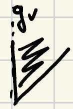
Semester 2

Modelling of photon-pair generation in dual-rail lithium niobate photonic nano-wire set up

Meeting 6th Feb (start 2nd semester work)

TODO
☐ Fix group velocity plots : not alligned the "right" way in P
– add lines

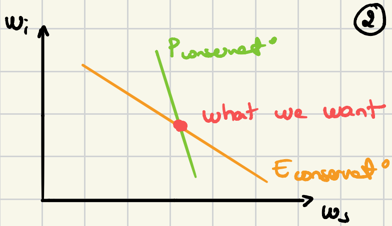


Error in presentat°: χ_2 materials are required for SPDC
nothing todo with keeping pulses in waveguide

SPDC has 2 requirements: ① Energy conservat°
$\omega_p = \omega_s + \omega_i$

② Momentum conservat°
$B(\omega_p) = B(\omega_s) + B(\omega_i)$

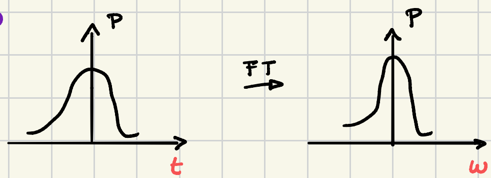
similar but not the same outside of vacuum
$B = n_e k = n_e \frac{\omega}{c}$
vacuum $n_e = 1$



Heisenberg principle

definite momentum if no idea where positioned
– no definite momentum: "spread"
we find a middle point when both are available

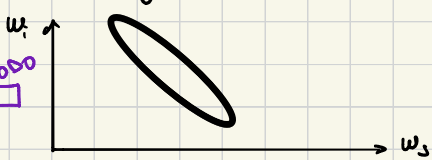
TODO
☐



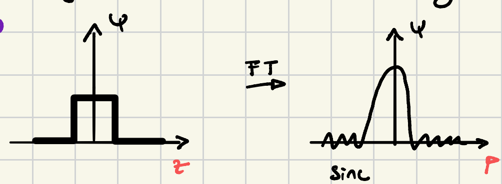
Heisenberg ⇒ gives us length of waveguide Δz ∴ no uncertainty in Δp

spread of freq in P

TODO
☐



TODO
☐



Check: Formula 4 Sam Eseine

wavef° resulting 2 photons JSA (Joint spectrum amplitude)
JSI (... intensity)

$|\Psi_2\rangle = \iint f(\omega_i, \omega_s) |\omega_i\rangle |\omega_s\rangle \, d\omega_i \, d\omega_s$

$J = \alpha(\omega_s, \omega_i) \, \Phi(\omega_s, \omega_i)$

spectrum of pump — sinc f° cons. of P

$\omega_p = \omega_s + \omega_i$

ΔB = momentum mismatch

$\Delta\beta = \beta_p - \beta_s - \beta_i$

Tuesday 13th

Integral eqt° 7 $\sim \text{sinc}\left(\frac{\Delta\beta L}{2}\right)$

$\Delta\beta = \beta_p - \beta_s - \beta_i$

$$J(\omega_s,\omega_i) = \rho_2 exp\left\{\frac{(\omega_p - \omega_s - \omega_i)^2 t_0^2}{2}\right\} sinc\left[\frac{\Delta\beta L}{2}\right] exp\left\{i\frac{\Delta\beta L}{2}\right\} \quad (7)$$

1.35 — 1.65 } wavelengths → plotted as freq ω

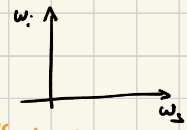
1.5 μm

interpolate

photon - disp

pump - disp

interpolat°



$\beta_s(\omega_s)$

$\beta_i(\omega_i)$

$\beta_p(\omega_s + \omega_i)$

how we get the $\text{sinc}\left(\frac{\Delta\beta L}{2}\right)$

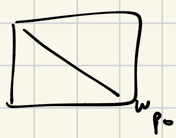
$\omega_p = \omega_s + \omega_i$

Connect° 1st sem (after plot above)

$\omega = \omega_s + \omega_i$

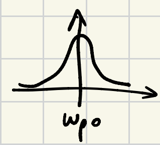
$\underbrace{\omega_s + \omega_i = \omega_{p0}}$

fixed it to smth 750nm } changing it moves ↑ or ↓



$\alpha(\omega) \sim$

$\sim \exp\left(-\frac{(\omega - \omega_{p0})^2}{\Delta^2}\right)$

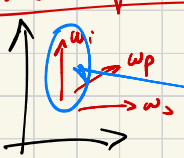


3rd phase

put both plots together

see prev page

How to compute this:



meshgrid: matlab

$\begin{pmatrix} \omega_s \rightarrow \end{pmatrix} \cdot \begin{pmatrix} \omega_i \downarrow \dots \end{pmatrix} = \begin{pmatrix} \omega_p \end{pmatrix}$

upside down

$\downarrow \beta_s \qquad \downarrow \beta_i \qquad \downarrow p$

w_s = [ws1, ... , wsN];
w_i = [wi1, ... , wiM]

[S, I] = meshgrid(w_s, w_i)

betas = disp(S);

beta i = disp(I);

Beta p = disp-pump(S+I);

phi = sinc-my (Betap - betas - beta i)

don't use the embedded sinc f°

pcolor (S, I, phi)

Correct°

spectrum pump from fem 1

≥

spectrum pump = f° z coordinate

integral in z

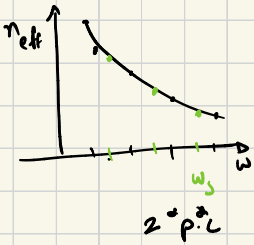
eqt° 6 Esein

evaluate int numerically via (6)

spectrum of alpha $\stackrel{!}{=}$ numerical spectrum

20th Feb

Fix x file order



spline $(\omega, n_{eff}, \omega_s) \to n_{eff}(\omega_s)$

make a starter

photon disper° file wavelength microns 1e-6

$\Rightarrow n_s, n_p, n_i$: meshgrid

make matrix 1st

spline uses matrix

np = spline (...., $\omega_s + \omega_i$)

Pump (2nd)

assume gaussian

alpha = exp(-(ω_s+ω_i))**2 *(10**-25)^2 /10^2

x reasonable (t_0^2 : duration pulse sam's)

ω_{p0} = 2πc/(?)e-9

central freq pump

Product phi · alpha plot : current chirp

Coupling : eqt°(6) → get sinc · eq (7)

integrat° by hand

1st eq (6) = pump f° alpha - doesn't depend on z → out

TODO : insert eq (5) → (6)

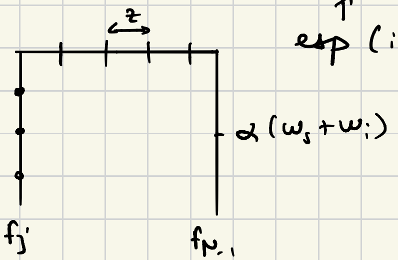
evaluate numerically : trapezium rule in grid z

create a grid of z

waveguide : 3cm

$$\int_0^L f(z)\,dz \approx \sum f_j \,\Delta z$$

$$\exp(i \Delta \beta z_j)$$



My work 23rd Feb

$$\Phi(\omega_s, \omega_i) = \int_0^L \rho_2 \exp\{ i \Delta \beta z \} \, dz$$

$$= \left[\rho_2 \, i \Delta \beta e^{i \Delta \beta z} \right]_0^L$$

$$= \rho_2 \, i \Delta \beta \left[e^{i \Delta \beta L} - 1 \right]$$