CHARACTERIZATION OF THE SR POLARIZATION STATE AT SPEAR3

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Abstract

The polarization state of synchrotron radiation can be characterized as a function of vertical observation angle and compared with theory.

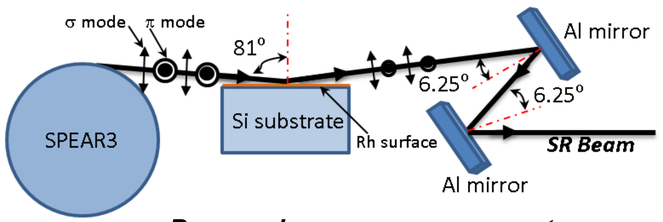
Schwinger's equations provide the theory for the SR angular- and spectrum distribution.

With a polarizer , QWP and power meter driven by an automated system the Stokes parameters were measured and beam polarization ellipse evaluated.

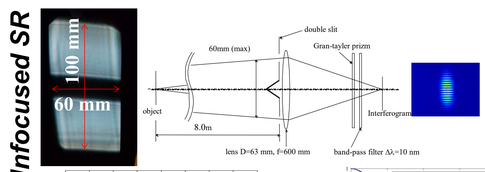
Agreement between measurement and theory is good when the effect of a reflective metal mirror is taken into account.

Visible light diagnostic beamline

SR beamline end-station

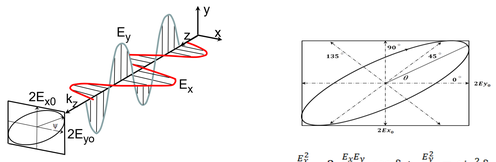


Beam coherence measurements



$$I(y) = I_0\left[\sin c\left(\frac{2\pi\delta}{\lambda R}y\right)\right]\cdot\left[1+|\gamma|\cos\left(\frac{2\pi l}{\lambda R}y+\Phi\right)\right]$$

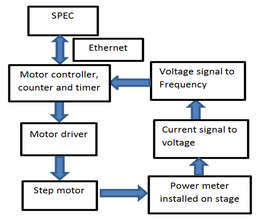
Beam polarization measurements



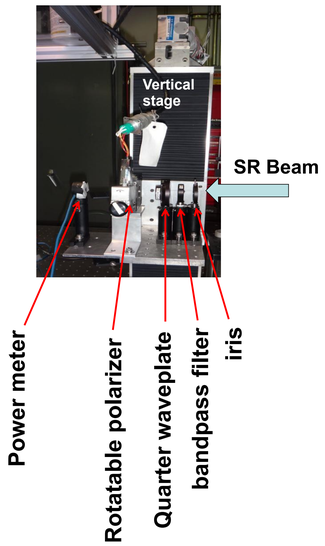
$$\frac{E_x^2}{E_{x0}^2} - 2\frac{E_xE_y}{E_{x0}E_{y0}}\cos\delta + \frac{E_y^2}{E_{y0}^2} = sin^2\delta$$

Polarization Measurement System

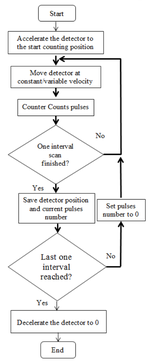
Computer control system



Vertical scanning stage



Continuous scan algorithm

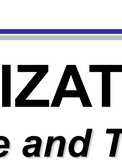


SR emission and reflection at pick-off mirror

Schwinger's Equations

$$E_{x0} \triangleq \tilde{E}_\sigma(\omega,\psi) = \frac{-\sqrt{3}e\gamma}{(2\pi)^{3/2}\epsilon_o c r_p}\left(\frac{|\omega|}{2\omega_c}\right)(1+\gamma^2\psi^2)K_{2/3}(\frac{\omega}{\omega_c},\gamma\psi)$$

$$E_{y0} \triangleq \tilde{E}_\pi(\omega,\psi) = \frac{i\sqrt{3}e\gamma}{(2\pi)^{3/2}\epsilon_o c r_p}\left(\frac{|\omega|}{2\omega_c}\right)\gamma\psi\sqrt{1+\gamma^2\psi^2}K_{1/3}(\frac{\omega}{\omega_c},\gamma\psi)$$



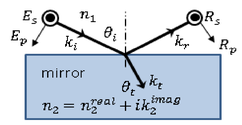
Julian Schwinger

Horizontal Polarization

Vertical Polarization

Visible component

Rhodium pickoff mirror (81° incidence angle)

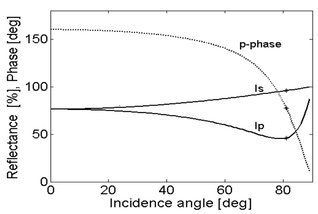


$$r_s = \frac{R_s}{E_s} = \frac{n_1\cos\theta_i - n_2\cos\theta_t}{n_1\cos\theta_i + n_2\cos\theta_t}$$

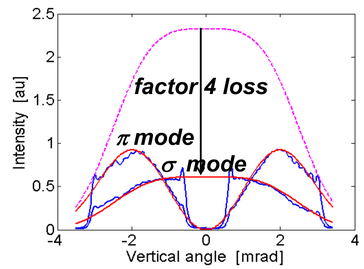
$$r_p = \frac{R_p}{E_p} = \frac{n_2\cos\theta_i - n_1\cos\theta_t}{n_1\cos\theta_t + n_2\cos\theta_i}$$

S- and P-wave reflection at mirror

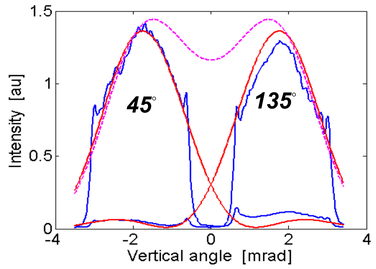
Wavelength (nm)		430	532	650
Refractive index		1.64	1.93	2.19
Extinction index		4.37	4.89	5.74
Reflectivity	r_s	0.98	0.98	0.98
	r_p	0.70	0.68	0.68
	I_p/I_s	0.51	0.48	0.48
Reflection phase	$\Delta\emptyset_S$	-176.4°	-176.9°	-177.3°
	$\Delta\emptyset_P$	-70.1°	-77.2°	-87.0°
	$\Delta\emptyset_{S/P}$	-16.3°	-9.7°	-0.3°



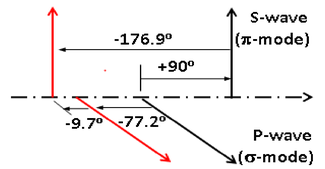
Beam polarization measurements at 532nm



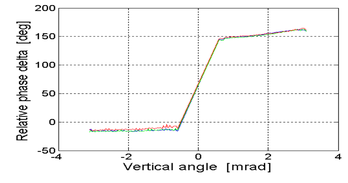
σ and π mode intensities (expect only factor 2 loss)



Polarizer at 45° and 135°



Phase shift at Rh mirror



Measured relative phase

Intensities Characterize Polarization State

Stokes parameters

$$S_0 = E_{x0}^2 + E_{y0}^2 = I_{0^o} + I_{90^o}$$

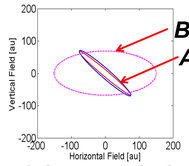
$$S_1 = E_{x0}^2 - E_{y0}^2 = I_{0^o} - I_{90^o}$$

$$S_2 = 2E_{x0}E_{y0}\cos(\delta) = I_{45^o} - I_{135^o}$$

$$S_3 = 2E_{x0}E_{y0}\sin(\delta) = I_{45^o}^{QWP} - I_{135^o}^{QWP}$$

δ is the relative phase between E_x and E_y

George Gabriel Stokes



Measured beam polarization ellipse

Summary

- *Unfocused SR in diagnostic beam line*
- *Measured the SR beam polarization state*
- *Field attenuation and phase shift at Rh mirror*
- *Compare with SR theory – agreement is good*
- *Calculate Stokes parameters*
- *Calculate polarization ellipse*