$\LaTeX 2_\varepsilon$ Template

April 1, 2018

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

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

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

5. $$|\psi\rangle = \exp\Big\{-\frac{i}{\hbar}\int_{-\infty}^{\infty} dt H(t)\Big\}|0\rangle \approx -\frac{i}{\hbar}\int_{-\infty}^{\infty} dt H|0\rangle$$

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.
$$A^\dagger_{mn} = \int d\mathbf{q}_s \frac{u_{mn}(q_s)}{\sqrt{q_s}} e^{in\phi_s} a^\dagger_{\mathbf{q}_s}$$

12.
$$B^\dagger_{mn} = \int d\mathbf{q}_i \frac{v_{mn}(q_i)}{\sqrt{q_i}} e^{-in\phi_i} a^\dagger_{\mathbf{q}_i}$$

13.
$$H = i\hbar\Gamma \sum_{m,n} \sqrt{\lambda_{mn}} (A^\dagger_{mn} B^\dagger_{mn} - A_{mn} B_{mn})$$

14.
$$\frac{dA_{mn}}{dt} = \frac{i}{\hbar} [H, A_{mn}]$$

15.
$$A^{out}_{mn} = A^{in}_{mn} \cosh[G\sqrt{\lambda_{mn}}] + [B^{in}_{mn}]^\dagger \sinh[G\sqrt{\lambda_{mn}}]$$

16.
$$B^{out}_{mn} = B^{in}_{mn} \cosh[G\sqrt{\lambda_{mn}}] + [A^{in}_{mn}]^\dagger \sinh[G\sqrt{\lambda_{mn}}]$$

17.
$$\frac{da_{\mathbf{q}_{s,i}}}{dt} = \Gamma \sum_{m,n} \sqrt{\lambda_{mn}} \frac{u_{mn}(q_s)}{\sqrt{q_s}} [A^\dagger_{mn} e^{-in\phi_{s,i}} + B^\dagger_{mn} e^{in\phi_{s,i}}]$$

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.

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

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.

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

27.

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

28.

$$a_1^\dagger \to r_ja_1^\dagger + it_ja_2^\dagger$$

29.

$$a_2^\dagger \to r_ja_2^\dagger + it_ja_1^\dagger$$

30. 4 channels

31.

$$|\psi_4\rangle = \sum_{i,j,k,m} \beta_{i,j,k,m} (a_1^\dagger)^i (a_2^\dagger)^j (a_3^\dagger)^k (a_4^\dagger)^m |0\rangle^{\otimes 4}$$

32. both ideal detectors were clicked

33.

$$|\psi_{after}\rangle = 0$$

34. First and only one ideal detector was clicked

35. final state

36.

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

37. example with two coherent states - alpha=1

38.

$$|\alpha\rangle \otimes |\alpha\rangle \approx e^{-1}(1+1)$$