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6.453 Quantum Optical Communication
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6.453 *Quantum Optical Communication* Lecture 22

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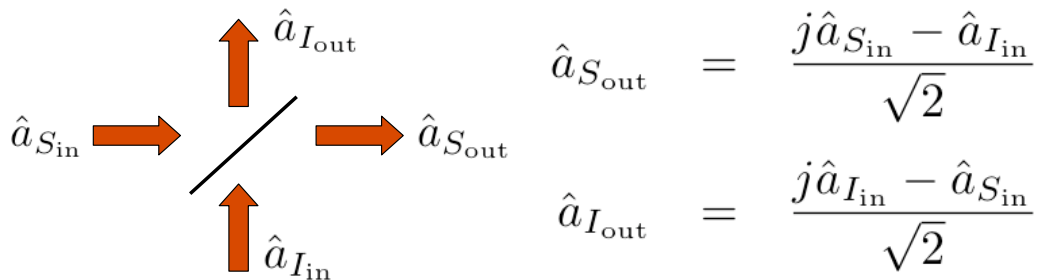
6.453 *Quantum Optical Communication* - Lecture 22

- Announcements
 - Pick up lecture notes, slides
 - Term papers are due in class on Tuesday, December 9th

- Quantum Signatures from Parametric Interactions
 - Hong-Ou-Mandel dip produced by parametric downconversion
 - Polarization entanglement produced by parametric downconversion
 - Photon twins from parametric amplifiers

Quantum Interference Between Single Photons

- Input State to 50/50 Beam Splitter: $|1\rangle_{S_{in}}|1\rangle_{I_{in}}$

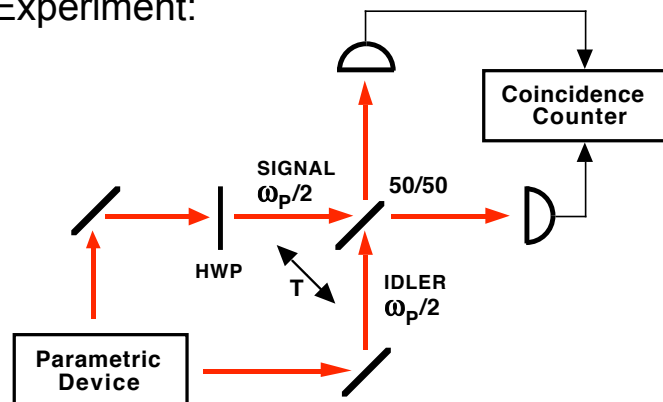


- Output State from 50/50 Beam Splitter:

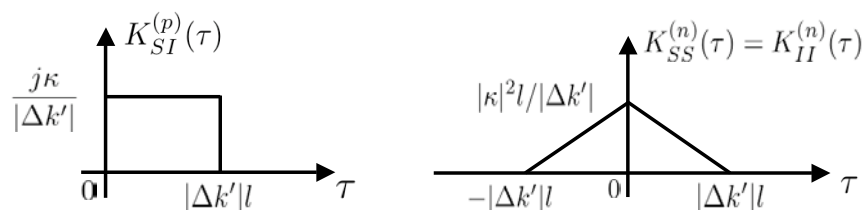
$$\frac{|2\rangle_{S_{out}}|0\rangle_{I_{out}} + |0\rangle_{S_{out}}|2\rangle_{I_{out}}}{\sqrt{2}}$$

Hong-Ou-Mandel Interferometer

- Type-II Experiment:



- PPKTP: 795 nm output wavelength, $\Delta k' = -3.3$ ps/cm



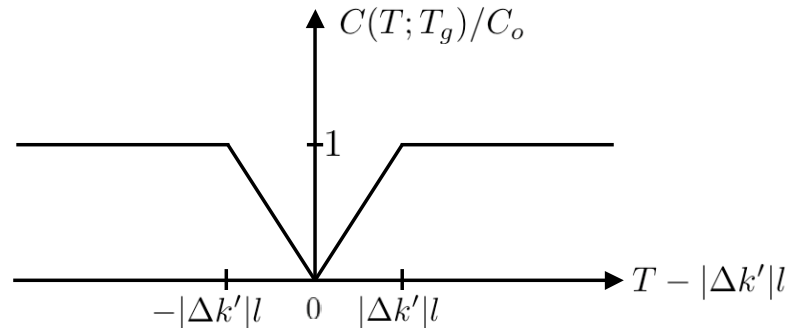
Hong-Ou-Mandel Coincidence Dip

- Average Low-Flux Coincidence Count in T_g -Sec-Long Gate:

$$C(T; T_g) = \left\langle \int_0^{T_g} dt \hat{E}'_{S_{out}}(t) \hat{E}'_{S_{out}}(t) \int_0^{T_g} du \hat{E}'_{I_{out}}(u) \hat{E}'_{I_{out}}(u) \right\rangle$$

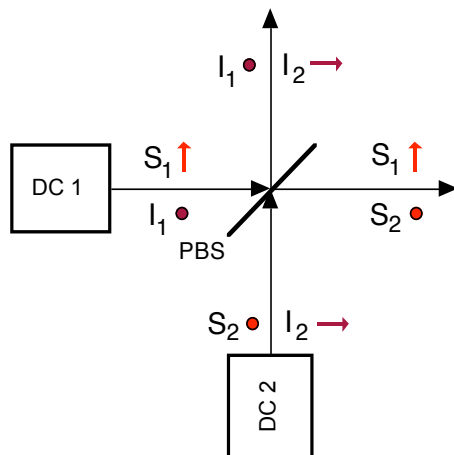
- Low-Flux Gaussian-State Coincidence Counting Theory:

$$C(T; T_g) = \frac{\eta^2 T_g}{4} \int d\tau |K_{SI}^{(p)}(\tau) - K_{SI}^{(p)}(-\tau + T)|^2$$



Polarization-Entanglement From Downconversion

- Anti-Phased Coherently-Pumped Type-II Downconverters:



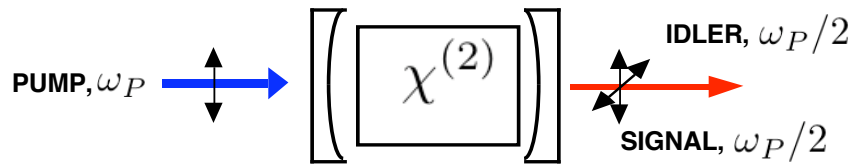
$$C_{\vec{i}\vec{i}'}(T_g) = \eta^2 T_g \frac{|\kappa|^2 l}{|\Delta k'|}$$

$$C_{\vec{i}\vec{i}}(T_g) = 0$$

\vec{i} and \vec{i}' conjugate polarizations

Type-II Optical Parametric Amplifier

- Doubly-Resonant Operation at Frequency Degeneracy



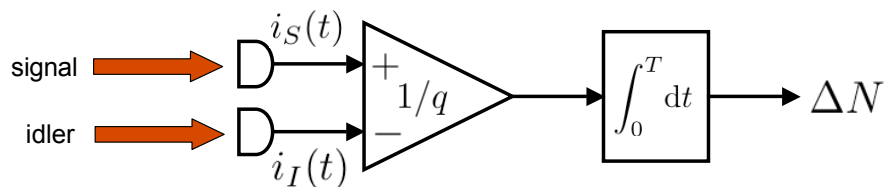
- Normally-Ordered and Phase-Sensitive Covariances:

$$K^{(n)}(\tau) = \frac{G\Gamma}{2} \left[\frac{e^{-(1-G)\Gamma|\tau|}}{1-G} - \frac{e^{-(1+G)\Gamma|\tau|}}{1+G} \right]$$

$$K_{SI}^{(p)}(\tau) = \frac{G\Gamma}{2} \left[\frac{e^{-(1-G)\Gamma|\tau|}}{1-G} + \frac{e^{-(1+G)\Gamma|\tau|}}{1+G} \right]$$

Photon Twins from a Parametric Amplifier

- Signal-Minus-Idler Photon Count Difference



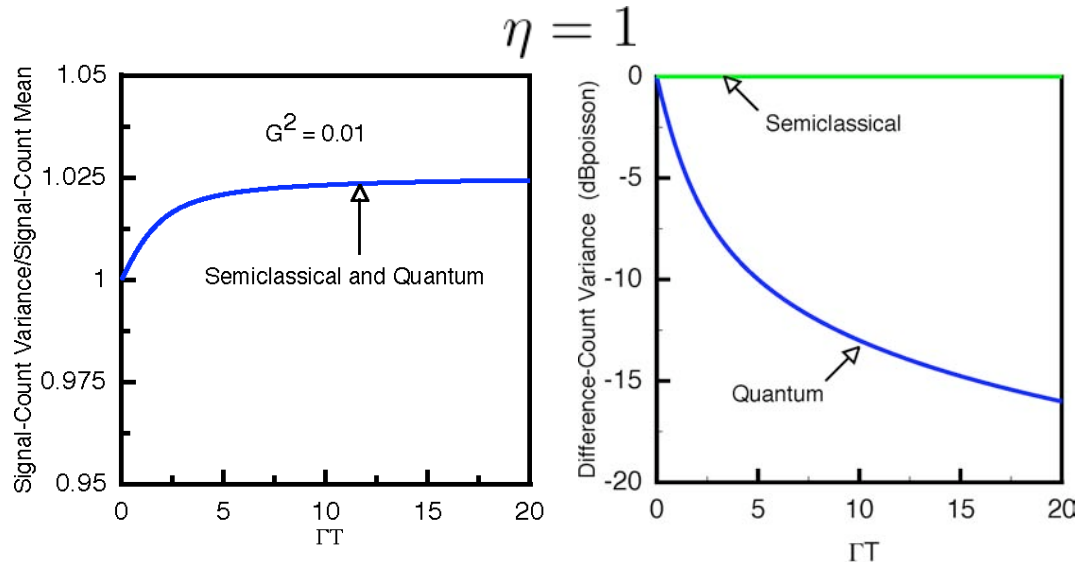
- Unity-Quantum-Efficiency Detection

$$\Delta N \leftrightarrow \widehat{\Delta N} = \int_0^T dt \left[\hat{E}_S^\dagger(t) \hat{E}_S(t) - \hat{E}_I^\dagger(t) \hat{E}_I(t) \right]$$

$$\frac{\langle \Delta N^2 \rangle}{\langle N_S \rangle + \langle N_I \rangle} = \frac{1 - e^{-2\Gamma T}}{2\Gamma T}$$

Photon Twins from a Parametric Amplifier

- Signal-Count and Signal-Minus-Idler Count Variances



Coming Attractions: Lecture 23

- Lecture 23:
More Quantum Optical Applications
 - Binary optical communication with squeezed states
 - Phase-sensing interferometry with squeezed states
 - Super-dense coding with entangled states
 - Quantum lithography with “N00N” states