

Particle spectrograph

Wave operator and propagator

| $\sigma_{1+}^{\#1}+\alpha\beta$ | $\sigma_{1+}^{\#2}+\alpha\beta$ | $\tau_{1+}^{\#1}+\alpha\beta$ | $\sigma_{1-}^{\#1}+\alpha$ | $\sigma_{1-}^{\#2}+\alpha$ | $\tau_{1-}^{\#1}+\alpha$ | $\tau_{1-}^{\#2}+\alpha$ |
|-------------------------------------|------------------------------------|--------------------------------------|--------------------------------|--|--------------------------|---|
| $\frac{6}{(3+2k^2)^2t_1}$ | $-\frac{6\sqrt{2}}{(3+2k^2)^2t_1}$ | $-\frac{6i\sqrt{2}k}{(3+2k^2)^2t_1}$ | 0 | 0 | 0 | 0 |
| $-\frac{6\sqrt{2}}{(3+2k^2)^2t_1}$ | $\frac{12}{(3+2k^2)^2t_1}$ | $\frac{12ik}{(3+2k^2)^2t_1}$ | 0 | 0 | 0 | 0 |
| $\frac{6i\sqrt{2}k}{(3+2k^2)^2t_1}$ | $-\frac{12ik}{(3+2k^2)^2t_1}$ | $\frac{12k^2}{(3+2k^2)^2t_1}$ | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | $\frac{\sqrt{2}}{t_1+2k^2t_1}$ | 0 | $\frac{2ik}{t_1+2k^2t_1}$ |
| 0 | 0 | 0 | $\frac{\sqrt{2}}{t_1+2k^2t_1}$ | $\frac{2k^2r_1+t_1}{(t_1+2k^2t_1)^2}$ | 0 | $\frac{i\sqrt{2}k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$ |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | $-\frac{2ik}{t_1+2k^2t_1}$ | $-\frac{i\sqrt{2}k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$ | 0 | $\frac{2k^2(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$ |

Quadratic (free) action

$$S=$$
$$\int\int\int\int(\frac{1}{3}(3t_1\omega_{\alpha}^{\alpha'}\omega_{,\theta}^{\theta}+3f^{\alpha\beta}\tau_{\alpha\beta}+3\omega^{\alpha\beta\chi}\sigma_{\alpha\beta\chi}-6t_1\omega_{\alpha\theta}^{\theta}\partial_{,\theta}f^{\alpha'}+6t_1\omega_{,\theta}^{\theta}\partial'f^{\alpha}-3t_1\partial_{,\theta}f_{\theta}^{\theta}\partial'f_{\alpha}^{\alpha}-6r_1\partial_{\beta}\omega_{,\theta}^{\theta}\partial_{,\theta}\omega_{\beta}^{\theta}+6r_1\partial_{,\theta}\omega_{\beta}^{\theta}\partial_{,\theta}\omega_{\beta}^{\theta}-3t_1\partial_{,\theta}f_{\alpha}^{\alpha'}\partial_{\theta}f_{\alpha}^{\theta}+6t_1\partial'f_{\alpha}^{\alpha}\partial_{\theta}f_{\alpha}^{\theta}+6r_1\partial_{\alpha}\omega^{\alpha\beta'}\partial_{\theta}\omega_{,\beta}^{\theta}+12r_1\partial'f_{\alpha}^{\alpha}\partial_{\theta}f_{\alpha}^{\theta}+6r_1\partial_{\alpha}\omega^{\alpha\beta}\partial_{\theta}\omega_{,\beta}^{\theta}-12r_1\partial'f_{\alpha}^{\alpha}\partial_{\theta}\omega_{\beta}^{\theta}-6r_1\partial_{\alpha}\omega^{\alpha\beta'}\partial_{\theta}\omega_{,\beta}^{\theta}+12r_1\partial'f_{\alpha}^{\alpha}\partial_{\theta}\omega_{,\beta}^{\theta}+2t_1\omega_{,\theta\alpha}^{\theta}\partial_{\theta}f^{\alpha'}-2t_1\partial_{\alpha}f_{,\theta}^{\theta}\partial_{\theta}f^{\alpha'}-2t_1\partial_{\alpha}f_{\theta}^{\theta}\partial_{\theta}f^{\alpha'}+t_1\partial_{,\theta}f_{\alpha\theta}^{\alpha'}\partial_{\theta}f^{\alpha'}+t_1\partial_{\theta}f_{\alpha}^{\alpha'}\partial_{\theta}f^{\alpha'}+t_1\omega_{\alpha\theta}^{\theta}(\omega^{\alpha'\theta}+2\partial_{\theta}f^{\alpha'})+t_1\omega_{\alpha\theta}^{\theta}(\omega^{\alpha'\theta}+4\partial_{\theta}f^{\alpha'})-4r_1\partial_{\beta}\omega_{\alpha\theta}^{\theta}\partial_{\theta}\omega^{\alpha\beta'}+2r_1\partial_{\beta}\omega_{\alpha\theta}^{\theta}\partial_{\theta}\omega^{\alpha\beta'}-8r_1\partial_{\beta}\omega_{,\theta\alpha}^{\theta}\partial_{\theta}\omega^{\alpha\beta'}-2r_1\partial_{,\theta}\omega_{\alpha\beta}^{\alpha\beta'}\partial_{\theta}\omega^{\alpha\beta'}+2r_1\partial_{\theta}\omega_{\alpha\beta}^{\alpha\beta'}\partial_{\theta}\omega^{\alpha\beta'}+2r_1\partial_{\theta}\omega_{\alpha\beta}^{\alpha\beta'}\partial_{\theta}\omega^{\alpha\beta'})[t,x,y,z]dzdydxdt$$

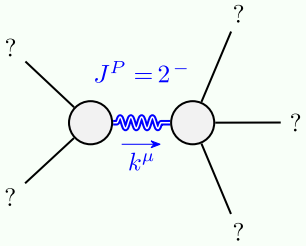
| $\omega_{1+}^{\#1}+\alpha\beta$ | $\omega_{1+}^{\#2}+\alpha\beta$ | $f_{1+}^{\#1}+\alpha\beta$ | $\omega_{1-}^{\#1}+\alpha$ | $\omega_{1-}^{\#2}+\alpha$ | $f_{1-}^{\#1}+\alpha$ | $f_{1-}^{\#2}+\alpha$ |
|---------------------------------|---------------------------------|-----------------------------|----------------------------|----------------------------|-----------------------|-----------------------|
| $\frac{t_1}{6}$ | $-\frac{t_1}{3\sqrt{2}}$ | $-\frac{ik t_1}{3\sqrt{2}}$ | 0 | 0 | 0 | 0 |
| $-\frac{t_1}{3\sqrt{2}}$ | $\frac{t_1}{3}$ | $\frac{ik t_1}{3}$ | 0 | 0 | 0 | 0 |
| $\frac{ik t_1}{3\sqrt{2}}$ | $-\frac{1}{3}ik t_1$ | $\frac{k^2 t_1}{3}$ | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | $-k^2r_1-\frac{t_1}{2}$ | $\frac{t_1}{\sqrt{2}}$ | 0 | $ik t_1$ |
| 0 | 0 | 0 | $\frac{t_1}{\sqrt{2}}$ | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | $-ik t_1$ | 0 | 0 | 0 |

| $\sigma_{2+}^{\#1}+\alpha\beta$ | $\tau_{2+}^{\#1}+\alpha\beta$ | $\sigma_{2-}^{\#1}+\alpha\beta\chi$ |
|-------------------------------------|--------------------------------------|-------------------------------------|
| $\frac{2}{(1+2k^2)^2t_1}$ | $-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$ | 0 |
| $\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$ | $\frac{4k^2}{(1+2k^2)^2t_1}$ | 0 |
| 0 | 0 | $\frac{2}{2k^2r_1+t_1}$ |

| $\omega_0^{\#1}+\alpha\beta$ | $f_0^{\#1}+\alpha\beta$ | $\omega_0^{\#2}+\alpha\beta$ | $f_0^{\#2}+\alpha\beta$ | $\omega_0^{\#1}+\alpha\beta\chi$ |
|------------------------------|----------------------------|------------------------------|-------------------------|----------------------------------|
| $-t_1$ | $i\sqrt{2}kt_1$ | 0 | 0 | 0 |
| $-i\sqrt{2}kt_1$ | $-2k^2t_1$ | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 |
| $\frac{t_1}{2}$ | $-\frac{ik t_1}{\sqrt{2}}$ | 0 | 0 | 0 |
| $\frac{ik t_1}{\sqrt{2}}$ | k^2t_1 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | $\frac{t_1}{2}$ |

| Source constraints/gauge generators | |
|---|----------------|
| SO(3) irreps | Multiplicities |
| $\sigma_0^{\#1} == 0$ | 1 |
| $\tau_0^{\#2} == 0$ | 1 |
| $\tau_0^{\#1} - 2ik\sigma_0^{\#1} == 0$ | 1 |
| $\tau_1^{\#2\alpha} + 2ik\sigma_1^{\#2\alpha} == 0$ | 3 |
| $\tau_1^{\#1\alpha} == 0$ | 3 |
| $\tau_1^{\#1\alpha\beta} - 2ik\sigma_1^{\#1\alpha\beta} == 0$ | 3 |
| $2\sigma_1^{\#1\alpha\beta} + \sigma_1^{\#2\alpha\beta} == 0$ | 3 |
| $\tau_2^{\#1\alpha\beta} - 2ik\sigma_2^{\#1\alpha\beta} == 0$ | 5 |
| Total constraints: | 20 |

Massive and massless spectra



| Massive particle | |
|------------------|-------------------------|
| Pole residue: | $-\frac{1}{r_1} > 0$ |
| Polarisations: | 5 |
| Square mass: | $-\frac{t_1}{2r_1} > 0$ |
| Spin: | 2 |
| Parity: | Odd |

(No massless particles)

Unitarity conditions

$$r_1 < 0 \&\& t_1 > 0$$