Parameter estimation with correlated photon pairs

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Motivation

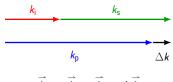




Energy conservation



Momentum conservation



$$\vec{k}_{\mathrm{p}} = \vec{k}_{\mathrm{s}} + \vec{k}_{\mathrm{i}} - \Delta \vec{k}$$



Results

Transmittance model

Conventional approach:

$$N_{
m tot}^{
m ref} = \eta_{
m idl} \ N_{
m g} + N_{
m noise}^{
m ref}$$
 $N_{
m tot}^{
m sam} = T \ \eta_{
m idl} \ N_{
m g} + N_{
m noise}^{
m sam}$

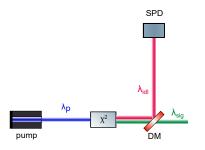
Coincidence approach:

Simulation

$$N_{
m cc}^{
m pure,sam} = \mathcal{T}\,\eta_{
m idl}\,\eta_{
m sig}\,N_{
m g},$$
 $N_{
m cc}^{
m pure,ref} = \eta_{
m idl}\,\eta_{
m sig}\,N_{
m d}$



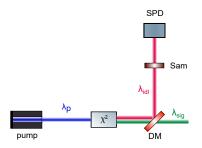
Conventional approach



$$N_{
m tot}^{
m ref} = \eta_{
m idl} N_{
m g} + N_{
m noise}^{
m ref}$$



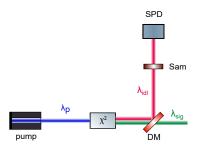
Conventional approach



$$egin{aligned} m{\mathcal{N}}_{ ext{tot}}^{ ext{ref}} &= \eta_{ ext{idI}} \, m{\mathcal{N}}_{ ext{g}} + m{\mathcal{N}}_{ ext{noise}}^{ ext{ref}} \ m{\mathcal{N}}_{ ext{tot}}^{ ext{sam}} &= m{\mathcal{T}} \, \eta_{ ext{idI}} \, m{\mathcal{N}}_{ ext{g}} + m{\mathcal{N}}_{ ext{noise}}^{ ext{sam}} \end{aligned}$$



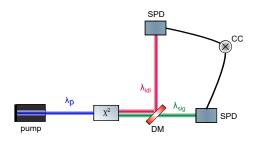
Conventional approach



$$N_{
m tot}^{
m ref} = \eta_{
m idl} N_{
m g} + N_{
m noise}^{
m ref}$$
 $N_{
m tot}^{
m sam} = T \, \eta_{
m idl} N_{
m g} + N_{
m noise}^{
m sam}$
 $\Rightarrow T = rac{N_{
m tot}^{
m sam} - N_{
m noise}^{
m sam}}{N_{
m ref}^{
m ref} - N_{
m ref}^{
m ref}}$



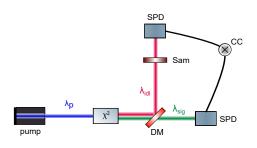
Coincidence approach



$$N_{
m cc,tot}^{
m ref} = \eta_{
m idl} \, \eta_{
m sig} \, N_{
m g} + N_{
m ac}^{
m ref}$$

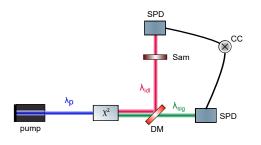


Coincidence approach





Coincidence approach



$$egin{align*} & \mathcal{N}_{ ext{cc,tot}}^{ ext{ref}} = \eta_{ ext{idl}} \, \eta_{ ext{sig}} \, \mathcal{N}_{ ext{g}} + \mathcal{N}_{ ext{ac}}^{ ext{ref}} \ & \mathcal{N}_{ ext{cc,tot}}^{ ext{sam}} = \mathcal{T} \, \eta_{ ext{idl}} \, \eta_{ ext{sig}} \, \mathcal{N}_{ ext{g}} + \mathcal{N}_{ ext{ac}}^{ ext{sam}} \ & \Rightarrow \mathcal{T} = rac{\mathcal{N}_{ ext{tot,cc}}^{ ext{sam}} - \mathcal{N}_{ ext{ac}}^{ ext{sam}}}{\mathcal{N}_{ ext{tot,cc}}^{ ext{ref}} - \mathcal{N}_{ ext{ac}}^{ ext{ref}}} \end{aligned}$$



Transmittance model

Conventional approach:

$$\mathsf{Var}(\mathcal{T}) = \left(\eta_{\mathsf{idl}} \, \mathit{N}_{\mathsf{g}}\right)^{-2} \left[\mathsf{Var}(\mathit{N}_{\mathsf{tot}}^{\mathsf{sam}}) + \mathsf{Var}\big(\mathit{N}_{\mathsf{noise}}^{\mathsf{sam}}\big) + \mathcal{T}^{2} \Big[\mathsf{Var}\big(\mathit{N}_{\mathsf{tot}}^{\mathsf{ref}}\big) + \mathsf{Var}\big(\mathit{N}_{\mathsf{noise}}^{\mathsf{ref}}\big) \Big] \right]$$

Coincidence approach:

$$\mathsf{Var}(\mathcal{T}) = \left(\eta_{\mathsf{sig}} \, \eta_{\mathsf{idl}} \, \mathsf{N}_{\mathsf{g}}\right)^{-2} \, \left[\mathsf{Var}\big(\mathsf{N}_{\mathsf{tot},\mathsf{cc}}^{\mathsf{sam}}\big) + \mathsf{Var}(\mathsf{N}_{\mathsf{ac}}^{\mathsf{sam}}) + \, \mathcal{T}^2 \Big[\mathsf{Var}\big(\mathsf{N}_{\mathsf{tot},\mathsf{cc}}^{\mathsf{ref}}\big) + \mathsf{Var}\big(\mathsf{N}_{\mathsf{ac}}^{\mathsf{ref}}\big) \Big] \right]$$

Transmittance model

Conventional approach:

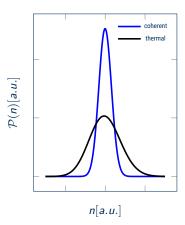
$$\mathsf{Var}(\mathcal{T}) = \left(\eta_{\mathsf{idl}} \, \mathit{N}_{\mathsf{g}}\right)^{-2} \left[\mathsf{Var}\big(\mathit{N}_{\mathsf{tot}}^{\mathsf{sam}}\big) + \mathsf{Var}\big(\mathit{N}_{\mathsf{noise}}^{\mathsf{sam}}\big) + \mathcal{T}^{2} \Big[\mathsf{Var}\big(\mathit{N}_{\mathsf{tot}}^{\mathsf{ref}}\big) + \mathsf{Var}\big(\mathit{N}_{\mathsf{noise}}^{\mathsf{ref}}\big) \Big] \right]$$

Coincidence approach:

$$\mathsf{Var}(\mathcal{T}) = \left(\eta_{\mathsf{sig}} \, \eta_{\mathsf{idl}} \, \mathit{N}_{\mathsf{g}}\right)^{-2} \, \left[\mathsf{Var}\big(\mathit{N}_{\mathsf{tot},\mathsf{cc}}^{\mathsf{sam}}\big) + \mathsf{Var}(\mathit{N}_{\mathsf{ac}}^{\mathsf{sam}}) + \, \mathcal{T}^{2} \Big[\mathsf{Var}\big(\mathit{N}_{\mathsf{tot},\mathsf{cc}}^{\mathsf{ref}}\big) + \mathsf{Var}\big(\mathit{N}_{\mathsf{ac}}^{\mathsf{ref}}\big) \Big] \right]$$



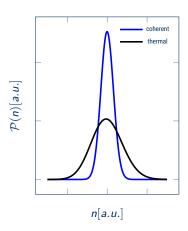
Photon statistics





Summary

Photon statistics



Coherent light:

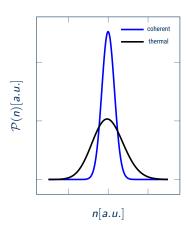
$$\mathcal{P}(n) = \frac{\langle n \rangle^n}{n!} e^{-\langle n \rangle}$$

$$Var(n) = \langle n \rangle$$



Summary

Photon statistics



Coherent light:

Results

$$\mathcal{P}(n) = \frac{\langle n \rangle^n}{n!} e^{-\langle n \rangle}$$
 $\mathsf{Var}(n) = \langle n \rangle$

Thermal light:

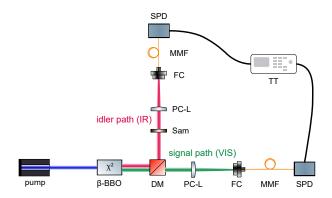
$$\mathcal{P}_{m}(n) = \frac{(n+m-1)!}{(m-1)! \, n!} \frac{m^{m} \langle n \rangle^{n}}{(m+\langle n \rangle)^{n+m}}$$

$$Var(n) = \langle n \rangle \left(1 + \frac{\langle n \rangle}{m} \right)$$



Motivation Theory Experiment Results Simulation Summary

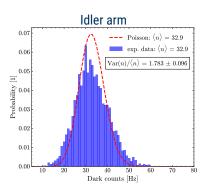
Experimental setup

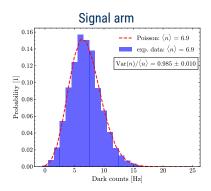






Dark counts

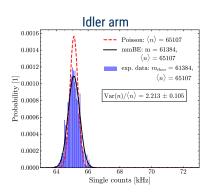


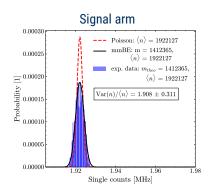






Single counts

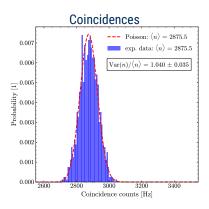


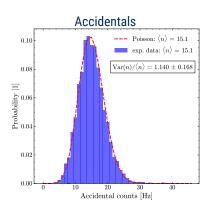






Coincidence counts

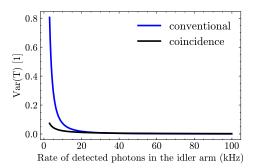








Simulation



Parameter	Value
η _{idl} (%)	0.09
η_{sig} (%)	2.6
R _{idl} (kHz)	3 - 100
R _{noise,idl} (kHz)	1000
R _{noise,sig} (Hz)	7
T (1)	0.9





Summary and Outlook

Git repository

public accessible:

https://git.tpi.uni-jena.de/mstnhsr/latexbeamer_corporatedesign

Feedback

marc.steinhauser@uni-jena.de





Slide title in Palatino Linotype Font

block environment (lower-case b)

itemize:

- First Level
 - Second Level

Third Level has no item mark

Block environment (upper-case B)

enumerate:

- First Level
 - 1.1 Second Level
 - 1.1.1 Third Level



