OHD-OKE (Optical Heterodyne Detected-Optical Kerr Effect)

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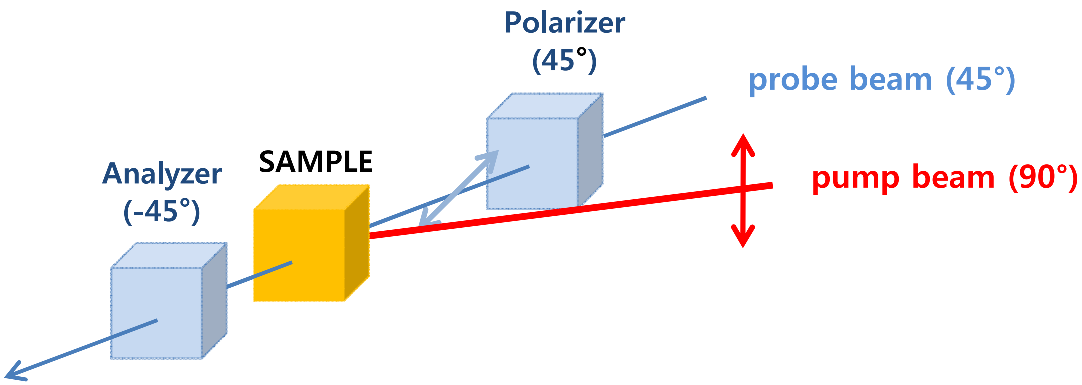
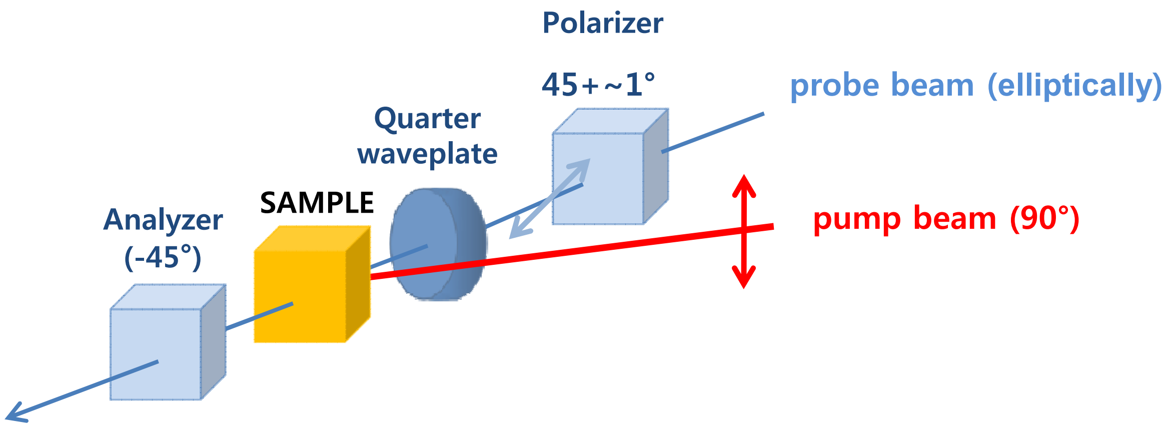
✓ OKE (Optical Kerr Effect)



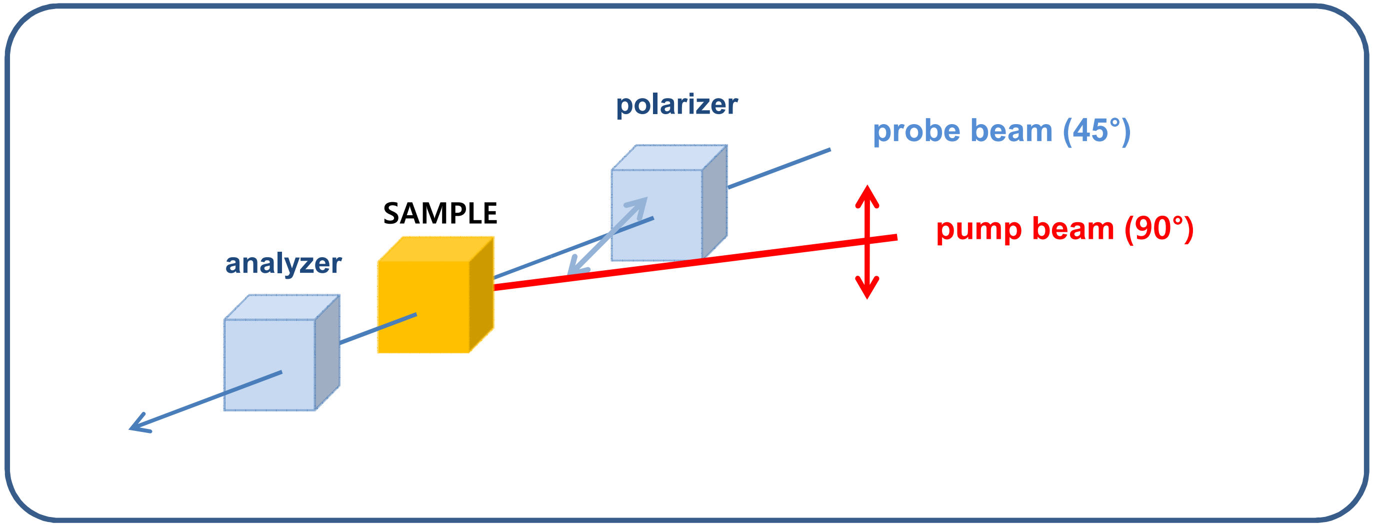
$$S_{OHD\text{-}OKE}(t) = I_{homodyne}$$

✓ OHD-OKE (Optical Heterodyne Detected-Optical Kerr Effect)



$$S_{OHD\text{-}OKE}(t) = I_{background} + I_{homodyne} + I_{heterodyne}$$

OKE Jones Matrix



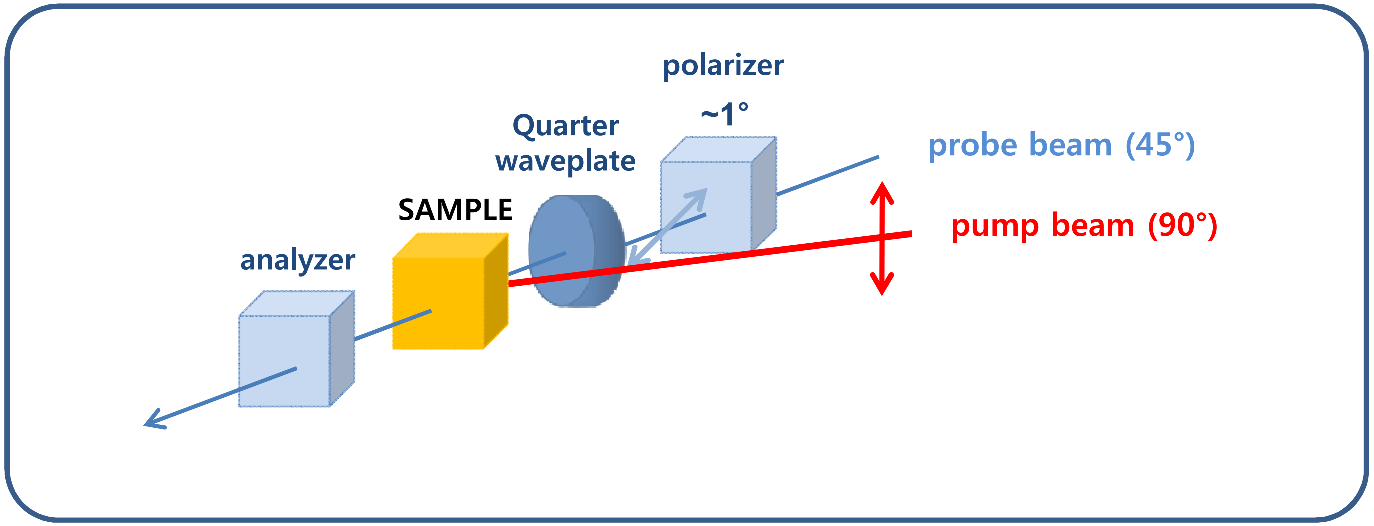
$$\begin{bmatrix} E_h \\ E_v \end{bmatrix} = \frac{1}{2}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{bmatrix} \cos 0^o & -\sin 0^o \\ \sin 0^o & \cos 0^o \end{bmatrix} \begin{bmatrix} e^{i\phi_x} & 0 \\ 0 & e^{i\phi_y} \end{bmatrix} \begin{bmatrix} \cos 0^o & \sin 0^o \\ -\sin 0^o & \cos 0^o \end{bmatrix} \frac{1}{2}\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

analyzer **SAMPLE** **polarizer** **probe beam**

$$= \frac{1}{4}\begin{bmatrix} e^{i\varphi_x} - e^{i\varphi_y} \\ -e^{i\varphi_x} + e^{i\varphi_y} \end{bmatrix}$$

$$\therefore I = < E^2 > = \frac{1}{2}\sin^2 \frac{(\varphi_x - \varphi_y)}{2} \simeq \frac{\Delta\phi^2}{4}$$

OHD-OKE Jones Matrix



$$\begin{bmatrix} E_h \\ E_v \end{bmatrix} = \frac{1}{2}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{bmatrix} \cos 0^o & -\sin 0^o \\ \sin 0^o & \cos 0^o \end{bmatrix} \begin{bmatrix} e^{i\phi_x} & 0 \\ 0 & e^{i\phi_y} \end{bmatrix} \begin{bmatrix} \cos 0^o & \sin 0^o \\ -\sin 0^o & \cos 0^o \end{bmatrix} \frac{1}{2}\begin{bmatrix} 1 & i \\ i & 1 \end{bmatrix} \begin{bmatrix} \cos\varphi & \sin\varphi \\ -\sin\varphi & \cos\varphi \end{bmatrix} \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\varphi & -\sin\varphi \\ \sin\varphi & \cos\varphi \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

analyzer | SAMPLE | Quarter waveplate | polarizer φ° | probe beam

$$I = \langle E^2 \rangle = \varphi^2 + \frac{\Delta\phi^2}{4} + \varphi\Delta\phi$$

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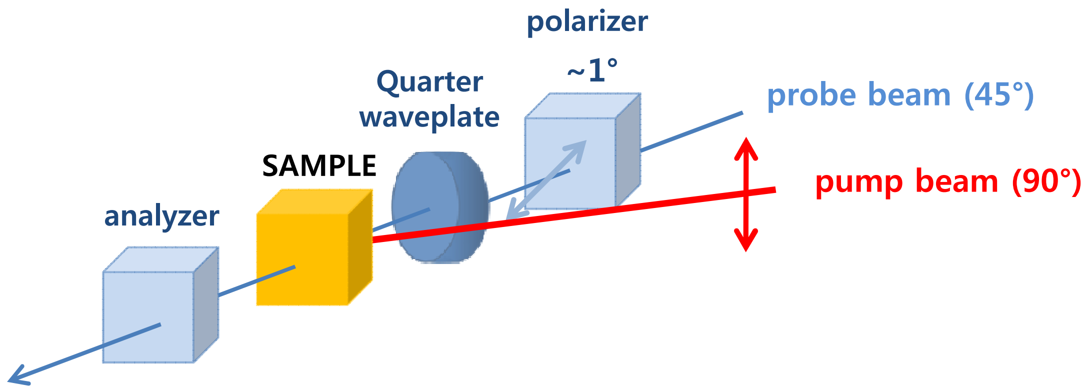
$$S_{OHD\text{-}OKE}(t) = I_{background} + I_{homodyne} + I_{heterodyne}$$



Detected signal field : $E_s = (\mathrm{Re}\,E_s + i\,\mathrm{Im}\,E_s)e^{-i\omega t}$ .... **(1)**

Local oscillator field : $E_{LO} = E_{probe}e^{-i\omega t}e^{i\pi/2}$ .... **(2)**

$$I_{(<1^o)} = \left|E_s + E_{LO}\right|^2 = \left|(\mathrm{Re}\,E_s + i\,\mathrm{Im}\,E_s)e^{-i\omega t} + E_{probe}e^{-i\omega t}e^{i\pi/2}\right|^2$$

$$= \left|e^{-i\omega t}\right|^2\left|(\mathrm{Re}\,E_s + i(\mathrm{Im}\,E_s + E_{probe})\right|^2 = E_{probe}{}^2 + [(\mathrm{Re}\,E_s)^2 + (\mathrm{Im}\,E_s)^2] + 2E_{probe}\,\mathrm{Im}\,E_s$$

$$= \boxed{I_{LO} + I_S + 2E_{probe}\,\mathrm{Im}\,E_s} \quad \text{............................ (3)}$$

$$I_{(<-1^o)} = \left|E_s + E_{LO}\right|^2 = \left|(\mathrm{Re}\,E_s + i\,\mathrm{Im}\,E_s)e^{-i\omega t} + E_{probe}e^{-i\omega t}e^{-i\pi/2}\right|^2$$

$$\boxed{= I_{LO} + I_S - 2E_{probe}\,\mathrm{Im}\,E_s} \quad \text{............................ (4)}$$

Polarizer angle (º)	$I_{SIGNAL} = I_{background} + I_{homodyne} + I_{heterodyne}$		
	$I_{background}$	$I_{homodyne}$	$I_{heterodyne}$
41	(0.284793)	− (0.282022) Cos[$\phi_x - \phi_y$]	+ (0.0396356) Sin[$\phi_x - \phi_y$]
42	(0.276132)	− (0.274619) Cos[$\phi_x - \phi_y$]	+ (0.0288637) Sin[$\phi_x - \phi_y$]
43	(0.267439)	− (0.266788) Cos[$\phi_x - \phi_y$]	+ (0.0186556) Sin[$\phi_x - \phi_y$]
44	(0.258725)	− (0.258567) Cos[$\phi_x - \phi_y$]	+ (0.00902937) Sin[$\phi_x - \phi_y$]
45		$\frac{1}{2}$ Sin$\left[\frac{1}{2}(\phi_x - \phi_y)\right]^2$	
46	(0.241275)	− (0.241128) Cos[$\phi_x - \phi_y$]	− (0.00842038) Sin[$\phi_x - \phi_y$]
47	(0.232561)	− (0.231994) Cos[$\phi_x - \phi_y$]	− (0.0162226) Sin[$\phi_x - \phi_y$]
48	(0.223868)	− (0.222642) Cos[$\phi_x - \phi_y$]	− (0.0234006) Sin[$\phi_x - \phi_y$]
49	(0.215207)	− (0.213112) Cos[$\phi_x - \phi_y$]	− (0.029951) Sin[$\phi_x - \phi_y$]

$$\sin^2(\phi_x - \phi_y) = \frac{1 - \cos(\phi_x - \phi_y)}{2}$$

OHD-OKE setup

BS : Beamspliter

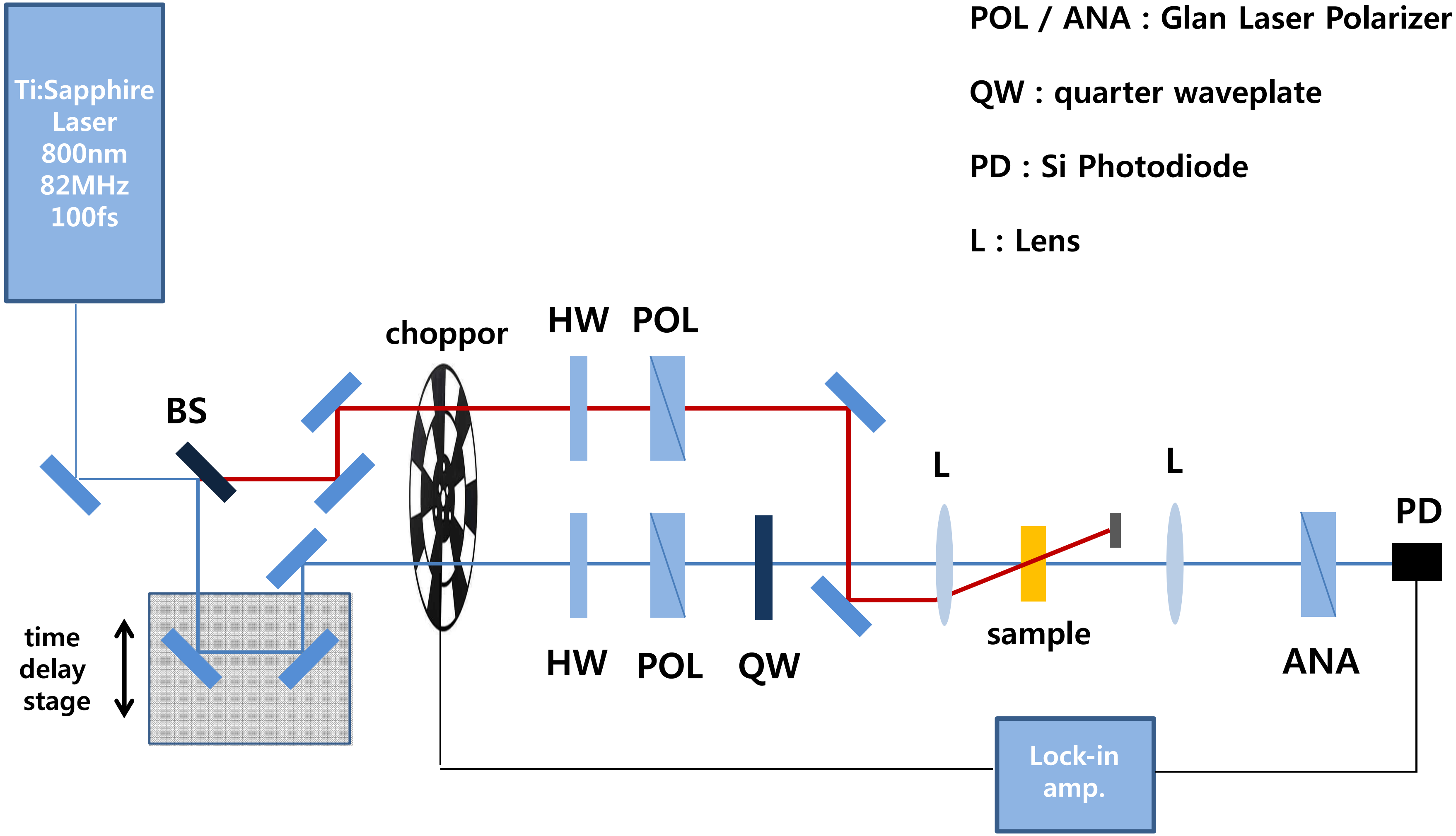
HW : Half waveplate

POL / ANA : Glan Laser Polarizer

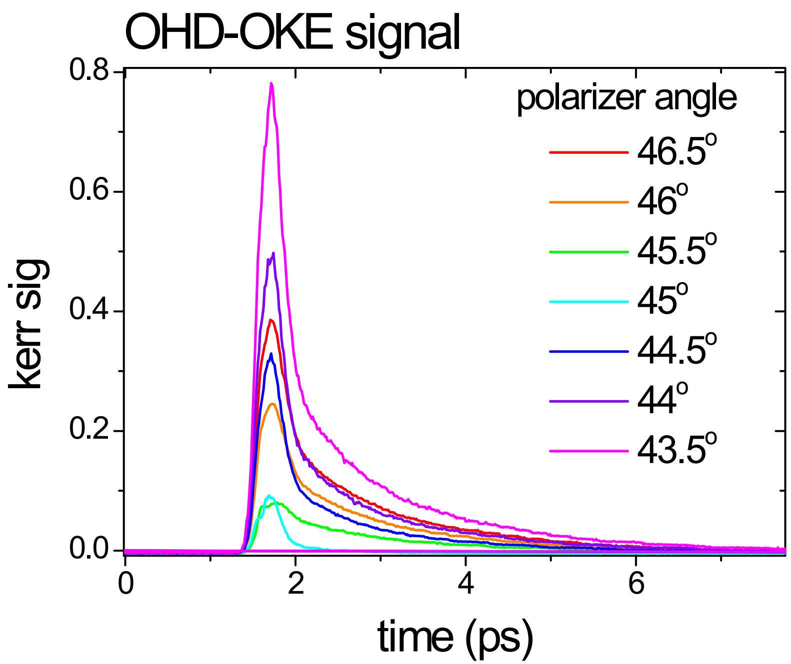
QW : quarter waveplate

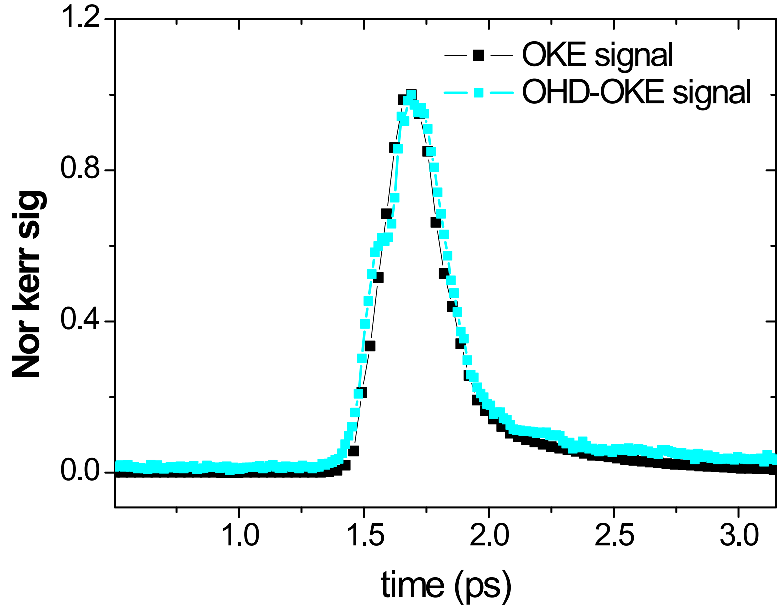
PD : Si Photodiode

L : Lens



Compare OKE and OHD-OKE signal (sample : CS_2)





OHD-OKE signal (sample : CS_2)