

Particle spectrograph

Wave operator and propagator

Source constraints			Fundamental fields		Multiplicities	
SO(3) irreps						
$\sigma_0^{\#1} == 0$			$\partial_\beta \sigma^{\alpha\beta}_\alpha == 0$		1	
$\tau_0^{\#1} == 0$			$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau_\alpha$		1	
$\tau_0^{\#2} == 0$			$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$		1	
$\tau_1^{\#2\alpha} == 0$			$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta}$		3	
$\tau_1^{\#1\alpha} == 0$			$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\beta\alpha}$		3	
$\sigma_1^{\#2\alpha} == 0$			$\partial_\chi \partial_\beta \sigma^{\alpha\beta\chi} == 0$		3	
$\tau_1^{\#1\alpha\beta} + i k \sigma_1^{\#2\alpha\beta} == 0$			$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\beta \tau^{\chi\alpha} + \partial_\chi \partial^\chi \tau^{\alpha\beta} +$ $2 \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2 \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi} ==$ $\partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha\chi} +$ $\partial_\chi \partial^\chi \tau^{\beta\alpha} + 2 \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}$		5	
$\tau_2^{\#1\alpha\beta\chi} == 0$			$3 \partial_\epsilon \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon} + 3 \partial_\epsilon \partial^\epsilon \partial_\chi \partial^\alpha \sigma^{\beta\delta}_\delta +$ $2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\chi\delta} + 4 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\delta\chi} +$ $2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\chi\delta\alpha} + 4 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\beta\delta} +$ $2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\alpha\delta\beta} + 2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\beta\chi\alpha} +$ $3 \eta^{\beta\chi} \partial_\phi \partial^\phi \partial_\epsilon \partial^\alpha \sigma^{\delta\epsilon}_\delta +$ $3 \eta^{\alpha\chi} \partial_\phi \partial^\phi \partial_\epsilon \partial_\delta \sigma^{\beta\delta\epsilon} +$ $3 \eta^{\beta\chi} \partial_\phi \partial^\phi \partial_\epsilon \partial^\alpha \sigma^{\alpha\delta}_\delta ==$ $3 \partial_\epsilon \partial_\delta \partial_\chi \partial^\alpha \sigma^{\alpha\delta\epsilon} + 3 \partial_\epsilon \partial^\epsilon \partial_\chi \partial^\beta \sigma^{\alpha\delta}_\delta +$ $2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\beta\chi\delta} + 4 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\delta\beta\chi} +$ $2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\chi\delta\alpha} + 4 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\beta\delta\alpha} +$ $4 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\alpha\delta\beta} + 2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\alpha\chi\beta} +$ $3 \eta^{\alpha\chi} \partial_\phi \partial^\phi \partial_\epsilon \partial^\beta \sigma^{\delta\epsilon}_\delta +$ $3 \eta^{\beta\chi} \partial_\phi \partial^\phi \partial_\epsilon \partial_\delta \sigma^{\alpha\delta\epsilon} +$ $3 \eta^{\alpha\chi} \partial_\phi \partial^\phi \partial_\epsilon \partial^\delta \sigma^{\beta\delta}_\delta$		5	
$\tau_2^{\#1\alpha\beta} == 0$			$4 \partial_\delta \partial_\chi \partial^\alpha \tau^{\beta\chi\delta} + 2 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^\chi_\chi +$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\alpha\beta} + 3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\alpha} +$ $2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} ==$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi} + 3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} +$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi} + 3 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha} +$ $2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \tau^\chi_\chi$		25	
Total constraints/gauge generators:						

Quadratic (free) action

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$$\begin{aligned} & \iiint (\frac{1}{6} \tau_{\alpha\beta} + 6 \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - 3 r_3 \partial_\beta \omega^{\beta}_{\alpha} \partial' \omega^{\alpha\beta}_{\theta} - 3 r_3 \partial_\alpha \omega^{\beta}_{\theta} \partial' \omega^{\alpha\beta}_{\beta} - 3 r_3 \partial_\alpha \omega^{\beta}_{\theta} \partial' \omega^{\alpha\beta}_{\alpha} - 3 \\ & \qquad r_3 \partial_\alpha \omega^{\alpha\beta\gamma} \partial_\theta \omega^{\beta}_{\gamma} + 6 r_3 \partial' \omega^{\alpha\beta}_{\alpha} \partial_\theta \omega^{\beta}_{\gamma} - \\ & 3 r_3 \partial_\alpha \omega^{\alpha\beta\gamma} \partial_\theta \omega^{\beta}_{\gamma} + 6 r_3 \partial' \omega^{\alpha\beta}_{\alpha} \partial_\theta \omega^{\beta}_{\gamma} + \\ & 4 t_2 \omega_{\theta\alpha} \partial^\theta f^{\alpha\gamma} + 2 t_2 \partial_\alpha f^{\alpha\gamma}_{\theta} \partial^\theta f^{\alpha\gamma} - t_2 \partial_\alpha f_{\theta} \partial^\theta f^{\alpha\gamma} - \\ & t_2 \partial_\gamma f_{\alpha\theta} \partial^\theta f^{\alpha\gamma} + t_2 \partial_\theta f^{\alpha\gamma}_{\alpha} \partial^\theta f^{\alpha\gamma} - t_2 \partial_\theta f^{\alpha\gamma}_{\alpha} \partial^\theta f^{\alpha\gamma} - \\ & 4 t_2 \omega_{\alpha\theta\gamma} (\omega^{\alpha\gamma\theta} + \partial^\theta f^{\alpha\gamma}) + 2 t_2 \omega_{\alpha\theta\gamma} (\omega^{\alpha\gamma\theta} + 2 \partial^\theta f^{\alpha\gamma}) - \\ & 24 r_3 \partial_\beta \omega^{\beta}_{\theta} \partial^\theta \omega^{\alpha\beta\gamma} + 6 r_5 \partial_\alpha \omega^{\beta}_{\theta} \partial^\theta \omega^{\alpha\gamma}_{\alpha} - \\ & 6 r_5 \partial_\theta \omega^{\beta}_{\theta} \partial^\theta \omega^{\alpha\gamma}_{\alpha} - 6 r_5 \partial_\alpha \omega^{\alpha\gamma\theta} \partial_\theta \omega^{\beta}_{\theta} + \\ & 12 r_5 \partial^\theta \omega^{\alpha\gamma}_{\alpha} \partial_\alpha \omega^{\beta}_{\theta} + 6 r_5 \partial_\alpha \omega^{\alpha\gamma\theta} \partial_\theta \omega^{\beta}_{\theta} - \\ & 12 r_5 \partial^\theta \omega^{\alpha\gamma}_{\alpha} \partial_\alpha \omega^{\beta}_{\theta}) [t, x, y, z] dz dy dx dt \end{aligned}$$

$\sigma_1^{\#1} \dagger^{\alpha\beta}$	$\sigma_1^{\#2} \dagger^{\alpha\beta}$	$\tau_1^{\#1} \dagger^{\alpha\beta}$	$\sigma_1^{\#1} \dagger^\alpha$	$\sigma_1^{\#2} \dagger^\alpha$	$\tau_1^{\#1} \dagger^\alpha$	$\tau_1^{\#2} \dagger^\alpha$
$\frac{1}{k^2 (2 r_3 + r_5)}$	$-\frac{\sqrt{2}}{k^2 (1 + k^2) (2 r_3 + r_5)}$	$-\frac{i \sqrt{2}}{k (1 + k^2) (2 r_3 + r_5)}$	0	0	0	0
$-\frac{\sqrt{2}}{k^2 (1 + k^2) (2 r_3 + r_5)}$	$\frac{3 k^2 (2 r_3 + r_5) + 2 t_2}{(k + k^3)^2 (2 r_3 + r_5) t_2}$	$\frac{i (3 k^2 (2 r_3 + r_5) + 2 t_2)}{k (1 + k^2)^2 (2 r_3 + r_5) t_2}$	0	0	0	0
$-\frac{i \sqrt{2}}{k (1 + k^2) (2 r_3 + r_5)}$	$-\frac{i (3 k^2 (2 r_3 + r_5) + 2 t_2)}{k (1 + k^2)^2 (2 r_3 + r_5) t_2}$	$\frac{3 k^2 (2 r_3 + r_5) + 2 t_2}{(1 + k^2)^2 (2 r_3 + r_5) t_2}$	0	0	0	0
0	0	0	$\frac{2}{k^2 (r_3 + 2 r_5)}$	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

$\omega_1^{\#1} \dagger^{\alpha\beta}$	$\omega_1^{\#2} \dagger^{\alpha\beta}$	$f_1^{\#1} \dagger^{\alpha\beta}$	$\omega_1^{\#1} \dagger^\alpha$	$\omega_1^{\#2} \dagger^\alpha$	$f_1^{\#1} \dagger^\alpha$	$f_1^{\#2} \dagger^\alpha$
$k^2 (2 r_3 + r_5) + \frac{2 t_2}{3}$	$\frac{\sqrt{2} t_2}{3}$	$\frac{1}{3} i \sqrt{2} k t_2$	0	0	0	0
$\frac{\sqrt{2} t_2}{3}$	$\frac{t_2}{3}$	$\frac{i k t_2}{3}$	0	0	0	0
$-\frac{1}{3} i \sqrt{2} k t_2$	$-\frac{1}{3} i k t_2$	$\frac{k^2 t_2}{3}$	0	0	0	0
0	0	0	$\frac{1}{2} k^2 (r_3 + 2 r_5)$	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

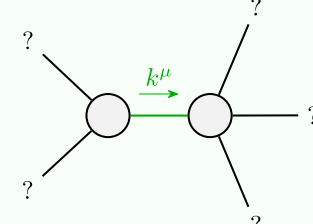
$\omega_0^{\#1} \dagger$	$\omega_0^{\#1}$	$f_0^{\#1}$	$f_0^{\#2}$	$\omega_0^{\#1}$
0	0	0	0	0
$f_0^{\#1} \dagger$	0	0	0	0
$f_0^{\#2} \dagger$	0	0	0	0
$\omega_0^{\#1} \dagger$	0	0	0	t_2

$\omega_2^{\#1} \dagger^{\alpha\beta}$	$\omega_2^{\#1}$	$f_2^{\#1}$	$\omega_2^{\#1}$
$-\frac{3 k^2 r_3}{2}$	0	0	0
$f_2^{\#1} \dagger^{\alpha\beta}$	0	0	0
$\omega_2^{\#1} \dagger^{\alpha\beta\chi}$	0	0	0

$\sigma_0^{\#1} \dagger$	$\sigma_0^{\#1}$	$\tau_0^{\#1}$	$\tau_0^{\#2}$	$\sigma_0^{\#1}$
0	0	0	0	0
$\tau_0^{\#1} \dagger$	0	0	0	0
$\tau_0^{\#2} \dagger$	0	0	0	0
$\sigma_0^{\#1} \dagger$	0	0	0	$\frac{1}{t_2}$

$\sigma_2^{\#1} \dagger^{\alpha\beta}$	$\sigma_2^{\#1}$	$\tau_2^{\#1}$	$\sigma_2^{\#1}$
$-\frac{2}{3 k^2 r_3}$	0	0	0
$\tau_2^{\#1} \dagger^{\alpha\beta}$	0	0	0
$\sigma_2^{\#1} \dagger^{\alpha\beta\chi}$	0	0	0

Massive and massless spectra



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

(No massive particles)

Unitarity conditions

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