

Particle spectrograph

Wave operator and propagator

| $\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\sigma_{1+}^{\#2} \sigma_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\sigma_{1-}^{\#1} \sigma_{1-}^{\#2} \dagger^{\alpha}$ | $\sigma_{1-}^{\#2} \dagger^{\alpha}$ | $\tau_{1-}^{\#1} \tau_{1-}^{\#2} \dagger^{\alpha}$ |
|---|---|--|--|---|
| $\frac{1}{k^2(2r_3+r_5)}$ | 0 | 0 | 0 | 0 |
| $\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$ | 0 | 0 | 0 | 0 |
| $\tau_{1+}^{\#1} \dagger^{\alpha\beta}$ | 0 | 0 | 0 | 0 |
| $\sigma_{1-}^{\#1} \dagger^{\alpha}$ | 0 | $\frac{2}{k^2(r_3+2r_5)}$ | $\frac{2\sqrt{2}}{k^2(1+2k^2)(r_3+2r_5)}$ | $\frac{4i}{k(1+2k^2)(r_3+2r_5)}$ |
| $\sigma_{1-}^{\#2} \dagger^{\alpha}$ | 0 | $\frac{2\sqrt{2}}{k^2(1+2k^2)(r_3+2r_5)}$ | $\frac{3k^2(r_3+2r_5)+4t_3}{(k+2k^3)^2(r_3+2r_5)t_3}$ | $\frac{i\sqrt{2}(3k^2(r_3+2r_5)+4t_3)}{k(1+2k^2)^2(r_3+2r_5)t_3}$ |
| $\tau_{1-}^{\#1} \dagger^{\alpha}$ | 0 | 0 | 0 | 0 |
| $\tau_{1-}^{\#2} \dagger^{\alpha}$ | 0 | $-\frac{4i}{k(1+2k^2)(r_3+2r_5)}$ | $-\frac{i\sqrt{2}(3k^2(r_3+2r_5)+4t_3)}{k(1+2k^2)^2(r_3+2r_5)t_3}$ | $\frac{6k^2(r_3+2r_5)+8t_3}{(1+2k^2)^2(r_3+2r_5)t_3}$ |

Quadratic (free) action

S==
$$\iiint \{ (\frac{1}{6} (-4t_3 \omega_{\alpha}^{\kappa} \omega_{\kappa}^{\alpha i} \tau_{\alpha\beta} + 6 f^{\alpha\beta} \tau_{\alpha\beta} + 6 \omega_{\alpha\beta\chi}^{\kappa} \sigma_{\alpha\beta\chi} + 8t_3 \omega_{\alpha}^{\kappa} \partial_{\kappa} f^{\alpha i} - 8t_3 \omega_{\kappa}^{\alpha} \partial_{\kappa} f^{\alpha i} + 4t_3 \partial_{\kappa} f_{\kappa}^{\alpha} \partial_{\kappa} f^{\alpha} - 3r_3 \partial_{\beta} \omega_{\beta}^{\theta} \partial_{\theta} \omega_{\alpha}^{\alpha\beta} - 3r_3 \partial_{\kappa} \omega_{\beta}^{\theta} \partial_{\theta} \omega_{\alpha}^{\alpha\beta} - 3r_3 \partial_{\alpha} \omega_{\beta}^{\theta} \partial_{\theta} \omega_{\beta}^{\alpha\beta} + 6r_3 \partial' \omega_{\alpha}^{\alpha\beta} \partial_{\theta} \omega_{\beta}^{\theta} + 6r_3 \partial_{\beta} \omega_{\alpha}^{\alpha\beta} \partial_{\theta} \omega_{\beta}^{\theta} - 3r_3 \partial_{\alpha} \omega_{\beta}^{\theta} \partial_{\theta} \omega_{\beta}^{\alpha\beta} + 6r_3 \partial_{\beta} \omega_{\alpha}^{\alpha\beta} \partial_{\theta} \omega_{\alpha\theta}^{\alpha\beta} - 4r_2 \partial_{\beta} \omega_{\alpha\theta}^{\alpha\beta} \partial_{\theta} \omega_{\alpha\theta}^{\alpha\beta} + 4r_2 \partial_{\beta} \omega_{\alpha\theta}^{\alpha\beta} \partial_{\theta} \omega_{\beta\theta}^{\alpha\beta} - 24r_3 \partial_{\beta} \omega_{\beta\theta}^{\alpha\beta} \partial_{\theta} \omega_{\alpha\theta}^{\alpha\beta} - 2r_2 \partial_{\kappa} \omega_{\alpha\beta\theta}^{\alpha\beta} \partial_{\theta} \omega_{\alpha\beta\theta}^{\alpha\beta} + 2r_2 \partial_{\theta} \omega_{\alpha\beta\theta}^{\alpha\beta} \partial_{\theta} \omega_{\alpha\beta\theta}^{\alpha\beta} - 4r_2 \partial_{\theta} \omega_{\alpha\beta\theta}^{\alpha\beta} \partial_{\theta} \omega_{\kappa}^{\alpha i} + 6r_5 \partial_{\kappa} \omega_{\theta}^{\alpha i} \partial_{\theta} \omega_{\alpha}^{\alpha i} + 4t_3 \partial_{\kappa} f_{\alpha}^{\alpha i} \partial_{\kappa} f_{\alpha}^{\alpha i} - 8t_3 \partial_{\kappa} f_{\alpha}^{\alpha i} \partial_{\kappa} f_{\alpha}^{\alpha i} - 6r_5 \partial_{\alpha} \omega_{\alpha\theta}^{\alpha i} \partial_{\theta} \omega_{\kappa}^{\alpha i} + 12r_5 \partial_{\theta} \omega_{\alpha}^{\alpha i} \partial_{\kappa} \omega_{\kappa}^{\alpha i} + 6r_5 \partial_{\alpha} \omega_{\alpha\theta}^{\alpha i} \partial_{\kappa} \omega_{\theta}^{\alpha i} - 12r_5 \partial_{\theta} \omega_{\alpha}^{\alpha i} \partial_{\kappa} \omega_{\theta}^{\alpha i}) [t, x, y, z] dz dy dx dt$$

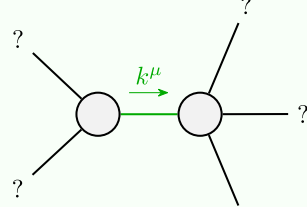
| $\omega_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\omega_{1+}^{\#2} \omega_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\omega_{1-}^{\#1} \omega_{1-}^{\#2} \dagger^{\alpha}$ | $\omega_{1-}^{\#2} \dagger^{\alpha}$ | $f_{1-}^{\#2} \dagger^{\alpha}$ |
|---|---|--|--------------------------------------|---------------------------------|
| $k^2(2r_3+r_5)$ | 0 | 0 | 0 | 0 |
| $\omega_{1+}^{\#2} \dagger^{\alpha\beta}$ | 0 | 0 | 0 | 0 |
| $f_{1+}^{\#1} \dagger^{\alpha\beta}$ | 0 | 0 | 0 | 0 |
| $\omega_{1-}^{\#1} \dagger^{\alpha}$ | 0 | $k^2(\frac{r_3}{2}+r_5)+\frac{2t_3}{3}$ | $-\frac{\sqrt{2}t_3}{3}$ | $-\frac{2}{3}i k t_3$ |
| $\omega_{1-}^{\#2} \dagger^{\alpha}$ | 0 | $-\frac{\sqrt{2}t_3}{3}$ | $\frac{t_3}{3}$ | $\frac{1}{3}i \sqrt{2} k t_3$ |
| $f_{1-}^{\#1} \dagger^{\alpha}$ | 0 | 0 | 0 | 0 |
| $f_{1-}^{\#2} \dagger^{\alpha}$ | 0 | $\frac{2ikt_3}{3}$ | $-\frac{1}{3}i \sqrt{2} k t_3$ | $\frac{2k^2t_3}{3}$ |

| Source constraints/gauge generators | Multiplicities |
|---|----------------|
| $\tau_{0+}^{\#2} == 0$ | 1 |
| $\tau_{0+}^{\#1} - 2i k \sigma_{0+}^{\#1} == 0$ | 1 |
| $\tau_{1-}^{\#2\alpha} + 2i k \sigma_{1-}^{\#2\alpha} == 0$ | 3 |
| $\tau_{1-}^{\#1\alpha} == 0$ | 3 |
| $\tau_{1+}^{\#1\alpha\beta} == 0$ | 3 |
| $\sigma_{1+}^{\#2\alpha\beta} == 0$ | 3 |
| $\sigma_{2-}^{\#1\alpha\beta\chi} == 0$ | 5 |
| $\tau_{2+}^{\#1\alpha\beta} == 0$ | 5 |
| Total constraints: | 24 |

| $\omega_{2+}^{\#1} \dagger^{\alpha\beta}$ | $f_{2+}^{\#1} \dagger^{\alpha\beta}$ | $\omega_{2-}^{\#1} \dagger^{\alpha\beta\chi}$ |
|---|---|---|
| $-\frac{3k^2r_3}{2}$ | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| $\sigma_{2+}^{\#1} \dagger^{\alpha\beta}$ | $\tau_{2+}^{\#1} \dagger^{\alpha\beta}$ | $\sigma_{2-}^{\#1} \dagger^{\alpha\beta\chi}$ |
| $-\frac{2}{3k^2r_3}$ | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |

| $\sigma_{0+}^{\#1} \dagger$ | $\tau_{0+}^{\#1}$ | $\tau_{0+}^{\#2}$ | $\sigma_{0-}^{\#1}$ |
|------------------------------------|-------------------------------------|-------------------|---------------------|
| $\frac{1}{(1+2k^2)^2t_3}$ | $-\frac{i\sqrt{2}k}{(1+2k^2)^2t_3}$ | 0 | 0 |
| $\frac{i\sqrt{2}k}{(1+2k^2)^2t_3}$ | $\frac{2k^2}{(1+2k^2)^2t_3}$ | 0 | 0 |
| 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | $\frac{1}{k^2r_2}$ |
| $\omega_{0+}^{\#1} \dagger$ | $f_{0+}^{\#1}$ | $f_{0+}^{\#2}$ | $\omega_{0-}^{\#1}$ |
| t_3 | $-i\sqrt{2} k t_3$ | 0 | 0 |
| $i\sqrt{2} k t_3$ | $2k^2 t_3$ | 0 | 0 |
| 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | $k^2 r_2$ |

Massive and massless spectra



Quadratic pole

Pole residue: $-\frac{1}{r_3(2r_3+r_5)(r_3+2r_5)p^2} > 0$

Polarisations: 2

(No massive particles)

Unitarity conditions

$r_3 < 0 \&\& (r_5 < -\frac{r_3}{2} \parallel r_5 > -2r_3) \parallel r_3 > 0 \&\& -2r_3 < r_5 < -\frac{r_3}{2}$