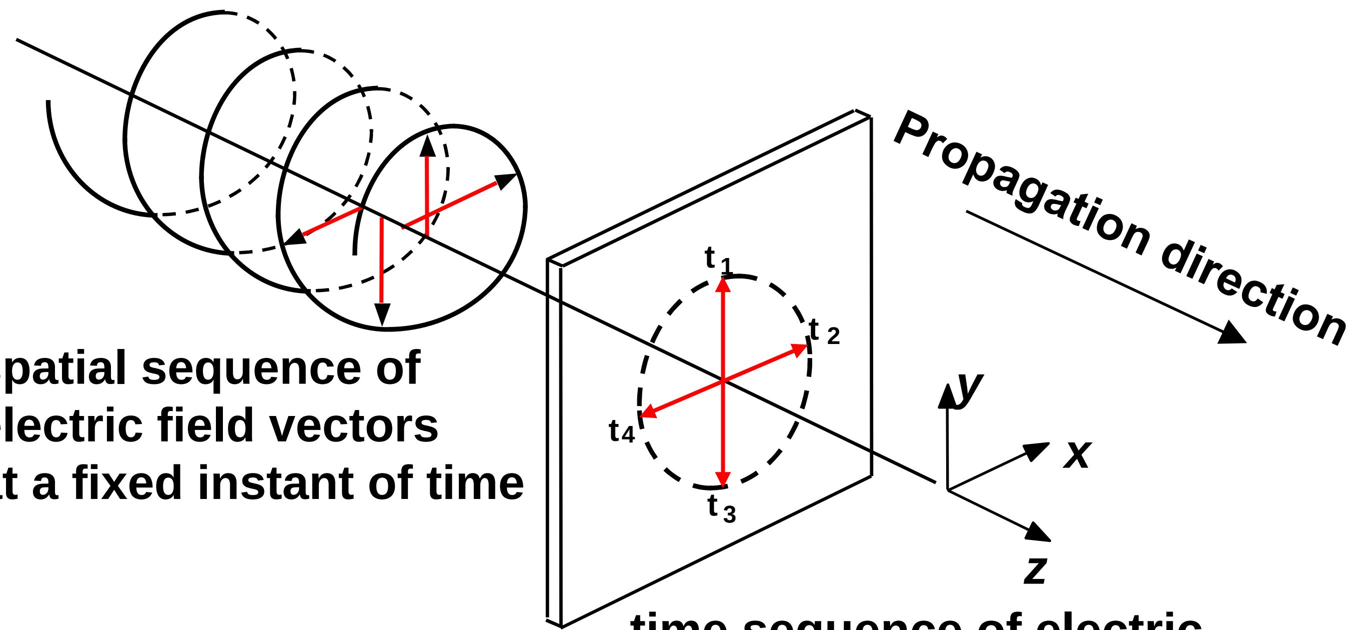
Polarisation Elektromagnetischer Wellen

by Thomas Zwick

INSTITUT FÜR HOCHFREQUENZTECHNIK UND ELEKTRONIK

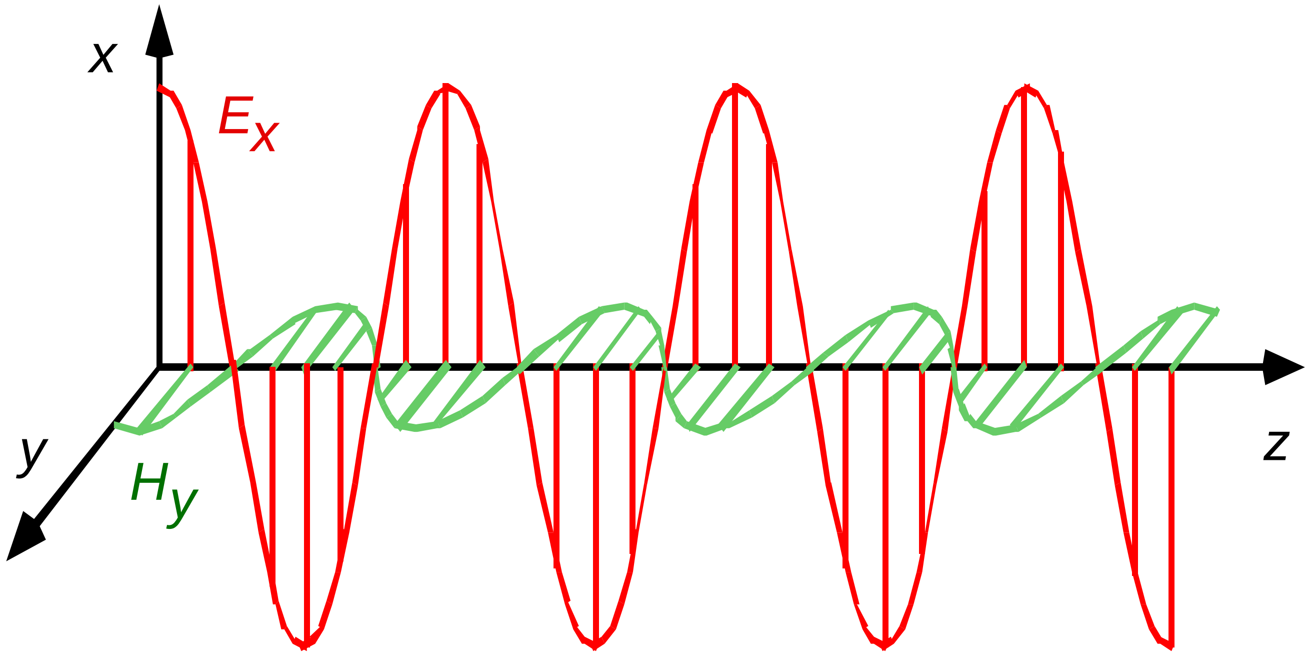
Polarization - Definition



According to the IEEE Standard Definitions for Antennas, the polarization of a radiated wave is defined as „that property of a radiated electromagnetic wave describing the time-varying direction and relative magnitude of the electric field vector at a fixed location in space, and the sense in which it is traced as observed along the direction of propagation“. In other words, polarization is the curve traced out by the end point of the arrow representing the instantaneous electric field.

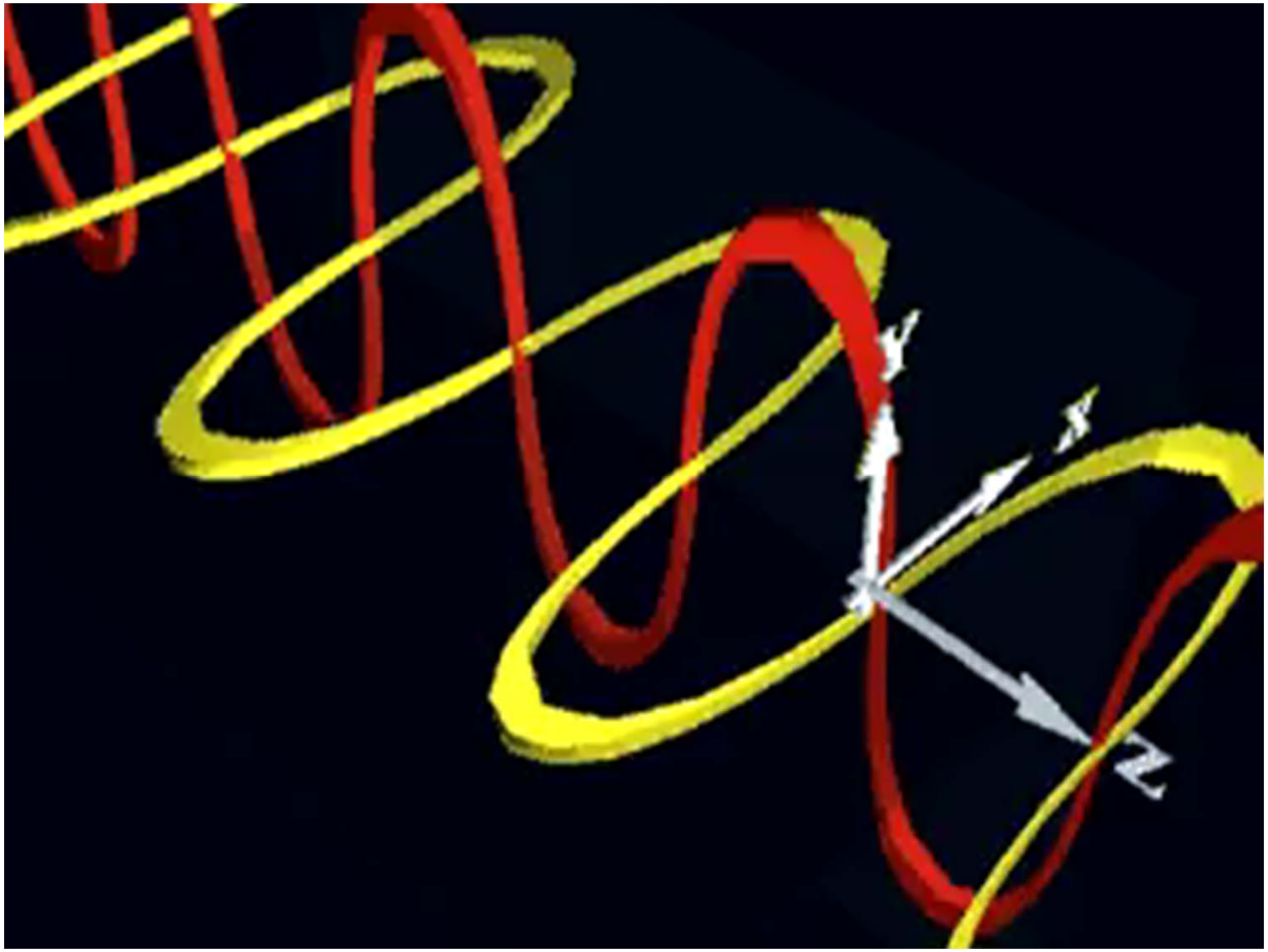
Linear Vertikal Polarisierte Welle

Linear vertical polarization: $\vec{\underline{E}}(z,t) = \hat{e}_x \cdot \underline{E}_x \cdot e^{j(\omega t - kz)} = \hat{e}_x \cdot E_x \cdot e^{j(\omega t - kz + \delta)}$



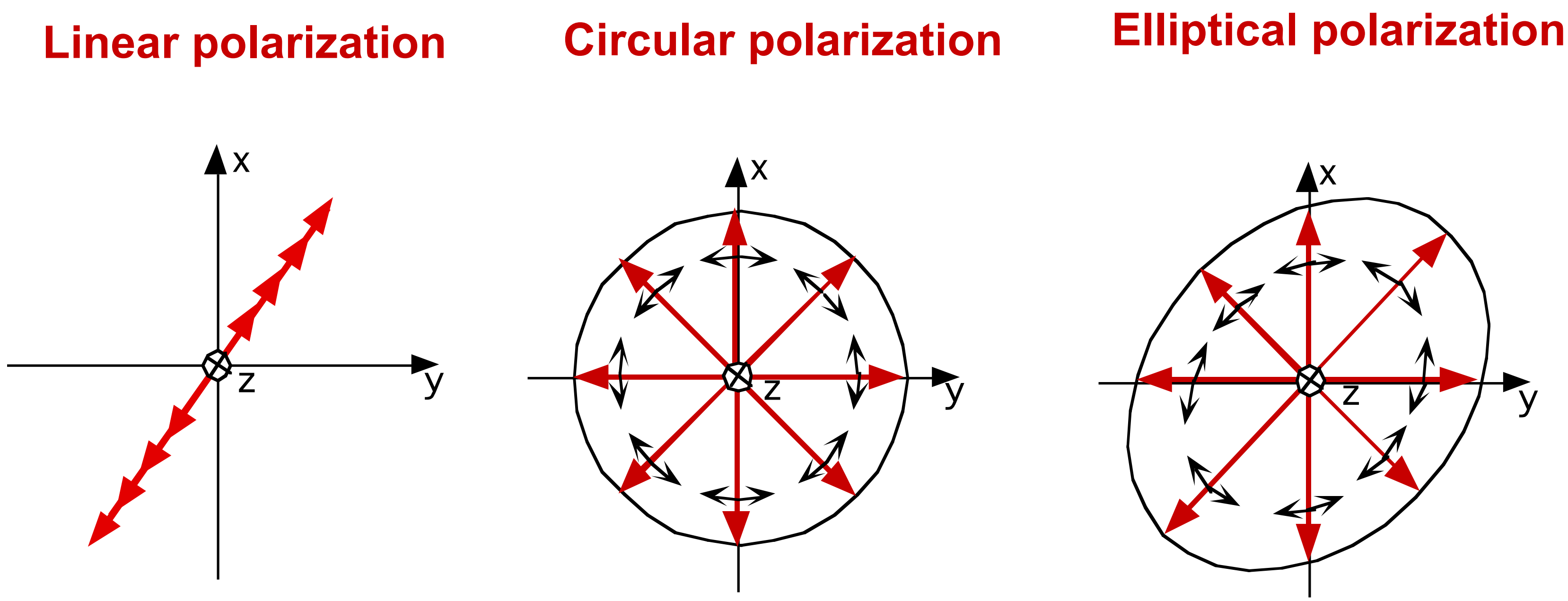
Arbitrary linear polarization: $\vec{\underline{E}}(z,t) = (\hat{e}_x \cdot E_x + \hat{e}_y \cdot E_y) \cdot e^{j(\omega t - kz + \delta)}$

Linear Vertikal Polarisierte Welle



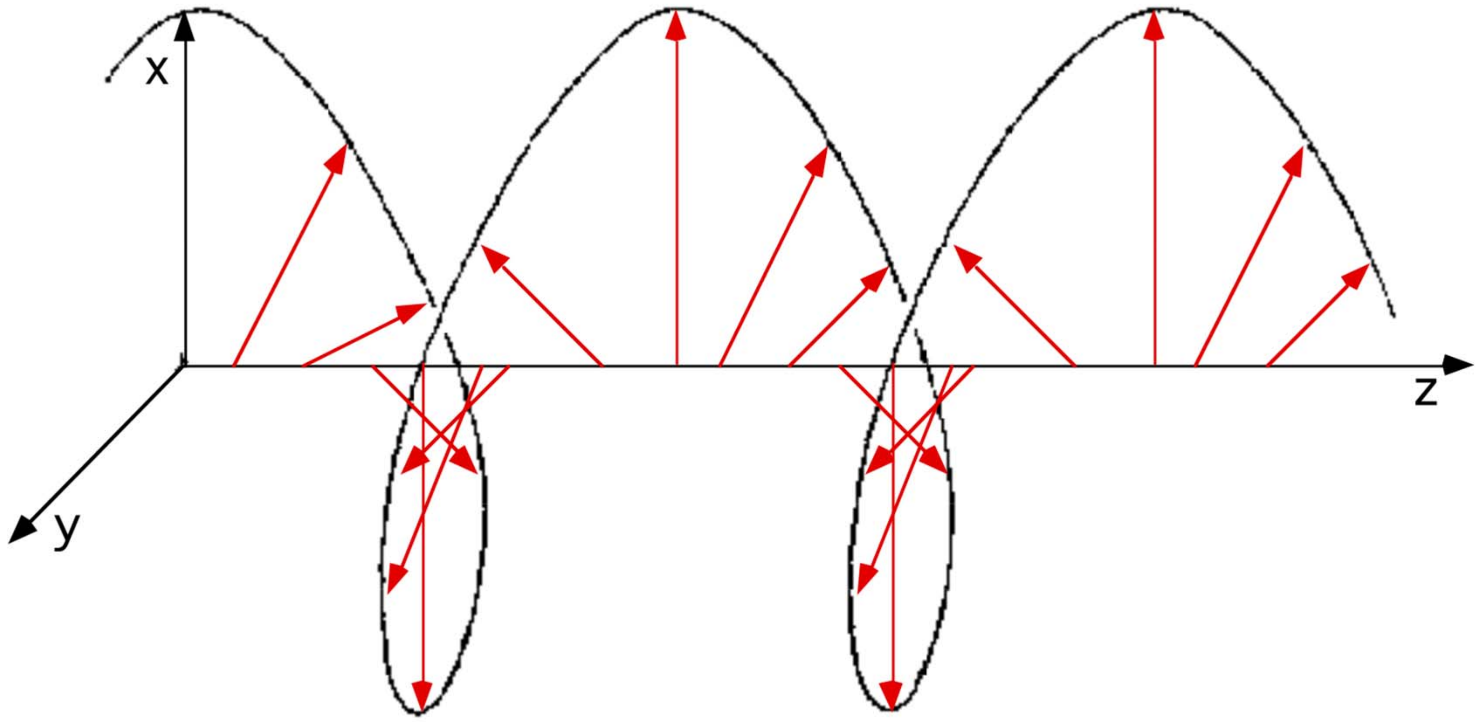
propagation speed = speed of light c_0

Elektrischer Feld Vektor Verschiedener Polarisationen

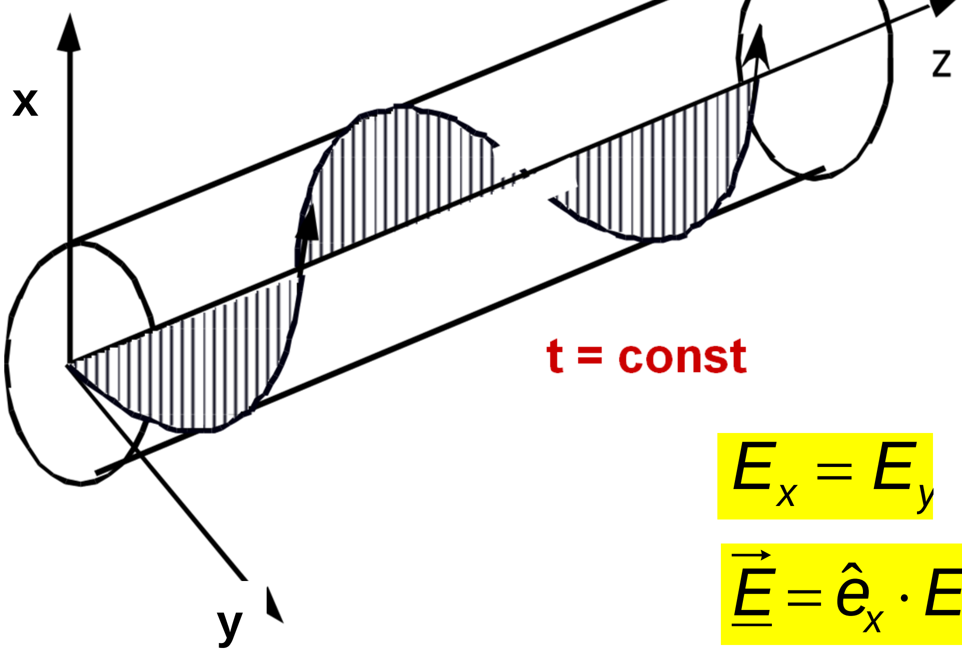


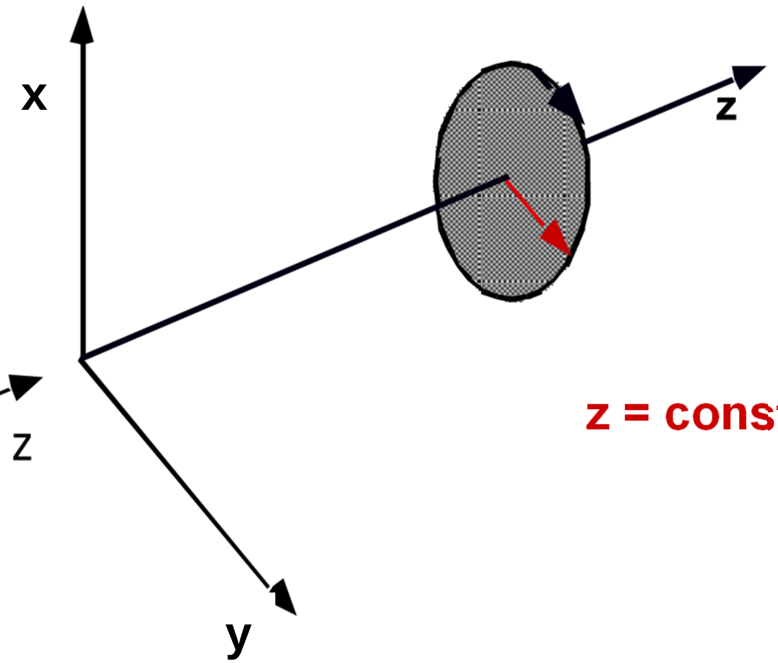
Institut für Hochfrequenztechnik und Elektronik

Zirkular Polarisierte Welle



Right Hand Circular (RHC) Polarization

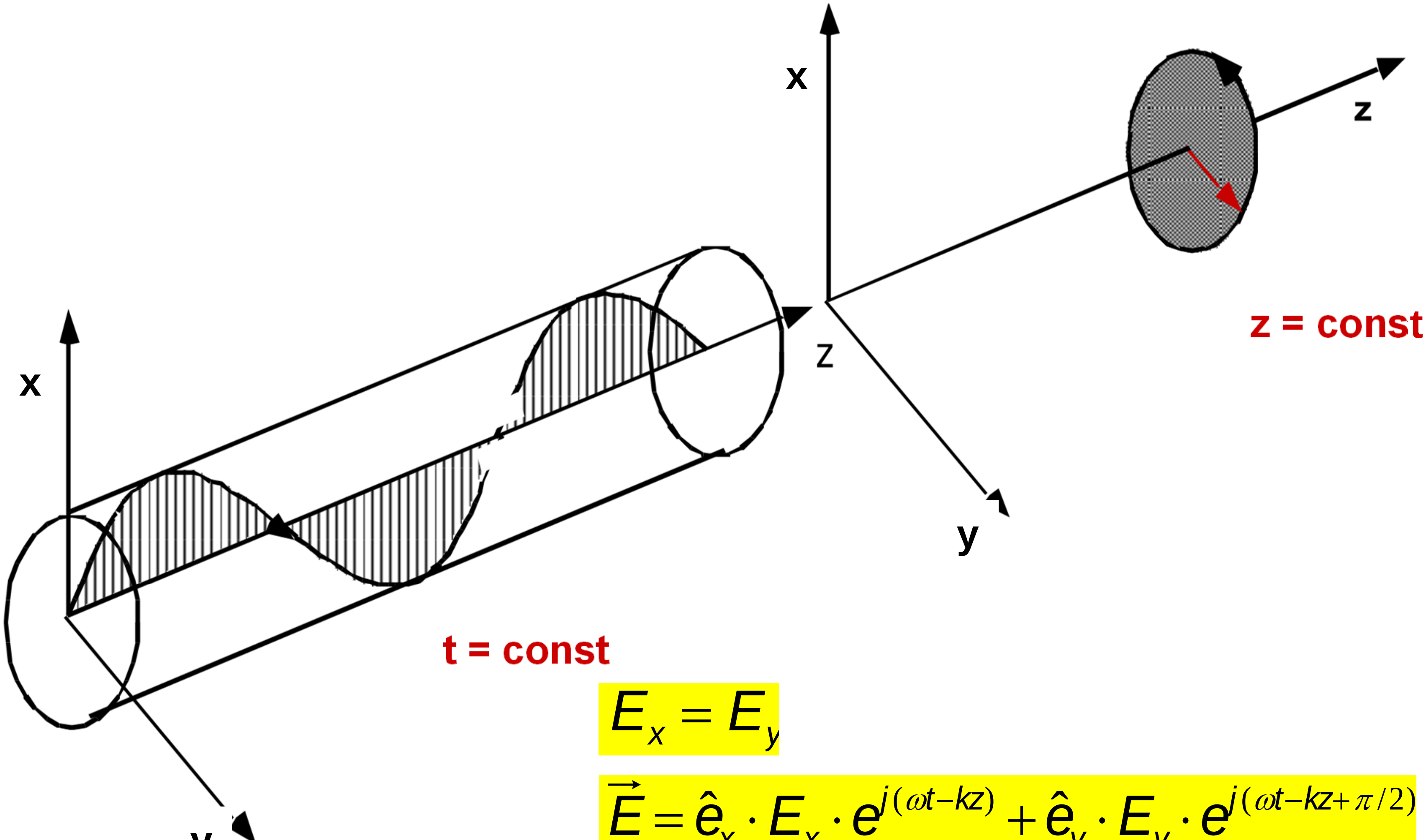




$$E_x = E_y$$

$$\vec{\underline{E}} = \hat{e}_x \cdot E_x \cdot e^{j(\omega t - kz)} + \hat{e}_y \cdot E_y \cdot e^{j(\omega t - kz - \pi/2)}$$

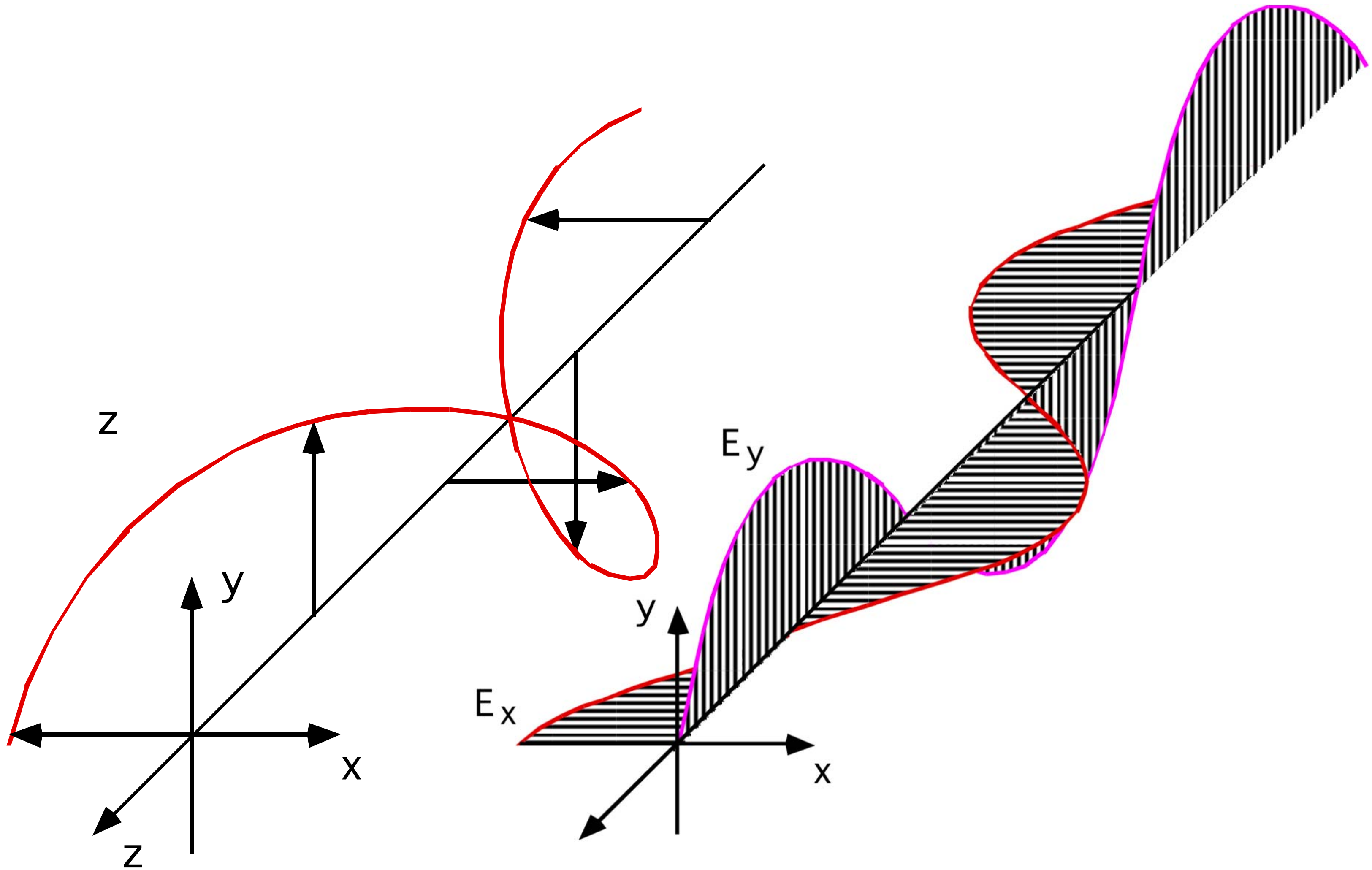
Left Hand Circular (LHC) Polarization



$$E_x = E_y$$

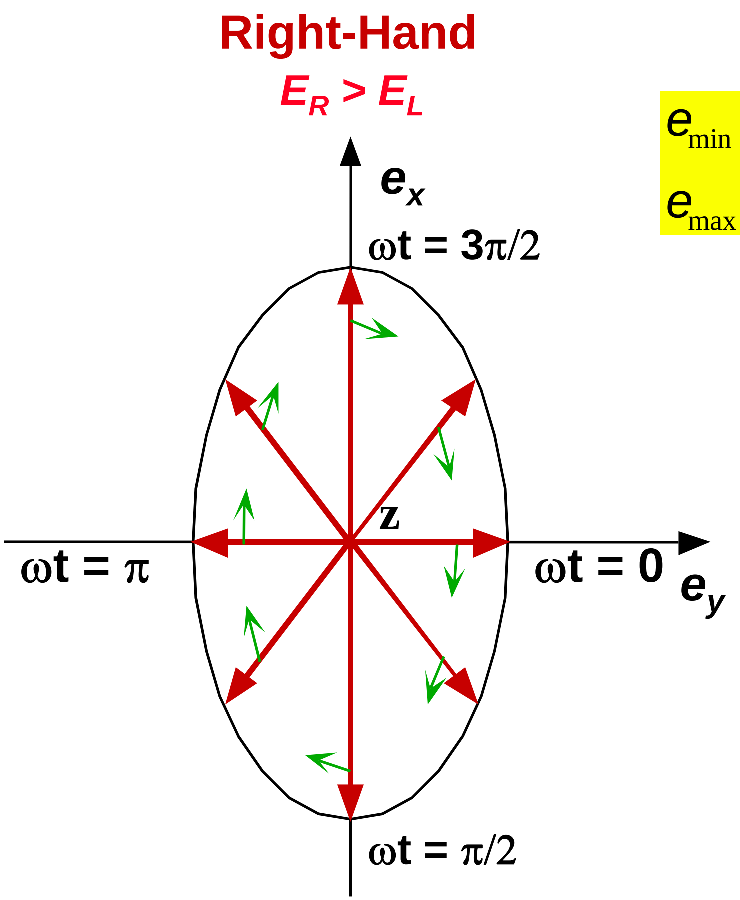
$$\underline{\vec{E}} = \hat{e}_x \cdot E_x \cdot e^{j(\omega t - kz)} + \hat{e}_y \cdot E_y \cdot e^{j(\omega t - kz + \pi/2)}$$

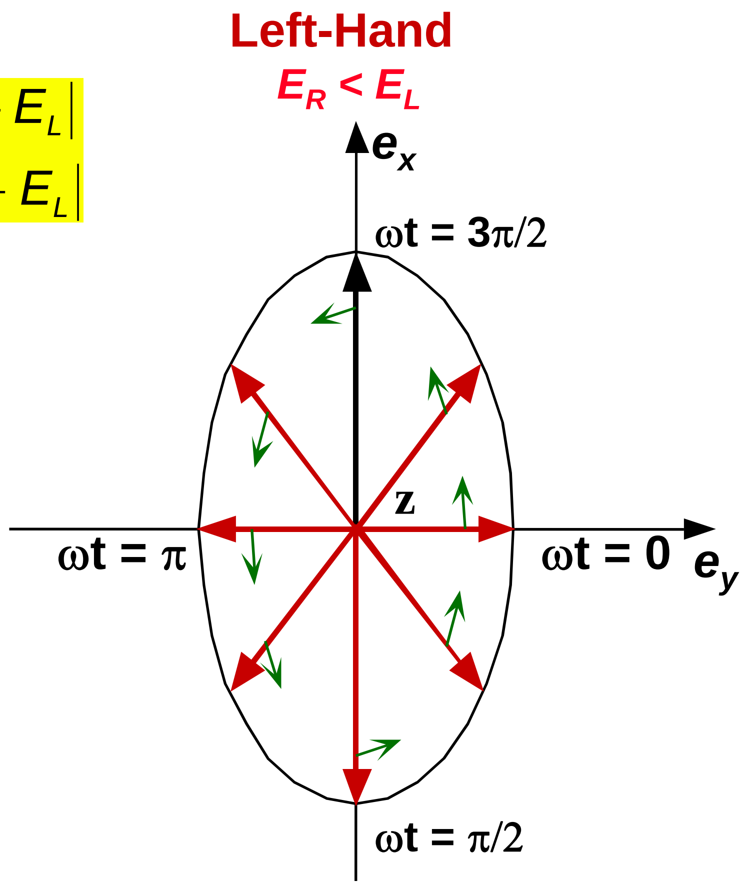
Entstehung zirkularer (elliptischer) Polarisation



Elliptische Polarisation (z = const)

$$e_{\min} = |E_R - E_L|$$
$$e_{\max} = |E_R + E_L|$$





Polarimetric Definitions

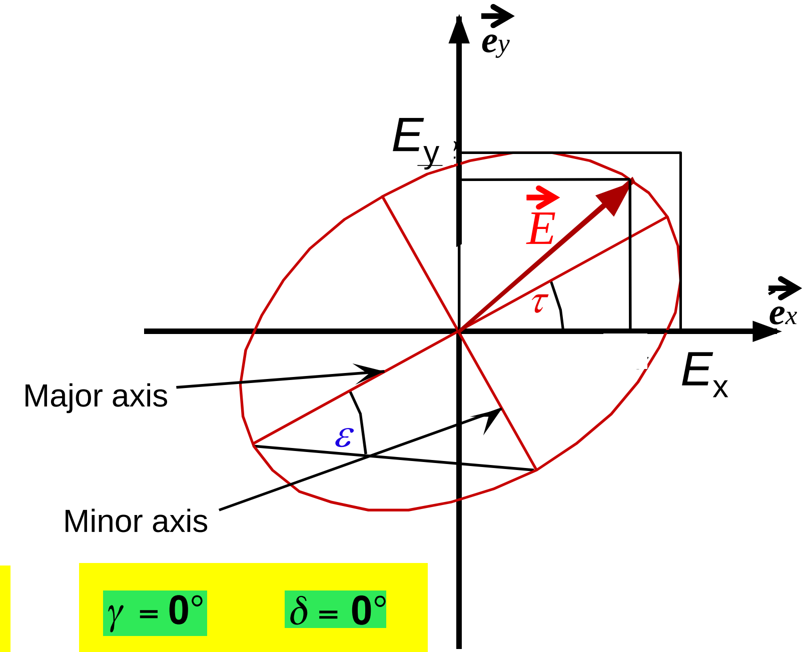
General polarised wave: $\vec{\underline{E}} = \left(\hat{e}_x \underline{E}_x + \hat{e}_y \underline{E}_y\right) e^{j(\omega t - kz)} = \hat{e}_x E_x e^{j(\omega t - kz + \delta_x)} + \hat{e}_y E_y e^{j(\omega t - kz + \delta_y)}$

Ellipticity angle ε: $\varepsilon = \arctan \gamma$

Tilt angle τ: $\tan 2\tau = 2\cos\delta \dfrac{E_x E_y}{E_x^2 - E_y^2}$

Amplitude ratio γ: $\gamma = \dfrac{\text{minor axis}}{\text{major axis}}$

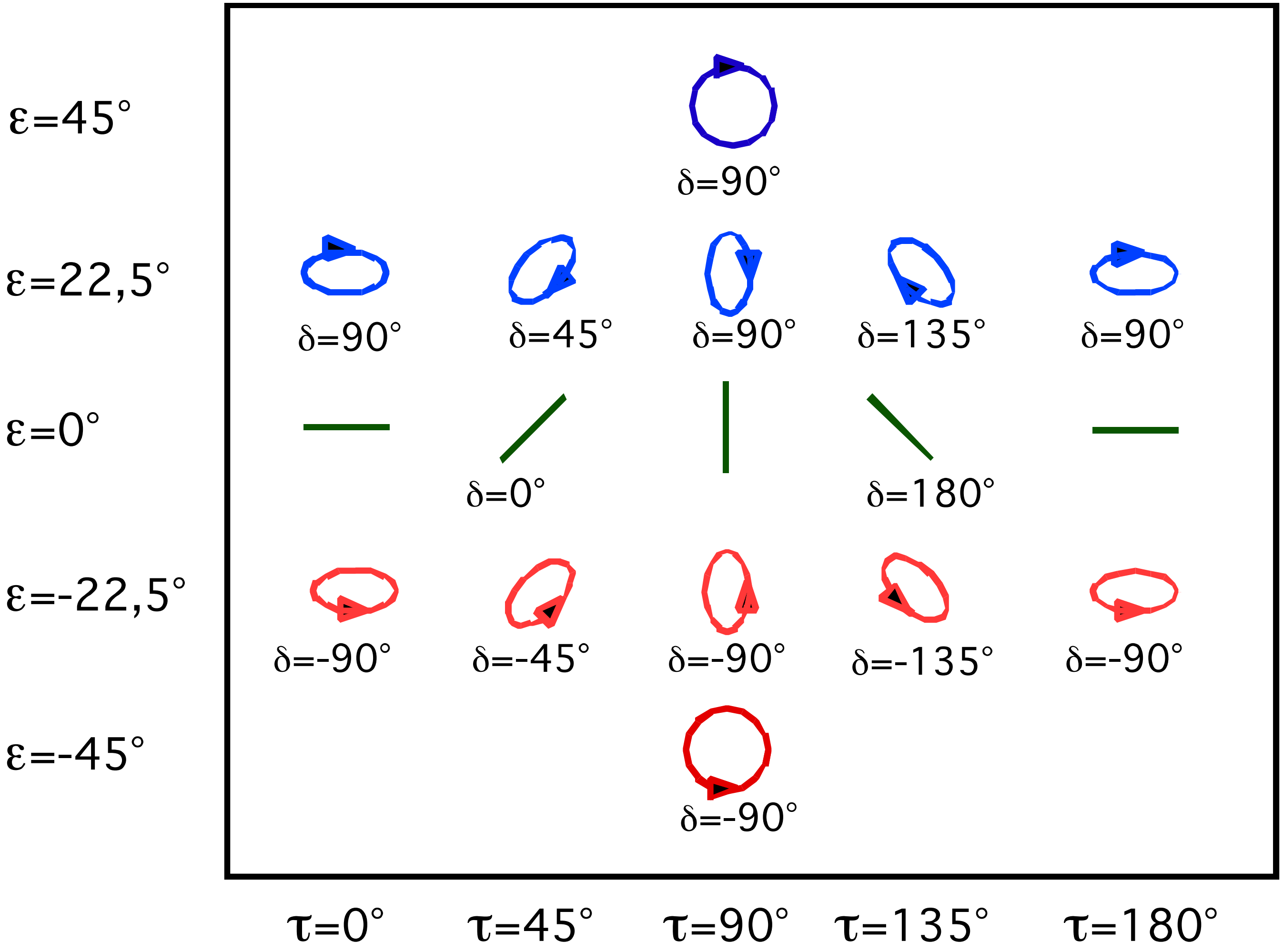
Phase difference δ: $\delta = \delta_y - \delta_x$



horizontal	$\varepsilon = 0°$	$\tau = 0°$	$\gamma = 0°$	$\delta = 0°$
vertical	$\varepsilon = 0°$	$\tau = 90°$	$\gamma = 90°$	$\delta = 0°$
right hand circular	$\varepsilon = -45°$	$\tau = 0°.....180°$	$\gamma = 45°$	$\delta = -90°$
left hand circular	$\varepsilon = 45°$	$\tau = 0°.....180°$	$\gamma = 45°$	$\delta = 90°$

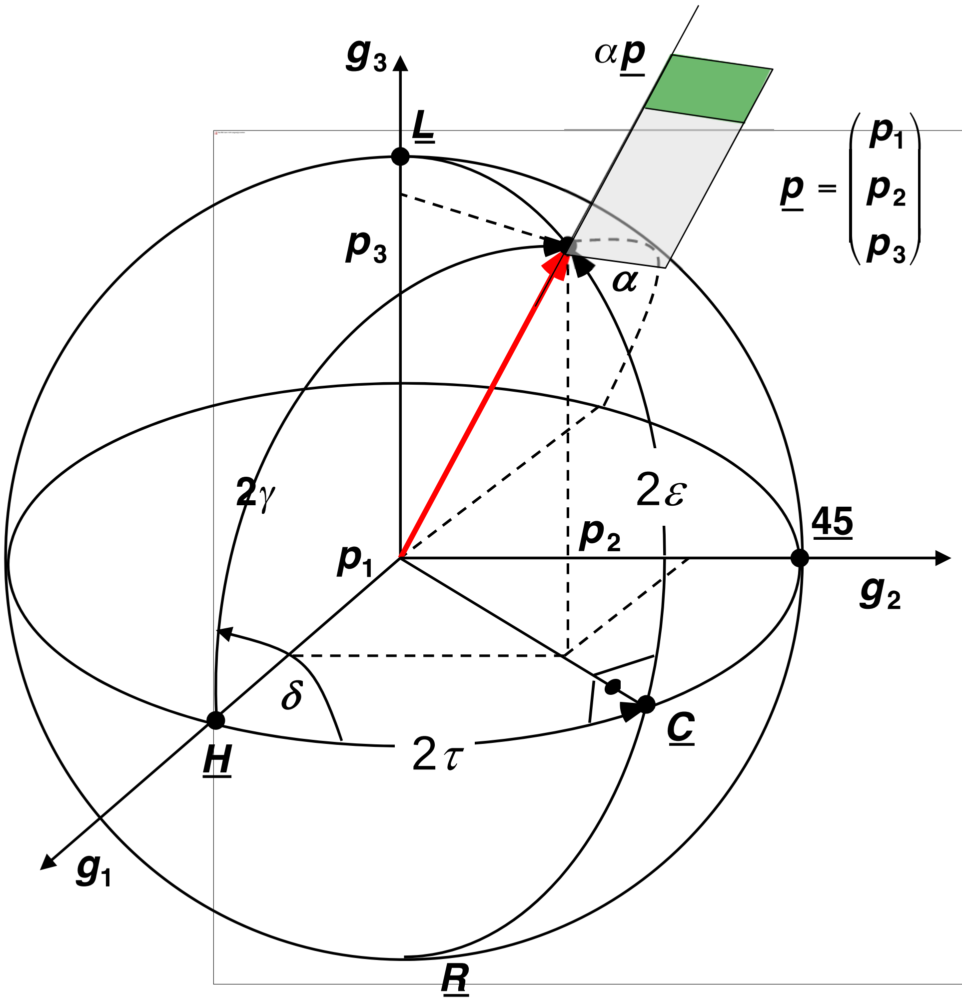
Polarization States of Plane Waves

(ε = ellipticity angle, τ =tilt angle)



Institut für Hochfrequenztechnik und Elektronik

Poincaré-Sphere



$$\tan 2\tau = 2\cos\delta \frac{E_x E_y}{E_x^2 - E_y^2}$$

$$\sin 2\varepsilon = 2\sin\delta \frac{E_x E_y}{E_x^2 + E_y^2}$$

$$\delta = \delta_y - \delta_x$$

$$\vec{\underline{E}} = (\underline{E}_x + \underline{E}_y) \cdot e^{j(\omega t - kz)} = E_x \cdot e^{j(\omega t - kz + \delta_x)} + E_y \cdot e^{j(\omega t - kz + \delta_y)}$$

Polarization States on the Poincaré-Sphere