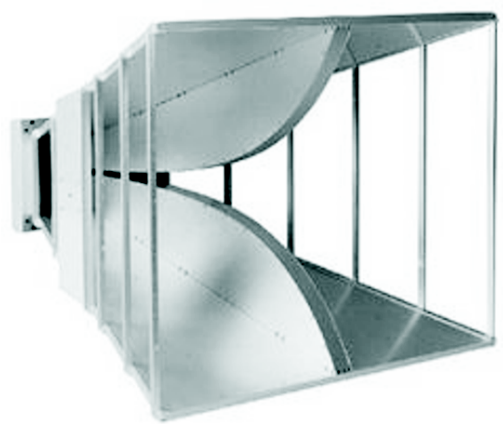
Yagi-Antenne



Hornantennen

Gebräuchliche Antennen

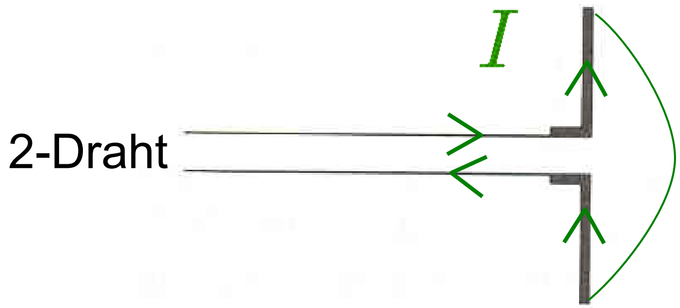
Logarithmisch-periodische (Log-per) Antenne



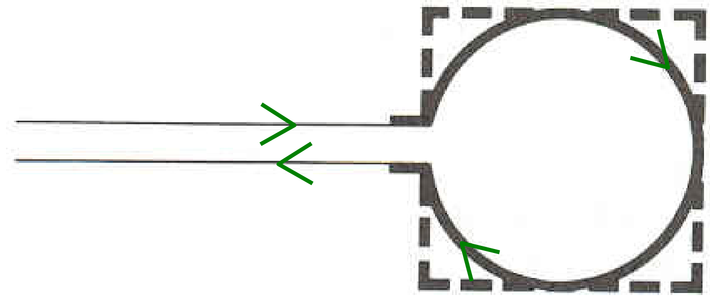
Double-Ridged Hornantenne

Patch-Antenne

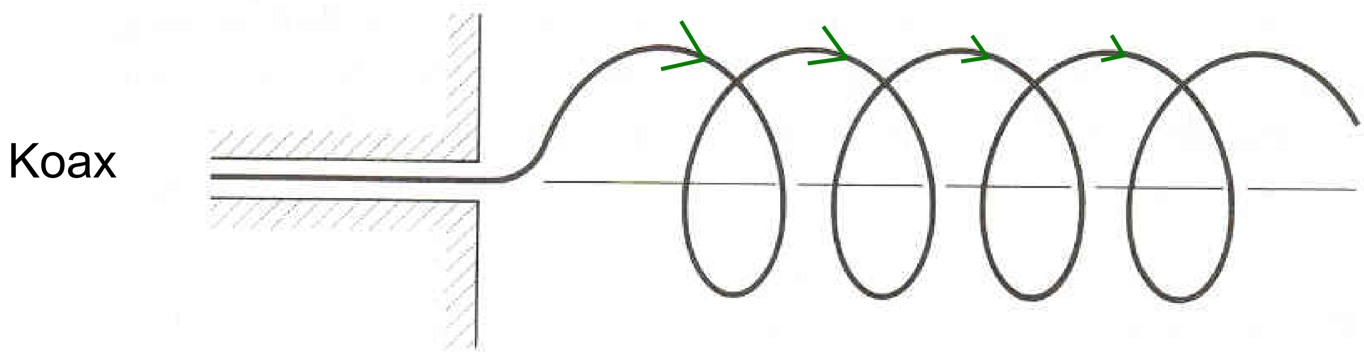
Draht-Antennen



Dipol-Antenne



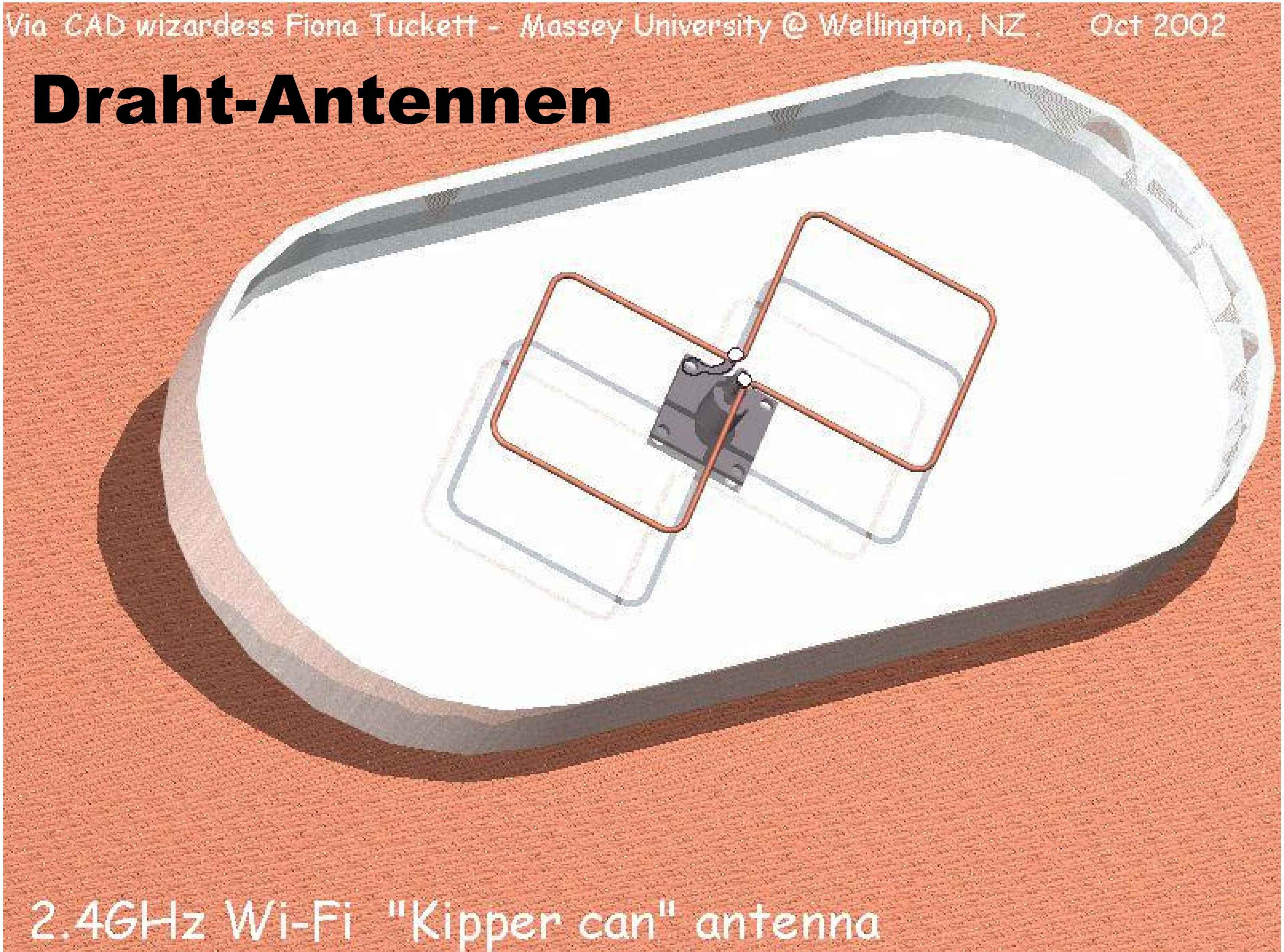
Loop-Antenne



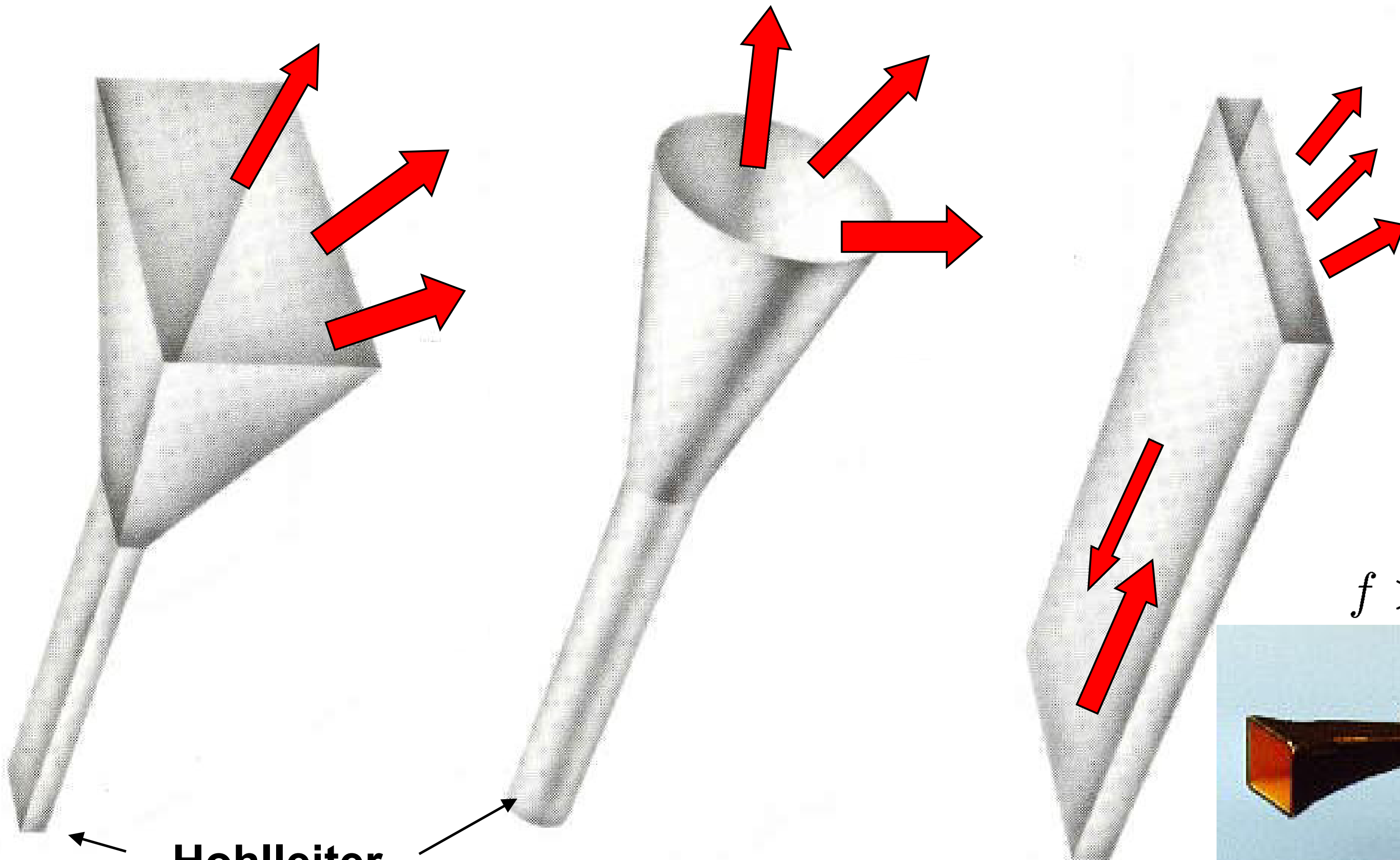
Helix-Antenne

Draht-Antennen

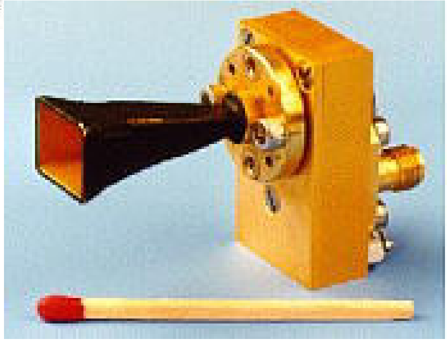
Draht-Antennen



Horn- und Apertur-Antennen



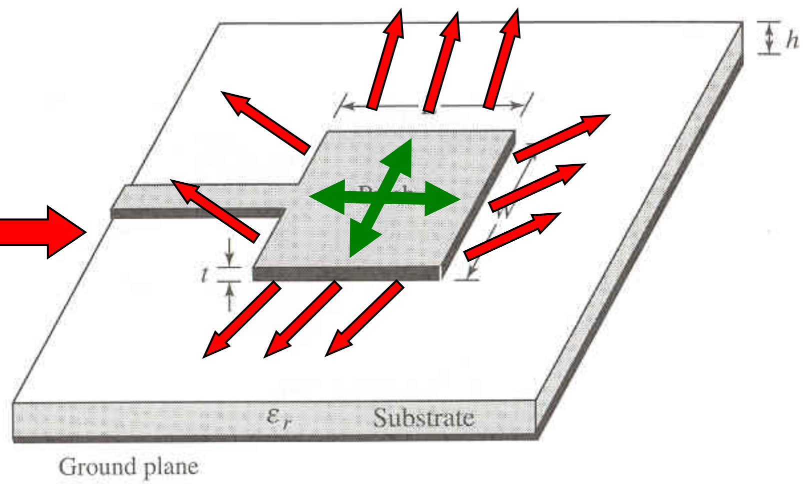
$f > 70\,\mathrm{GHz}$



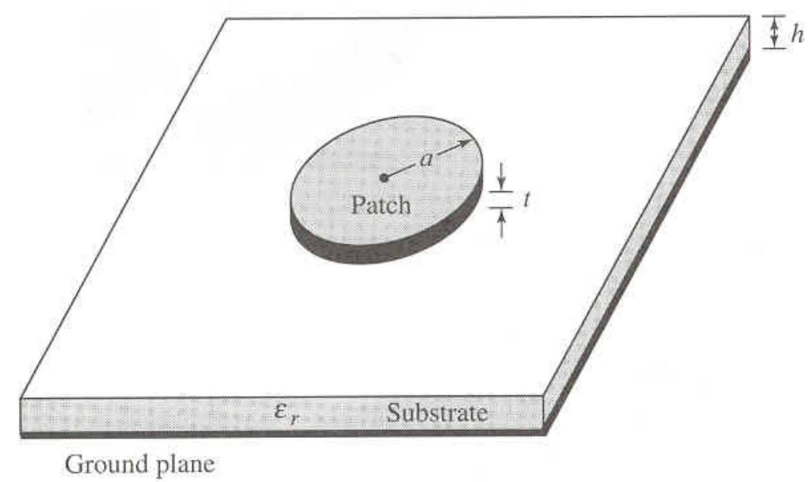
Genaue Kenntnis des Stromverlaufs auf der Antenne sekundär

Patch-Antennen

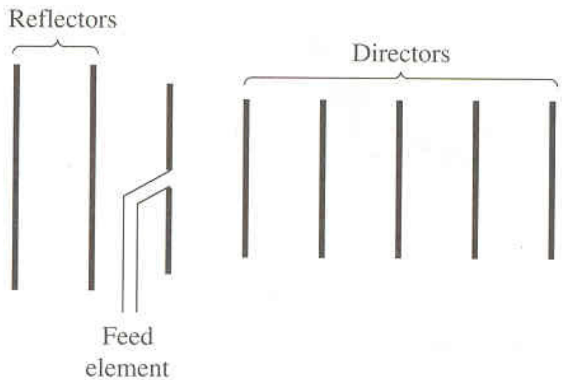
Speisung
(Stripline)



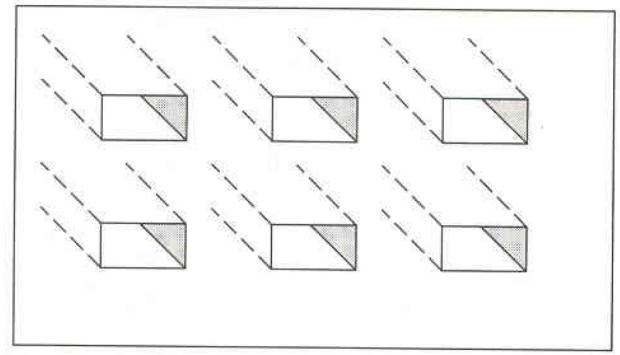
Man stellt sich eher
das Strahlenfeld vor.



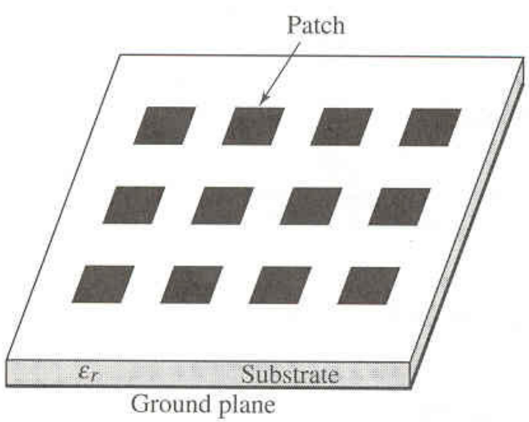
Antennen Arrays



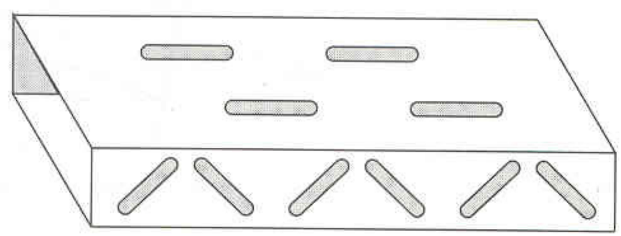
Yagi-Uda Antenne



Apertur-Array

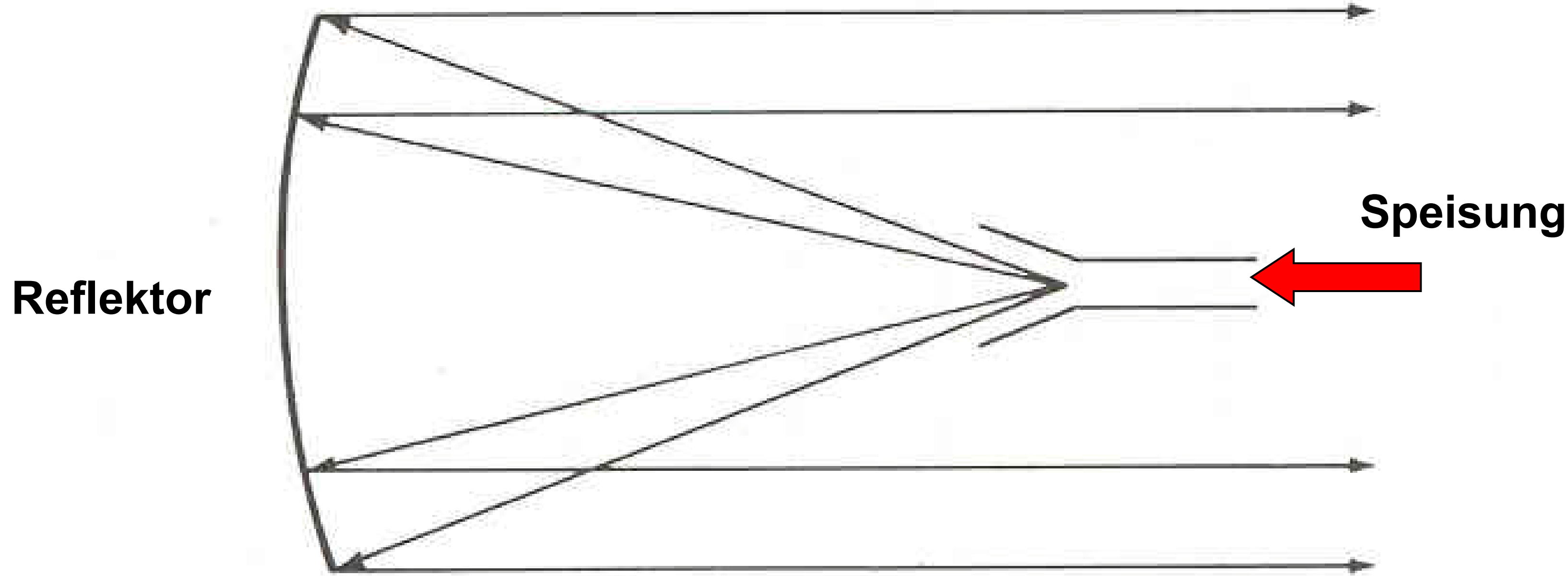


Patch-Array



Slotted-waveguide array

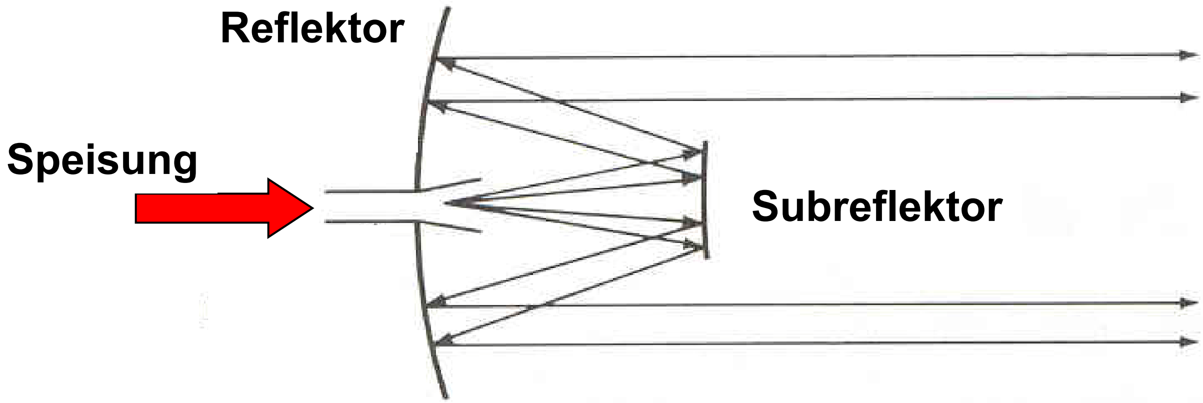
Reflektor Antennen



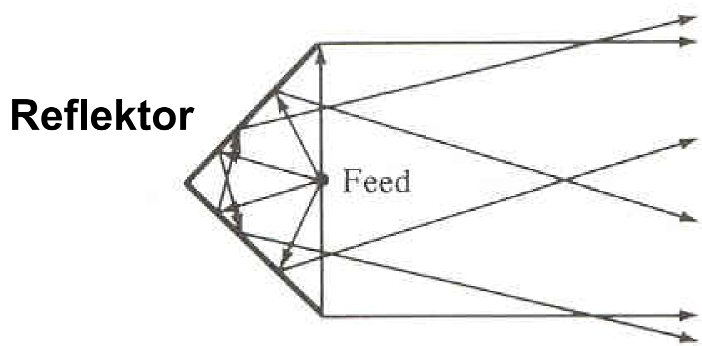
Parabol-Reflektor mit Frontspeisung

Praktisch rein optische Denkweise bei der Funktionserklärung!

Reflektor Antennen



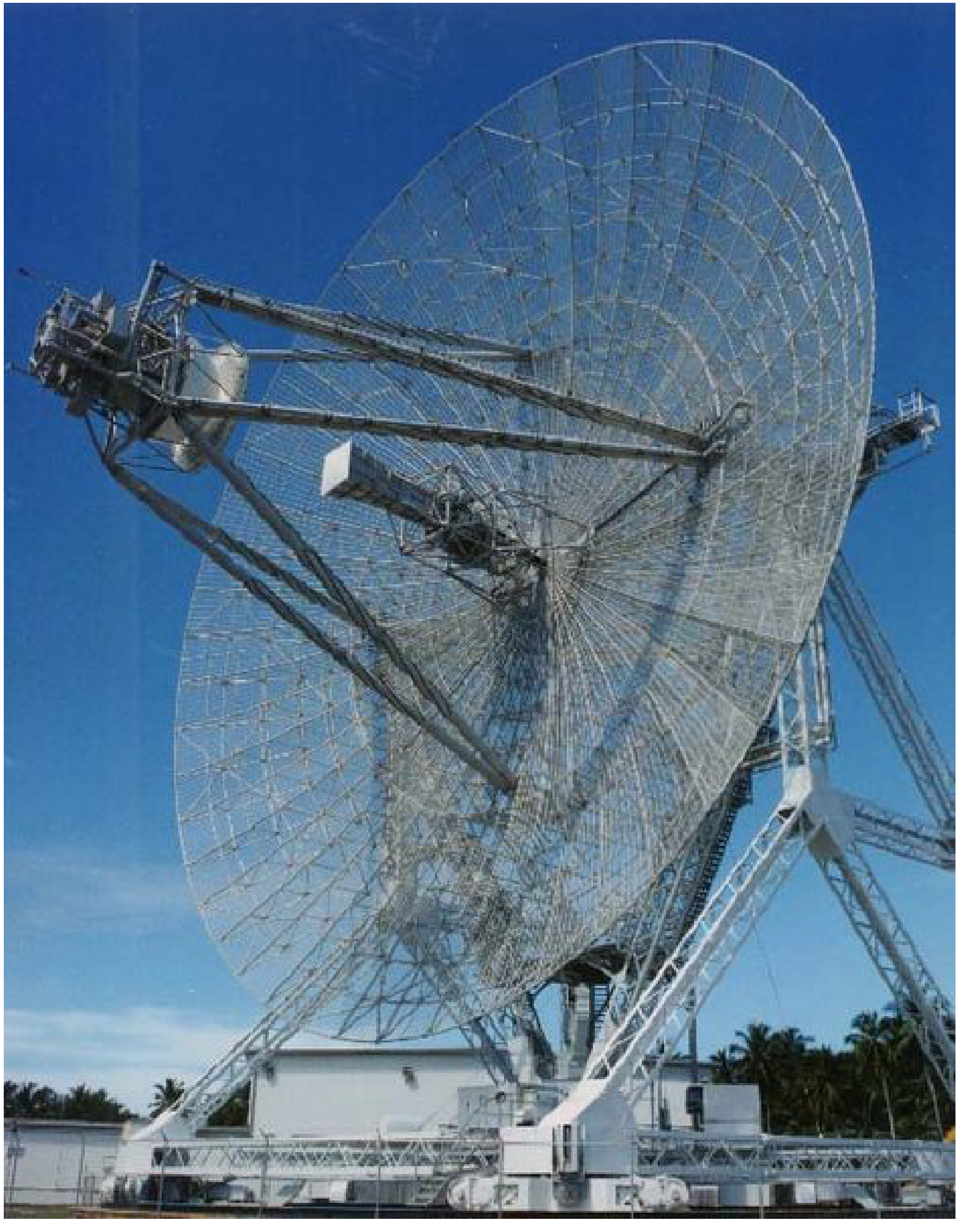
Parabol-Reflektor mit Cassegrain Speisung



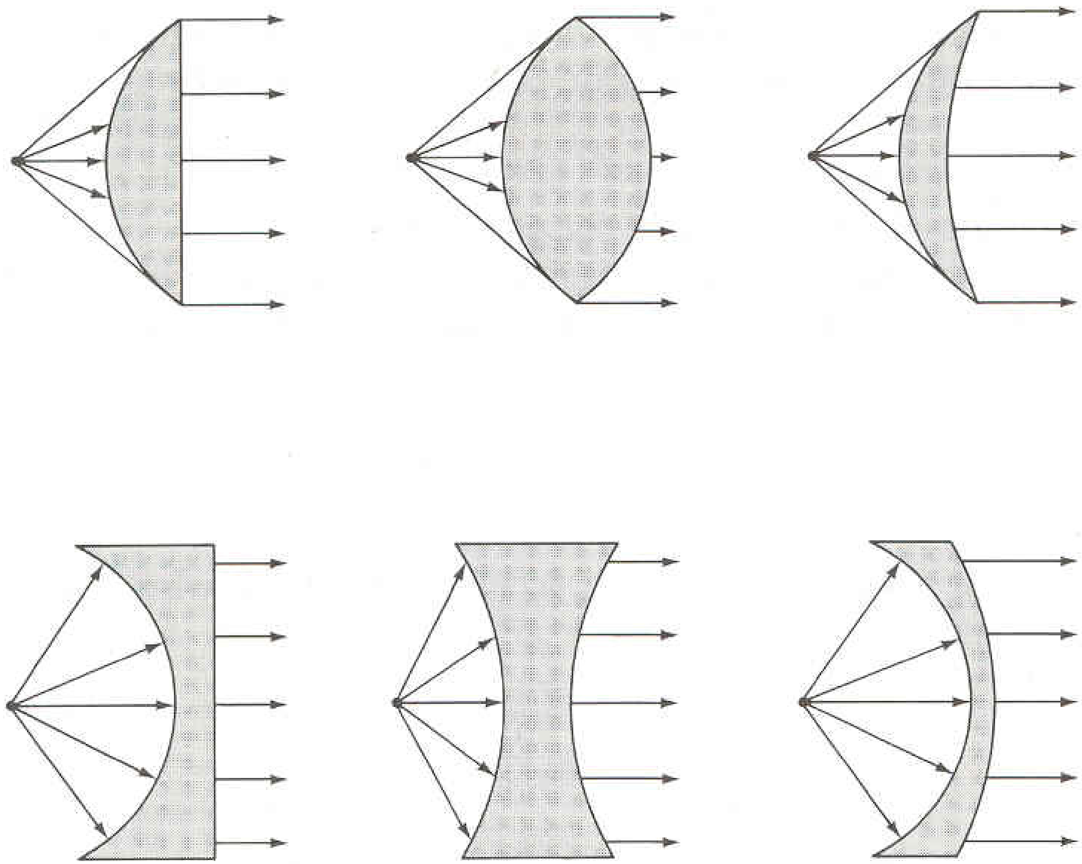
Corner-Reflektor

Reflektor Antennen

Cassegrain Antenne



Linsen Antennen



Beschreibung der Antennenfunktion

Zuleitung: Leitungstheorie!

Eingangs-Impedanz
Reflexionsfaktor

Auf der Antenne selbst:

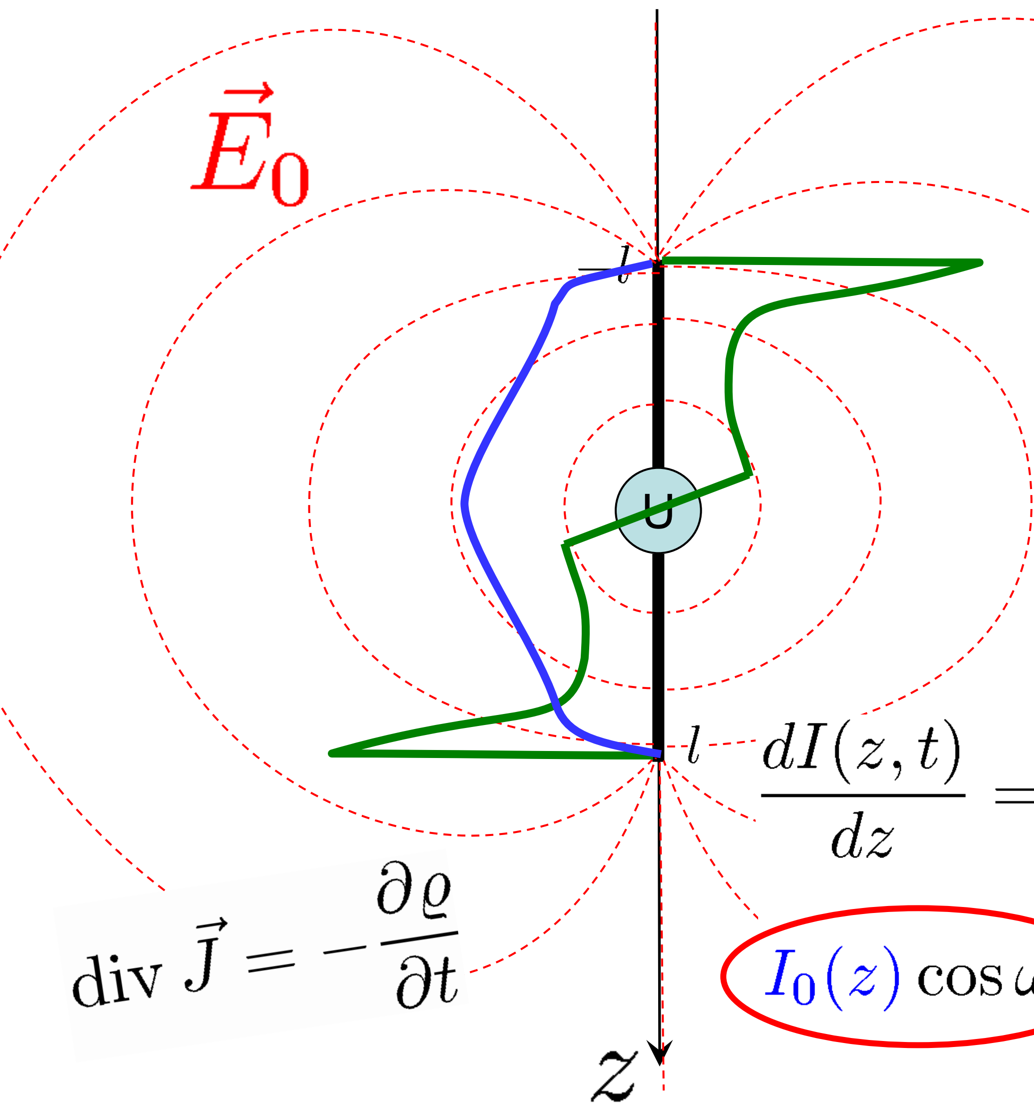
- Maxwell'sche Gleichungen
- Kirchhoff'sche Regeln
- Leitungstheorie
- Strahlenoptik

Wie ist genau die Stromverteilung?

Fernab der Antenne

- Strahlentheorie, ergänzt mit Polarisation und Phase.

Verhalten einer "kurzen" Dipol-Antenne



1. Finde das E-Feld

2. Finde $q_0(z)$ $\left[\frac{\mathrm{As}}{\mathrm{m}}\right]$

3. $\vec{E}_0 \sin \omega t$

$\Rightarrow q(z,t) = q_0(z) \sin \omega t$

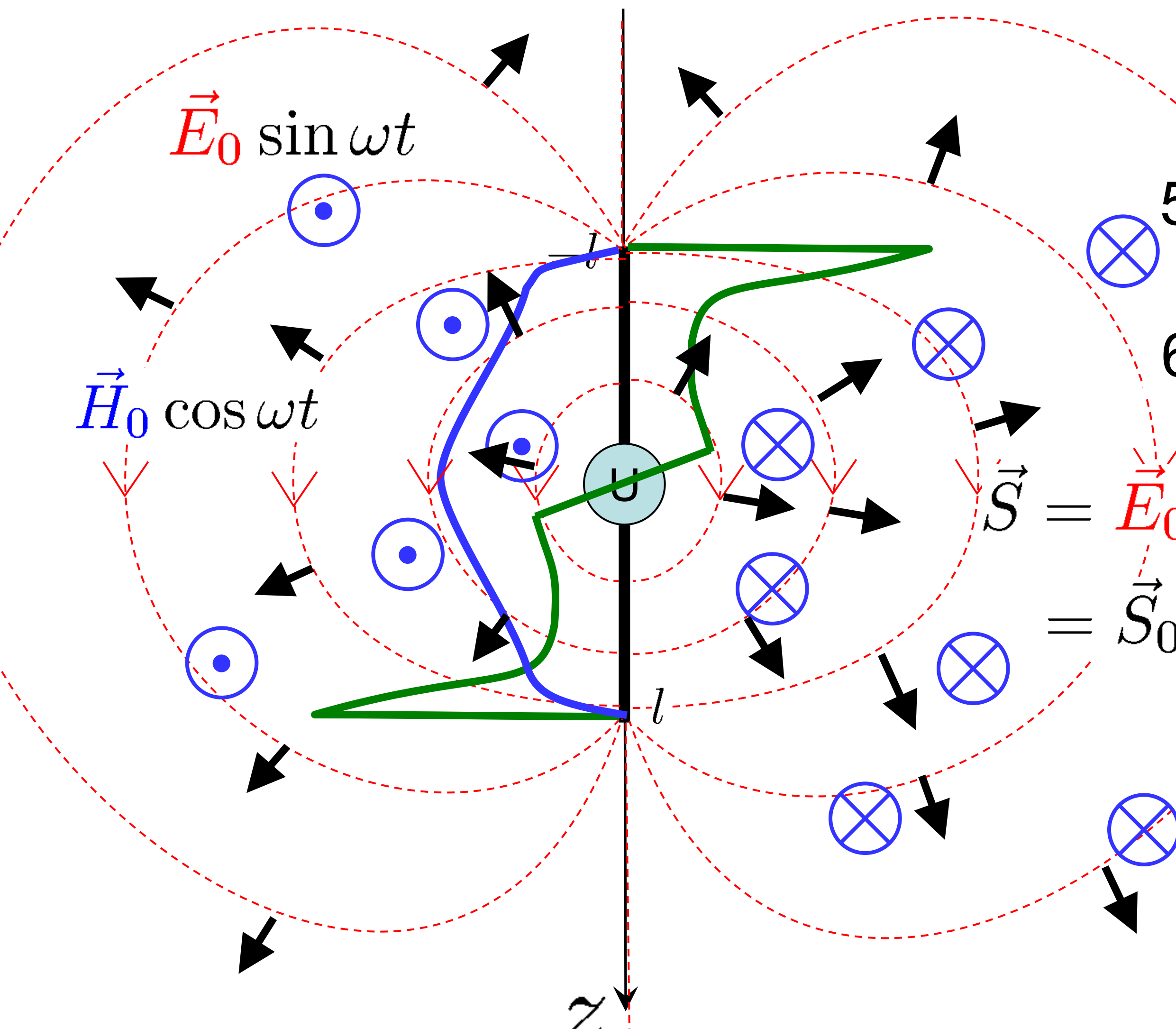
4. Variable Ladung ⟹ Strom

$$\frac{dI(z,t)}{dz} = -\frac{dq(z,t)}{dt} = -q_0(z)\omega \cos \omega t$$

$$\mathrm{div}\, \vec{J} = -\frac{\partial \varrho}{\partial t}$$

$$I_0(z) \cos \omega t = -\omega \cos \omega t \int_{-l}^{z} q_0(\tilde{z})\, d\tilde{z}$$

Verhalten einer "kurzen" Dipol-Antenne

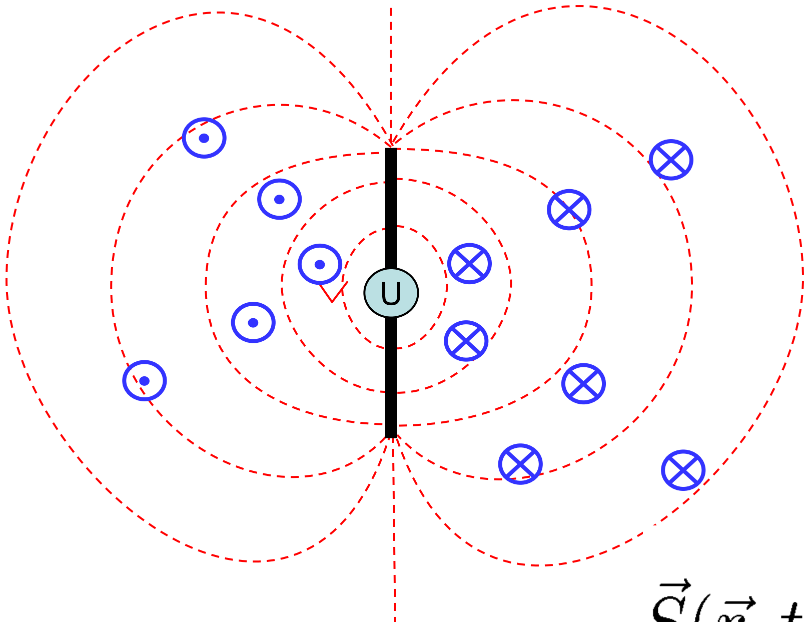


5. Finde das H-Feld

6. Poynting-Feld

$$\vec{S} = \vec{E}_0 \times \vec{H}_0 \cos\omega t \cdot \sin\omega t$$
$$= \vec{S}_0 \sin 2\omega t$$

Verhalten einer "kurzen" Dipol-Antenne



$$\vec{E}_0(\vec{r})\sin\omega t$$

$$\vec{H}_0(\vec{r})\cos\omega t$$

$$\vec{S}(\vec{r},t) = \frac{\vec{E}_0(\vec{r}) \times \vec{H}_0(\vec{r})}{2} \sin 2\omega t$$

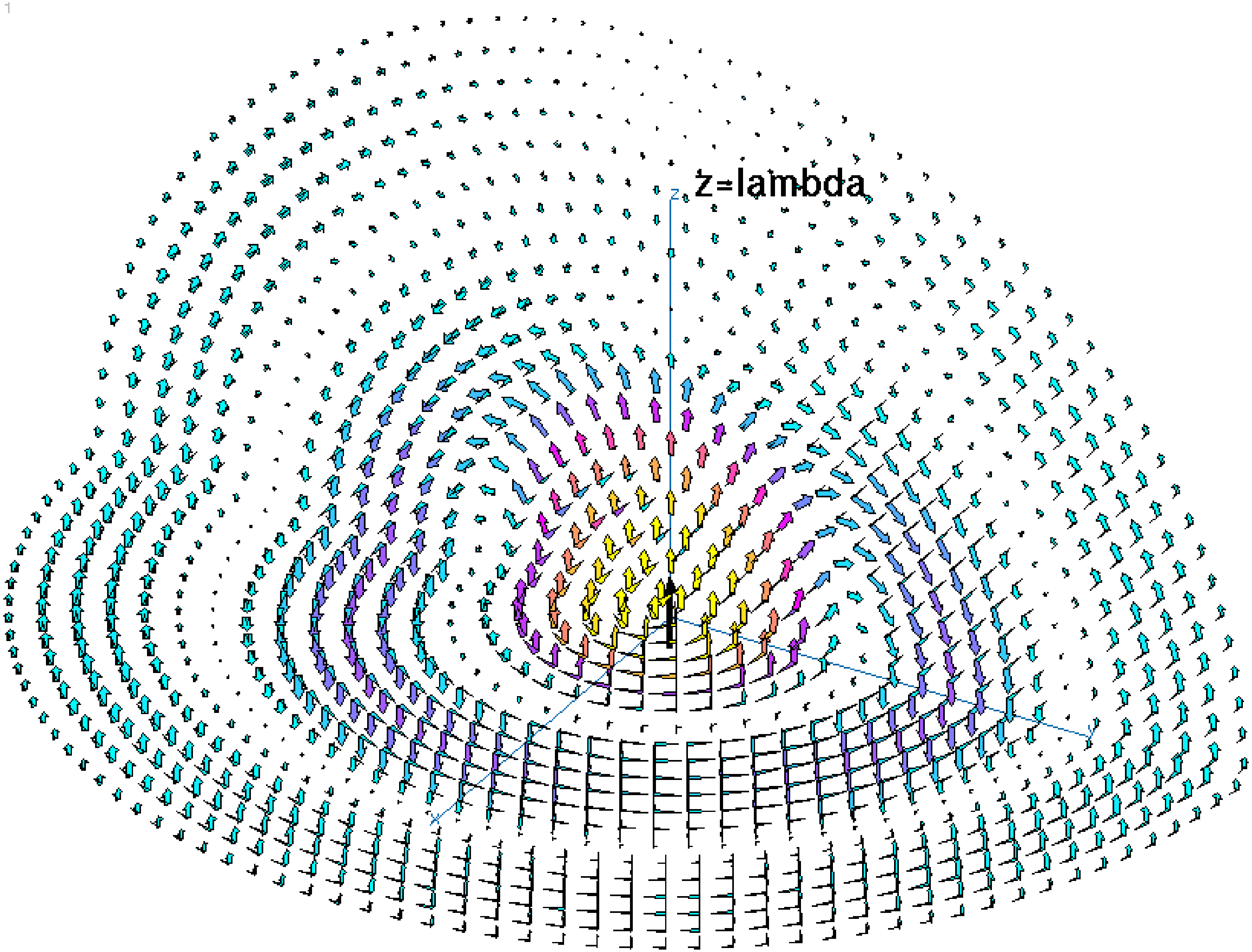
Keine Abstrahlung!???

Rein statische Nahfeld-Betrachtungen sind gefährlich!!

Hertz'scher Dipol

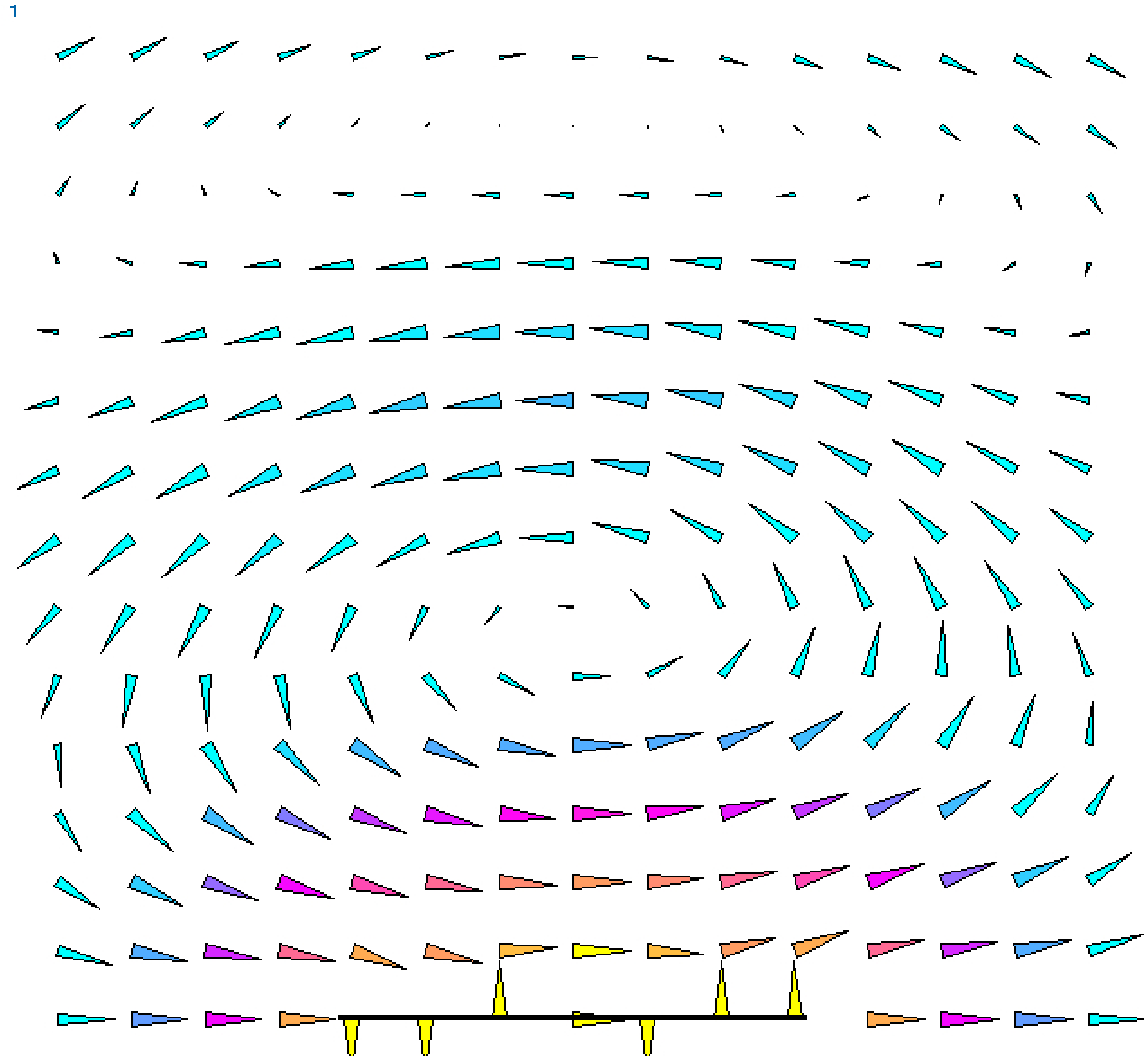
E-Feld: Pfeile

H-Feld: Dreiecke



Lambda/2-Dipol

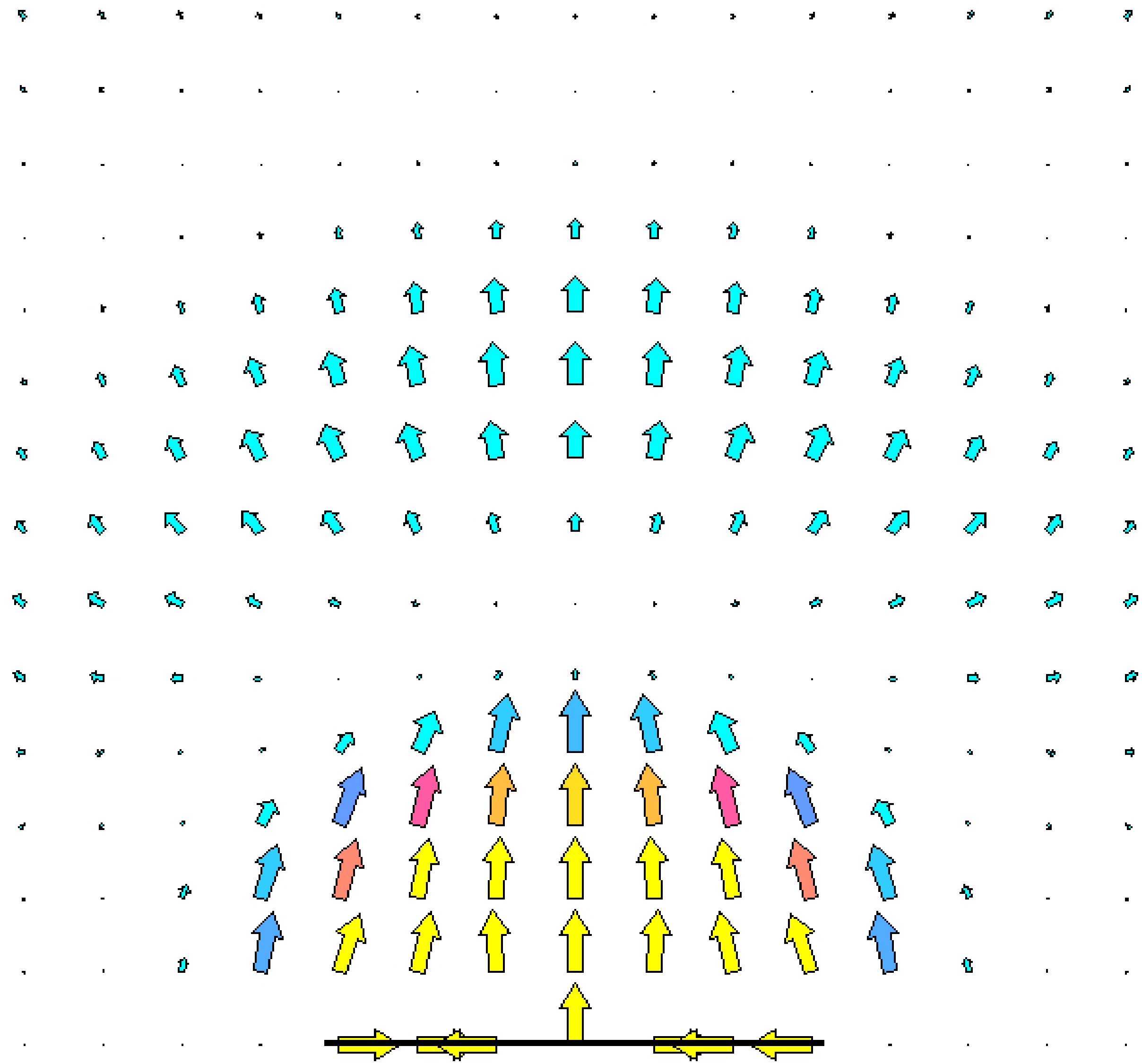
E-Feld



Felder & Komponenten II

Lambda/2-Dipol
S-Feld

1



Felder & Komponenten II

Lambda/2-Dipol
S-Feld