LaTeX 2_ε Template

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$$u_p^l(r,\phi) \propto r^l L_p^l(2r^2/w^2)e^{-r^2/w^2}\,\boxed{e^{-il\phi}} \tag{1}$$

1. Low gain.

2.
$$H \sim \int d^3\mathbf{r}\chi^{(2)}(\mathbf{r})E_p^{(+)}(\mathbf{r},t)E_s^{(-)}(\mathbf{r},t)E_i^{(-)}(\mathbf{r},t) + H.c.$$

3.
$$H = i\hbar\Gamma\int d\mathbf{q}_s d\mathbf{q}_i F(\mathbf{q}_s,\mathbf{q}_i)a_{\mathbf{q}_s}^\dagger a_{\mathbf{q}_i}^\dagger + H.c.$$

4.
$$F(\mathbf{q}_s,\mathbf{q}_i) = C\exp\left\{-\sigma^2\frac{(\mathbf{q}_s+\mathbf{q}_i)^2}{2}\right\}\mathrm{sinc}\left(\frac{L(\mathbf{q}_s-\mathbf{q}_i)^2}{4k_p}\right)\exp\left\{i\frac{L(\mathbf{q}_s-\mathbf{q}_i)^2}{4k_p}\right\}$$

5.
$$|\psi\rangle = \exp\left\{-\frac{i}{\hbar}\int_{-\infty}^{\infty}dtH(t)\right\}|0\rangle \approx -\frac{i}{\hbar}\int_{-\infty}^{\infty}dtH|0\rangle$$

6. Shmidt decomposition

7.
$$F(q_s,q_i,\phi_s-\phi_i) = \sum_n \chi_n(q_s,q_i)e^{in(\phi_s-\phi_i)}$$

8.
$$\chi_n(q_s,q_i) = \sum_m \sqrt{\lambda_{mn}}\frac{u_{mn}(q_s)}{\sqrt{q_s}}\frac{v_{mn}(q_i)}{\sqrt{q_i}}$$

9.

$$F(\mathbf{q}_s, \mathbf{q}_i) = \sum_{m,n} \sqrt{\lambda_{mn}} \frac{u_{mn}(q_s)}{\sqrt{q_s}} \frac{v_{mn}(q_i)}{\sqrt{q_i}} e^{in(\phi_s - \phi_i)}$$

10. broadband modes and hign gain

11.

$$A_{mn}^{\dagger} = \int d\mathbf{q}_s \frac{u_{mn}(q_s)}{\sqrt{q_s}} e^{in\phi_s} a_{\mathbf{q}_s}^{\dagger}$$

12.

$$B_{mn}^{\dagger} = \int d\mathbf{q}_i \frac{v_{mn}(q_i)}{\sqrt{q_i}} e^{-in\phi_i} a_{\mathbf{q}_i}^{\dagger}$$

13.

$$H = i\hbar\Gamma \sum_{m,n} \sqrt{\lambda_{mn}} (A_{mn}^{\dagger} B_{mn}^{\dagger} - A_{mn} B_{mn})$$

14.

$$\frac{dA_{mn}}{dt} = \frac{i}{\hbar}[H, A_{mn}]$$

15.

$$A_{mn}^{out} = A_{mn}^{in} \cosh[G\sqrt{\lambda_{mn}}] + [B_{mn}^{in}]^{\dagger} \sinh[G\sqrt{\lambda_{mn}}]$$

16.

$$B_{mn}^{out} = B_{mn}^{in} \cosh[G\sqrt{\lambda_{mn}}] + [A_{mn}^{in}]^{\dagger} \sinh[G\sqrt{\lambda_{mn}}]$$

17.

$$\frac{da_{\mathbf{q}_{s,i}}}{dt} = \Gamma \sum_{m,n} \sqrt{\lambda_{mn}} \frac{u_{mn}(q_s)}{\sqrt{q_s}} [A_{mn}^{\dagger} e^{-in\phi_{s,i}} + B_{mn}^{\dagger} e^{in\phi_{s,i}}]$$

18.

$$\langle N_s(\mathbf{q}_s) \rangle = \sum_{m,n} \frac{|u_{mn}(q_s)|^2}{q_s} (\sinh[G\sqrt{\lambda_{mn}}])^2$$

19. three crystals

20.

$$F(\mathbf{q}_s, \mathbf{q}_i) = C \exp\left\{ -\sigma^2 \frac{(\mathbf{q}_s + \mathbf{q}_i)^2}{2} \right\} \mathrm{sinc}\left(\frac{\Delta\widetilde{q}L}{2} \right)$$
$$\times \left(\exp\left\{ \frac{i\Delta\widetilde{q}L}{2} \right\} + \exp\left\{ i(\Delta\widetilde{q}^{air} d_1 + \frac{3}{2}\Delta\widetilde{q}L) \right\} + \exp\left\{ i(\Delta\widetilde{q}^{air}(d_1+d_2) + \frac{5}{2}\Delta\widetilde{q}L) \right\} \right)$$
$$(2)$$

21.

$$\Delta\widetilde{q} = \frac{(\mathbf{q}_s - \mathbf{q}_i)^2}{2k_p}$$

22.

$$\Delta\widetilde{q}^{air} = \frac{(\mathbf{q}_s - \mathbf{q}_i)^2}{2k_p} n_s + \frac{2\delta n^{air} k_s}{n_s}$$

23. splitters

24.

$$|\psi_{in}\rangle = g(a_1^\dagger)|0\rangle = \sum_{n=0} g_n (a_1^\dagger)^n |0\rangle$$

25.

$$|\psi_{aux}\rangle = f(a_2^\dagger)|0\rangle = \sum_{n=0} f_n (a_2^\dagger)^n |0\rangle$$

26.

$$|\psi\rangle = |\psi_{in}\rangle \otimes |\psi_{aux}\rangle = \sum_{m,n} \alpha_{m,n} (a_1^\dagger)^m (a_2^\dagger)^n |0\rangle^{\otimes 2}$$

27. loseless BS

28.

$$\sum_{m,n} |\alpha_{m,n}|^2 = 1$$

29.

$$\sum_{m,n} |\alpha_{m,n}^{(2)}|^2 = 1$$

30.

$$r_j^2 + t_j^2 + a_j^2 = 1$$

3

31.

$$a_1^\dagger \to r_j a_1^\dagger + it_j a_2^\dagger$$

32.

$$a_2^\dagger \to r_j a_2^\dagger + it_j a_1^\dagger$$

33. state in area 2 after first BS

34.

$$|\psi_2\rangle = \sum_{m,n} \alpha_{m,n}^{(2)} (a_1^\dagger)^m (a_2^\dagger)^n |0\rangle^{\otimes 2}$$

35. 4 channels

36.

$$|\psi_3\rangle = \sum_{p_1,p_2,p_3,p_4} \beta_{p_1,p_2,p_3,p_4} (a_1^\dagger)^{p_1} (a_2^\dagger)^{p_2} (a_3^\dagger)^{p_3} (a_4^\dagger)^{p_4} |0\rangle^{\otimes 4}$$

37. First and only one ideal detector was clicked

38.

$$|\psi_4\rangle = \sum_{\substack{p_1,p_2,p_4 \\ p_1>0,p_3=0}} |\beta_{p_1,p_2,0,p_4} \sqrt{p_1!p_2!p_4!}|^2 |p_2,p_4\rangle$$

39. First and third detectors were clicked

40.

$$|\psi_4\rangle = \sum_{\substack{p_1,p_2,p_3,p_4 \\ p_1>0,p_3>0}} |\beta_{p_1,p_2,p_3,p_4} \sqrt{p_1!p_2!p_3!p_4!}|^2 |p_2,p_4\rangle$$

41. No detection

42.

$$|\psi_4\rangle = \sum_{\substack{p_2,p_4 \\ p_1=0,p_3=0}} |\beta_{0,p_2,0,p_4} \sqrt{p_2!p_4!}|^2 |p_2,p_4\rangle$$

43. final state

44.

$$|\psi_{out}\rangle = \sum_{m,n} \alpha_{m,n}^{out} (a_1^\dagger)^m (a_2^\dagger)^n |0\rangle^{\otimes 2}$$

45. example with two coherent states - alpha=1

46.
$$|\psi\rangle = |\alpha\rangle \otimes |\alpha\rangle, \quad \alpha = 1$$

47. two coherent after BS

48.
$$|\psi_2\rangle \approx e^{-1}(1+\frac{1+i}{\sqrt{2}}a_1^\dagger+\frac{1+i}{\sqrt{2}}a_2^\dagger+ia_1^\dagger a_2^\dagger+\frac{i}{2}(a_1^\dagger)^2+\frac{i}{2}(a_2^\dagger)^2+\frac{i-1}{2\sqrt{2}}a_1^\dagger(a_2^\dagger)^2+\frac{i-1}{2\sqrt{2}}(a_1^\dagger)^2a_2^\dagger+...)$$

49. auto correlation
$$Autocorr_s(q,q^{'}) = \langle N_s(q)N_s(q^{'})\rangle - \langle N_s(q)\rangle\langle N_s(q^{'})\rangle =$$
$$= \langle a_s^\dagger(q)a_s(q)a_s^\dagger(q^{'})a_s(q^{'})\rangle - \langle a_s^\dagger(q)a_s(q)\rangle\langle a_s^\dagger(q^{'})a_s(q^{'})\rangle$$

50. cross correlation
$$Crosscorr(q,q^{'}) = \langle N_s(q)N_i(q^{'})\rangle - \langle N_s(q)\rangle\langle N_i(q^{'})\rangle =$$
$$= \langle a_s^\dagger(q)a_s(q)a_i^\dagger(q^{'})a_i(q^{'})\rangle - \langle a_s^\dagger(q)a_s(q)\rangle\langle a_i^\dagger(q^{'})a_i(q^{'})\rangle$$

51. POVM operators

52.
$$\Pi_{no-click} = \sum_{n=0}^{\infty}(1-\eta_{SPD})^n|n\rangle\langle n|$$

53.
$$\Pi_{click} = 1 - \Pi_{no-click} = \sum_{n=0}^{\infty}[1-(1-\eta_{SPD})^n]|n\rangle\langle n|$$

54. After projection

55.
$$|\psi_{out}\rangle = \Pi_{click}|\psi_{in}\rangle$$

56. First and only one ideal detector was clicked

57.
$$|\psi_4\rangle = \sum_{\substack{p_1,p_2,p_4 \\ p_1>0,p_3=0}} \beta_{p_1,p_2,0,p_4}\sqrt{p_1!p_2!p_4!}|p_2,p_4\rangle$$

58. First and third detectors were clicked

59.
$$|\psi_4\rangle = \sum_{\substack{p_1,p_2,p_3,p_4 \\ p_1>0,p_3>0}} \beta_{p_1,p_2,p_3,p_4} \sqrt{p_1!p_2!p_3!p_4!}|p_2,p_4\rangle$$

60. No detection

61.
$$|\psi_4\rangle = \sum_{\substack{p_2,p_4 \\ p_1=0,p_3=0}} \beta_{0,p_2,0,p_4} \sqrt{p_2!p_4!}|p_2,p_4\rangle$$