

Particle spectrograph

Wave operator and propagator

Source constraints		
SO(3) irreps	Fundamental fields	Multiplicities
$\tau_{0+}^{\#2} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$	1
$\tau_{0+}^{\#1} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau^\alpha_\alpha$	1
$\sigma_{0+}^{\#1} == 0$	$\partial_\beta \sigma^{\alpha\beta}_\alpha == 0$	1
$\tau_{1-}^{\#2\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha_\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta}$	3
$\tau_{1-}^{\#1\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha_\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\beta\alpha}$	3
$\sigma_{1-}^{\#2\alpha} == 0$	$\partial_\chi \partial_\beta \sigma^{\alpha\beta\chi} = 0$	3
$\tau_{1+}^{\#1\alpha\beta} + i k \sigma_{1+}^{\#1\alpha\beta} == 0$	$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\beta \tau^{\chi\alpha} + \partial_\chi \partial^\chi \tau^{\alpha\beta} + \partial_\beta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta} + \partial_\beta \partial^\delta \partial_\chi \sigma^{\beta\chi\alpha} == \partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha\chi} + \partial_\chi \partial^\chi \tau^{\beta\alpha} + \partial_\beta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + \partial_\beta \partial^\delta \partial_\chi \sigma^{\alpha\chi\beta}$	3
$\sigma_{1+}^{\#1\alpha\beta} == \sigma_{1+}^{\#2\alpha\beta}$	$3 \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2 \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi} + \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\chi\beta} == 3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \sigma^{\alpha\chi\delta} + \partial_\delta \partial^\delta \partial_\chi \sigma^{\beta\chi\delta} + 2 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \sigma^{\alpha\delta\chi} + 2 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\beta} + 2 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \sigma^{\alpha\delta\beta} + 2 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\beta} + 3 \eta^{\beta\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\delta\epsilon}_\delta + 3 \eta^{\alpha\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\beta\delta\epsilon} + 3 \eta^{\beta\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\alpha\delta}_\delta == 3 \partial_\epsilon \partial_\delta \partial^\chi \partial^\beta \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^\beta \sigma^{\alpha\delta\chi} + 2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\chi\delta\beta} + 2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\beta \sigma^{\alpha\delta\alpha} + 4 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\alpha\beta\chi} + 2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\alpha\chi\beta} + 3 \eta^{\alpha\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\delta\epsilon}_\delta + 3 \eta^{\beta\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\alpha\delta\epsilon} + 3 \eta^{\alpha\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\beta\delta}_\delta$	5
$\tau_{2+}^{\#1\alpha\beta} == 0$	$4 \partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2 \partial_\delta \partial^\delta \partial_\beta \partial^\alpha \tau^\chi_\chi + 3 \partial_\delta \partial^\delta \partial_\chi \tau^{\alpha\beta} + 3 \partial_\delta \partial^\delta \partial_\chi \tau^{\alpha\beta} + 3 \partial_\delta \partial^\delta \partial_\chi \tau^{\beta\alpha} + 2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \tau^{\chi\delta} == 3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi} + 3 \partial_\delta \partial^\delta \partial_\chi \tau^{\alpha\chi} + 3 \partial_\delta \partial^\delta \partial_\chi \tau^{\chi\alpha} + 2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \tau^\chi_\chi$	5
Total constraints/gauge generators:		28

Quadratic (free) action

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$$\begin{aligned} & \iiint \iiint \Big(6 \, f^{\alpha\beta} \, \tau_{\alpha\beta} + 6 \, \omega^{\alpha\beta\chi} \, \sigma_{\alpha\beta\chi} - 15 \, r_3 \, \partial_\beta \omega_{ \theta}^{ \theta} \partial_\gamma \omega^{\alpha\beta}_{ \alpha} + 9 \, r_3 \, \partial_\gamma \omega_{ \beta}^{ \theta} \partial_\gamma \omega^{\alpha\beta}_{ \theta} + \\ & 9 \, r_3 \, \partial_\alpha \omega^{\alpha\beta\gamma} \partial_\theta \omega_{ \beta}^{ \theta} - 18 \, r_3 \, \partial_\gamma \omega^{\alpha\beta}_{ \alpha} \partial_\theta \omega_{ \beta}^{ \theta} - \\ & 15 \, r_3 \, \partial_\alpha \omega^{\alpha\beta\gamma} \partial_\theta \omega_{ \beta}^{ \theta} + 30 \, r_3 \, \partial_\gamma \omega^{\alpha\beta}_{ \alpha} \partial_\theta \omega_{ \beta}^{ \theta} + \\ & 4 \, t_2 \, \omega_{\theta\alpha} \partial^\beta f^{\alpha\gamma} + t_2 \, \partial_\gamma \omega_{ \theta}^{ \theta} \partial_\beta f^{\alpha\gamma} - t_2 \, \partial_\alpha f_{ \theta}^{ \theta} \partial_\beta f^{\alpha\gamma} - t_2 \, \partial_\theta f_{ \alpha}^{ \theta} \partial_\beta f^{\alpha\gamma} - \\ & 4 \, t_2 \, \omega_{\alpha\theta} \left(\omega^{\alpha\theta} + \partial^\theta f^{\alpha\gamma} \right) + 2 \, t_2 \, \omega_{\alpha\theta} \left(\omega^{\alpha\theta} + 2 \, \partial^\theta f^{\alpha\gamma} \right) + \\ & 8 \, r_2 \, \partial_\beta \omega_{\alpha\theta} \partial^\theta \omega^{\alpha\beta\gamma} - 4 \, r_2 \, \partial_\beta \omega_{\alpha\theta} \partial^\theta \omega^{\alpha\beta\gamma} + \\ & 4 \, r_2 \, \partial_\beta \omega_{\theta\alpha} \partial^\theta \omega^{\alpha\beta\gamma} - 24 \, r_3 \, \partial_\beta \omega_{\theta\alpha} \partial^\theta \omega^{\alpha\beta\gamma} - \\ & 2 \, r_2 \, \partial_\gamma \omega_{\alpha\beta\theta} \partial^\theta \omega^{\alpha\beta\gamma} + 2 \, r_2 \, \partial_\theta \omega_{\alpha\beta\gamma} \partial^\theta \omega^{\alpha\beta\gamma} - \\ & 4 \, r_2 \, \partial_\theta \omega_{\alpha\beta\gamma} \partial^\theta \omega^{\alpha\beta\gamma} \Big) [t, x, y, z] dz dy dx dt \end{aligned}$$

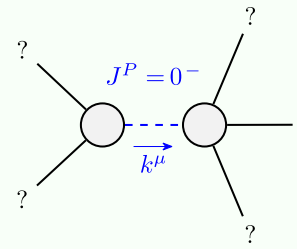
$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{2t_2}{3}$	$\frac{\sqrt{2}t_2}{3}$	$\frac{1}{3}i\sqrt{2}kt_2$	0	0	0	0
$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$\frac{\sqrt{2}t_2}{3}$	$\frac{t_2}{3}$	$\frac{ikt_2}{3}$	0	0	0	0
$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{1}{3}i\sqrt{2}kt_2$	$-\frac{1}{3}i\sqrt{2}kt_2$	$\frac{k^2t_2}{3}$	0	0	0	0
$\omega_{1-}^{\#1} \dagger^\alpha$	0	0	0	$-\frac{3k^2r_3}{2}$	0	0	0
$\omega_{1-}^{\#2} \dagger^\alpha$	0	0	0	0	0	0	0
$f_{1-}^{\#1} \dagger^\alpha$	0	0	0	0	0	0	0
$f_{1-}^{\#2} \dagger^\alpha$	0	0	0	0	0	0	0

$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{6}{(3+k^2)^2t_2}$	$\frac{3\sqrt{2}}{(3+k^2)^2t_2}$	$\frac{3i\sqrt{2}k}{(3+k^2)^2t_2}$	0	0	$\tau_{1-}^{\#1} \alpha$	$\tau_{1-}^{\#2} \alpha$	$f_{1-}^{\#1} \alpha$	$f_{1-}^{\#2} \alpha$
$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$\frac{3\sqrt{2}}{(3+k^2)^2t_2}$	$\frac{3}{(3+k^2)^2t_2}$	$\frac{3ik}{(3+k^2)^2t_2}$	0	0	0	0	0	0
$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{3i\sqrt{2}k}{(3+k^2)^2t_2}$	$-\frac{3ik}{(3+k^2)^2t_2}$	$\frac{3k^2}{(3+k^2)^2t_2}$	0	0	0	0	0	0
$\sigma_{1-}^{\#1} \dagger^\alpha$	0	0	0	0	$-\frac{2}{3k^2r_3}$	0	0	0	0
$\sigma_{1-}^{\#2} \dagger^\alpha$	0	0	0	0	0	0	0	0	0
$\tau_{1-}^{\#1} \dagger^\alpha$	0	0	0	0	0	0	0	0	0
$\tau_{1-}^{\#2} \dagger^\alpha$	0	0	0	0	0	0	0	0	0

$\sigma_{0+}^{\#1} \dagger$	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	$\frac{1}{k^2r_2+t_2}$

$\omega_{0+}^{\#1} \dagger$	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	$k^2r_2+t_2$

Massive and massless spectra



Massive particle

Pole residue: $-\frac{1}{r_2} > 0$

Polarisations: 1

Square mass: $-\frac{t_2}{r_2} > 0$

Spin: 0

Parity: Odd

No massless particles

Unitarity conditions

$r_2 < 0 \ \&\& \ t_2 > 0$