

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
$\sigma_{0+}^{\#1} == 0$	$\partial_\beta \sigma^{\alpha\beta}{}_\alpha == 0$	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
$\sigma_{1-}^{\#1\alpha} == 0$	$\partial_\chi \partial^\alpha \sigma^{\beta\chi}{}_\beta + \partial_\chi \partial^\chi \sigma^\alpha{}_\beta{}^\beta == \partial_\chi \partial_\beta \sigma^{\alpha\beta\chi}$	3
$\tau_{1+}^{\#1\alpha\beta} == 0$	$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\beta \tau^{\chi\alpha} + \partial_\chi \partial^\chi \tau^{\alpha\beta} == \partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha\chi} + \partial_\chi \partial^\chi \tau^{\beta\alpha}$	3
$\sigma_{1+}^{\#2\alpha\beta} == 0$	$\partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi} == \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}$	3
$\sigma_{1+}^{\#1\alpha\beta} == 0$	$\partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\chi\beta} == \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta} + \partial_\delta \partial^\delta \partial_\chi \sigma^{\beta\chi\alpha}$	3
$\sigma_{2+}^{\#1\alpha\beta} == 0$	$2\partial_\delta \partial^\beta \partial^\alpha \sigma^{\chi\delta}{}_\chi + 3(\partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\chi\beta} + \partial_\delta \partial^\delta \partial_\chi \sigma^{\beta\chi\alpha}) == 3\partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 3\partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 3\partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2\eta^{\alpha\beta}\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\chi\delta}{}_\chi$	5
$\sigma_{2-}^{\#1\alpha\beta\chi} == 0$	$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 \sigma^{\alpha\chi\delta} + 4\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\alpha\delta\chi} + 2\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\chi\delta\alpha} + 4\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\alpha\delta\chi} + 4\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\beta\delta\chi} + 2\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\alpha\delta\chi} + 2\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\beta\delta\alpha} + 4\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\alpha\beta\chi} + 2\partial_\epsilon \partial^\epsilon \partial_\delta \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^\alpha \sigma^{\delta\epsilon}{}_\delta == 3\partial_\epsilon \partial_\delta \partial^\chi \partial^\beta \sigma^{\alpha\delta\epsilon} + 3\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\alpha\delta}{}_\delta + 2\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\beta\chi\delta} + 4\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\beta\delta\chi} + 2\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\alpha\chi\delta} + 2\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\beta\delta\alpha} + 4\partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\alpha\beta\chi} + 2\partial_\epsilon \partial^\epsilon \partial_\delta \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^\alpha \sigma^{\delta\epsilon}{}_\delta + 3\eta^{\alpha\chi}\partial_\phi \partial^\phi \partial_\epsilon \partial^\beta \sigma^{\delta\epsilon}{}_\delta$	5
Total constraints/gauge generators:		33

Quadratic (free) action

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$$\begin{aligned} &\iiint\iiint (f^{\alpha\beta}\tau_{\alpha\beta} + \omega^{\alpha\beta\chi}\sigma_{\alpha\beta\chi} + \beta_1(-4\omega^{\chi}{}_{\chi}\partial_\rho f^{\alpha\beta}{}_a + 4\partial_\beta\omega^{\alpha\beta}{}_a + \omega^{\chi}{}_{\chi}\partial^\beta f^{\alpha}{}_a - \\ &\quad 2\partial_\beta f^{\chi}{}_{\chi}\partial^\beta f^{\alpha}{}_a - 2\partial_\beta f^{\alpha\beta}\partial_\chi f^{\chi}{}_a + 4\partial^\beta f^{\alpha}{}_a\partial_\chi f^{\chi}{}_a - \\ &\quad 4f^{\alpha\beta}(\partial_\beta\omega^{\chi}{}_{\chi} - \partial_\chi\omega^{\chi}{}_a{}_\beta) - 4f^{\alpha}{}_a\partial_\chi\omega^{\beta\chi}{}_\beta + \\ &\quad 4\omega_{\alpha\chi\beta}\partial^\chi f^{\alpha\beta} - 2\partial_\alpha f_{\beta\chi}\partial^\chi f^{\alpha\beta} - \partial_\alpha f_{\chi\beta}\partial^\chi f^{\alpha\beta} + \\ &\quad \partial_\beta f_{\alpha\chi}\partial^\chi f^{\alpha\beta} + \partial_\chi f_{\alpha\beta}\partial^\chi f^{\alpha\beta} + \partial_\chi f_{\beta\alpha}\partial^\chi f^{\alpha\beta}) + \\ &\quad \frac{1}{3}\alpha_3(4\partial_\beta\omega_{\alpha\chi\delta} - 2\partial_\beta\omega_{\alpha\delta\chi} + 2\partial_\beta\omega_{\chi\delta\alpha} - \partial_\chi\omega_{\alpha\beta\delta} + \\ &\quad \partial_\delta\omega_{\alpha\beta\chi} - 2\partial_\delta\omega_{\alpha\chi\beta})\partial^\delta\omega^{\alpha\beta\chi\chi})[t, x, y, z]dzdydxdt \end{aligned}$$

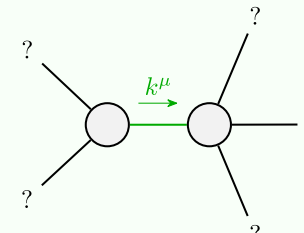
$\omega_{1+}^{\#1} + \alpha\beta$	$\omega_{1+}^{\#2} + \alpha\beta$	$f_{1+}^{\#1} + \alpha\beta$	$\omega_{1-}^{\#1} - \alpha$	$\omega_{1-}^{\#2} - \alpha$	$f_{1-}^{\#1} - \alpha$	$f_{1-}^{\#2}$
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
$\sigma_{1+}^{\#1} + \alpha\beta$	$\sigma_{1+}^{\#2} + \alpha\beta$	$\tau_{1+}^{\#1} + \alpha\beta$	$\sigma_{1-}^{\#1} - \alpha$	$\sigma_{1-}^{\#2} - \alpha$	$\tau_{1-}^{\#1} - \alpha$	$\tau_{1-}^{\#2}$
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
$\sigma_{2+}^{\#1} + \alpha\beta$	$\sigma_{2+}^{\#1} + \alpha\beta$	$\tau_{2+}^{\#1} + \alpha\beta$	$\sigma_{2-}^{\#1} - \alpha\beta\chi$			
0	0	0	0			
0	$\frac{1}{2\beta_1 k^2}$	0	0			
0	0	0	0			

$\omega_{0+}^{\#1} + \dagger$	$f_{0+}^{\#1} + \dagger$	$f_{0+}^{\#2} + \dagger$	$\omega_{0-}^{\#1} + \dagger$
0	0	0	0
0	$-4\beta_1 k^2$	0	0
0	0	0	0
0	0	0	$\frac{1}{\alpha_3 k^2}$

$\omega_{2+}^{\#1} + \alpha\beta$	$f_{2+}^{\#1} + \alpha\beta$	$\omega_{2-}^{\#1} + \alpha\beta\chi$
0	0	0
0	$2\beta_1 k^2$	0
0	0	0

$\omega_{2-}^{\#1} + \alpha\beta\chi$		
0	0	0

Massive and massless spectra



Quadratic pole

Pole residue: $\frac{1}{\beta_1} > 0$

Polarisations: 2

(No massive particles)

Unitarity conditions

$\beta_1 > 0$