

Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$\begin{aligned} S_F = & \int \int \int \int \left(\frac{1}{3} \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} + 3(2r_1 - 2r_3 - r_5) \partial_\lambda \omega^\alpha \partial_\lambda \omega^\alpha - 2r_1 \partial^\beta \omega^\alpha \partial_\theta \omega_{\alpha\beta}^\kappa - \right. \\ & 2r_1 \partial_\theta \omega_{\alpha\beta}^\kappa \partial_\kappa \omega^{\alpha\beta\theta} + 2r_1 \partial_\theta \omega_{\alpha\beta}^\kappa \partial_\kappa \omega^{\theta\alpha\beta} - 6r_1 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega^{\theta\kappa\lambda} + \\ & 6r_3 \partial_\alpha \omega_\lambda^\alpha \partial_\kappa \omega_\theta^{\theta\kappa\lambda} - 3r_5 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega_\theta^{\theta\kappa\lambda} + 6r_1 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\alpha^{\theta\kappa\lambda} - 6r_3 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\alpha^{\theta\kappa\lambda} - \\ & \partial_\kappa \omega^{\theta\kappa\lambda} + 3r_5 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\alpha^{\theta\kappa\lambda} + 6r_1 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega_\theta^{\kappa\lambda\theta} - 6r_3 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega_\theta^{\kappa\lambda\theta} - \\ & 3r_5 \partial_\alpha \omega_\lambda^\alpha \partial_\kappa \omega_\theta^{\kappa\lambda\theta} - 12r_1 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\alpha^{\kappa\lambda\theta} + 12r_3 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\alpha^{\kappa\lambda\theta} + \\ & 6r_5 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\alpha^{\kappa\lambda\theta} + 2r_1 \partial_\kappa \omega^{\alpha\beta\theta} \partial_\alpha \omega_{\beta\theta}^\kappa - 2r_1 \partial_\kappa \omega^{\theta\alpha\beta} \partial_\alpha \omega_{\beta\theta}^\kappa + \\ & 2r_1 \partial^\beta \omega_\lambda^{\alpha\lambda} \partial_\lambda \omega_{\alpha\beta}^{\lambda\theta} + 4r_1 \partial^\beta \omega_\lambda^{\lambda\alpha} \partial_\lambda \omega_{\alpha\beta}^{\lambda\theta} - 12r_3 \partial^\beta \omega_\lambda^{\lambda\alpha} \partial_\lambda \omega_{\alpha\beta}^{\lambda\theta} + 6r_1 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega_\lambda^{\theta\kappa} + \\ & \partial^\lambda \omega_\kappa^{\theta\kappa} - 6r_3 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega_\theta^{\theta\kappa} + 3r_5 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega_\theta^{\theta\kappa} - 6r_1 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\alpha^{\theta\kappa} + \\ & \left. 6r_3 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\alpha^{\theta\kappa} - 3r_5 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\alpha^{\theta\kappa} \right) [t, x, y, z] dz dy dx dt \end{aligned}$$

| | | | | | |
|--|--|--|--|--|--|
| $\omega_{2^+}^{\#1} \dagger^{\alpha\beta}$ | $\omega_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$ | $\sigma_{2^+}^{\#1} \dagger^{\alpha\beta}$ | $\sigma_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$ | $\omega_{0^+}^{\#1} \dagger$ | $\omega_{0^+}^{\#1} \dagger$ |
| 0 | 0 | 0 | 0 | $6k^2(-r_1+r_3)$ | 0 |
| 0 | $k^2 r_1$ | 0 | $\frac{1}{k^2 r_1}$ | 0 | 0 |
| $\omega_{1^+}^{\#1} \dagger^{\alpha\beta}$ | $\omega_{1^+}^{\#2} \dagger^{\alpha\beta}$ | $\omega_{1^+}^{\#1} \dagger^\alpha$ | $\omega_{1^+}^{\#2} \dagger^\alpha$ | $\sigma_{0^+}^{\#1} \dagger$ | $\sigma_{0^+}^{\#1} \dagger$ |
| $k^2(2r_3+r_5)$ | 0 | 0 | 0 | $\frac{1}{6k^2(-r_1+r_3)}$ | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | $k^2(-r_1+2r_3+r_5)$ | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| $\sigma_{1^+}^{\#1} \dagger^{\alpha\beta}$ | $\sigma_{1^+}^{\#2} \dagger^{\alpha\beta}$ | $\sigma_{1^+}^{\#1} \dagger^\alpha$ | $\sigma_{1^+}^{\#2} \dagger^\alpha$ | $\sigma_{1^+}^{\#1} \dagger^{\alpha\beta}$ | $\sigma_{1^+}^{\#2} \dagger^{\alpha\beta}$ |
| $\frac{1}{k^2(2r_3+r_5)}$ | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | $\frac{1}{k^2(-r_1+2r_3+r_5)}$ | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |

| Source constraints/gauge generators | Multiplicities |
|--------------------------------------|----------------|
| $\sigma_0^{\#1} == 0$ | 1 |
| $\sigma_1^{\#2\alpha} == 0$ | 3 |
| $\sigma_{1^+}^{\#2\alpha\beta} == 0$ | 3 |
| $\sigma_{2^+}^{\#1\alpha\beta} == 0$ | 5 |
| Total constraints: | 12 |

Massive and massless spectra

Quadratic pole

| | | |
|----------------|---|-------|
| Pole residue: | $\frac{1}{r_1(r_1-2r_3-r_5)(2r_3+r_5)}$ | > 0 |
| Polarisations: | 2 | |

(No massive particles)

Unitarity conditions

$r_1 < 0 \&\& (r_5 < r_1 - 2r_3 \parallel r_5 > -2r_3) \parallel r_1 > 0 \&\& -2r_3 < r_5 < r_1 - 2r_3$