

Particle spectrograph

Wave operator and propagator

Source constraints			Fundamental fields		Multiplicities
SO(3) irreps					
$\tau_{0+}^{\#2} == 0$			$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$		1
$\tau_{0+}^{\#1} == 0$			$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau^\alpha_\alpha$		1
$\tau_1^{\#2\alpha} + 2\,i\,k\,\sigma_1^{\#1\alpha} == 0$			$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} +$ $2\,(\partial_\theta \partial^\theta \partial_\chi \partial^\alpha \sigma^{\beta\chi}_\beta - \partial_\theta \partial^\theta \partial_\chi \partial_\beta \sigma^{\alpha\beta\chi} +$ $\partial_\theta \partial^\theta \partial_\chi \partial^\chi \sigma^{\alpha\beta}_\beta) == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta}$		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
$\sigma_1^{\#1\alpha} == \sigma_1^{\#2\alpha}$			$\partial_\chi \partial^\alpha \sigma^{\beta\chi}_\beta + \partial_\chi \partial^\chi \sigma^{\alpha\beta}_\beta == 0$		3
$\tau_1^{\#1\alpha\beta} + i\,k\,\sigma_1^{\#2\alpha\beta} == 0$			$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\beta \tau^\chi{}^\alpha + \partial_\chi \partial^\chi \tau^\alpha{}_\beta +$ $2\,\partial_\theta \partial_\chi \partial^\alpha \sigma^{\beta\chi\theta} + 2\,\partial_\theta \partial^\theta \partial_\chi \sigma^{\alpha\beta\chi} ==$ $\partial_\chi \partial^\alpha \tau^\chi{}^\beta + \partial_\chi \partial^\beta \tau^\alpha{}_\chi +$ $\partial_\chi \partial^\chi \tau^{\beta\alpha} + 2\,\partial_\theta \partial_\chi \partial^\beta \sigma^{\alpha\chi\theta}$		3
$\tau_2^{\#1\alpha\beta} - 2\,i\,k\,\sigma_2^{\#1\alpha\beta} == 0$			$-i\,(4\,\partial_\theta \partial_\chi \partial^\beta \partial^\alpha \tau^\chi{}^\theta + 2\,\partial_\theta \partial^\theta \partial_\beta \partial^\alpha \tau^\chi_\chi -$ $3\,\partial_\theta \partial^\theta \partial_\chi \partial^\alpha \tau^{\beta\chi} - 3\,\partial_\theta \partial^\theta \partial_\chi \partial^\alpha \tau^\chi{}^\beta -$ $3\,\partial_\theta \partial^\theta \partial_\chi \partial^\beta \tau^{\alpha\chi} - 3\,\partial_\theta \partial^\theta \partial_\chi \partial^\beta \tau^\chi{}^\alpha +$ $3\,\partial_\theta \partial^\theta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3\,\partial_\theta \partial^\theta \partial_\chi \partial^\chi \tau^{\beta\alpha} +$ $4\,i\,k^\chi\,\partial_\epsilon \partial_\chi \partial^\beta \partial^\alpha \sigma^{\delta\epsilon}_\delta -$ $6\,i\,k^\chi\,\partial_\epsilon \partial_\theta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon}_\delta -$ $6\,i\,k^\chi\,\partial_\epsilon \partial_\theta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon} +$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\theta \partial_\chi \tau^\chi{}^\delta +$ $6\,i\,k^\chi\,\partial_\epsilon \partial^\epsilon \partial_\theta \partial_\chi \sigma^{\alpha\delta\beta} +$ $6\,i\,k^\chi\,\partial_\epsilon \partial^\epsilon \partial_\theta \partial_\chi \sigma^{\beta\delta\alpha} -$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\theta \partial^\delta \tau^\chi_\chi -$ $4\,i\,\eta^{\alpha\beta}\,k^\chi\,\partial_\theta \partial^\theta \partial_\epsilon \partial_\chi \sigma^{\delta\epsilon}_\delta) == 0$		5
Total constraints/gauge generators:					19

Quadratic (free) action

$$S == \iiint (f^{\alpha\beta} \tau_{\alpha\beta} + \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} +$$
$$\frac{1}{6} t_1 (2 \omega^{\alpha\iota}_\alpha \omega_{\iota\theta}^\theta - 4 \omega_\alpha^\theta \partial_{\iota f}^{\alpha\iota} + 4 \omega_{\iota\theta}^\theta \partial_{\iota f}^{\alpha\iota} - 2 \partial_{\iota f}^\theta \partial_\theta$$
$$\partial_{\iota f}^\alpha - 2 \partial_{\iota f}^{\alpha\iota} \partial_{\theta f}^\theta + 4 \partial_{\iota f}^\alpha \partial_{\theta f}^\theta - 6 \partial_{\omega f}^{\alpha\iota} \partial_{\theta f}^{\alpha\iota} -$$
$$3 \partial_{\omega f}^{\alpha\iota} \partial^\theta f^{\alpha\iota} + 3 \partial_{\iota f}^{\alpha\theta} \partial^\theta f^{\alpha\iota} + 3 \partial_{\theta f}^{\alpha\iota} \partial^\theta f^{\alpha\iota} +$$
$$3 \partial_{\theta f}^{\alpha\iota} \partial^\theta f^{\alpha\iota} + 6 \omega_{\alpha\theta\iota} (\omega^{\alpha\iota\theta} + 2 \partial^\theta f^{\alpha\iota}) -$$
$$4 r_3 (\partial_\beta \omega_{\iota\theta}^\theta \partial_{\iota\omega}^{\alpha\beta} + \partial_\alpha \omega^{\alpha\beta\iota} \partial_\theta \omega_{\iota\beta}^\theta -$$
$$2 \partial_{\iota\omega}^{\alpha\beta} \partial_\theta \omega_{\iota\beta}^\theta + \partial_\beta \omega_{\iota\theta\alpha} \partial^\theta \omega^{\alpha\beta\iota}) +$$
$$\frac{1}{3} r_1 (9 \partial_\beta \omega_{\iota\theta}^\theta \partial_{\iota\omega}^{\alpha\beta} + 3 \partial_{\iota\omega}^{\alpha\beta} \partial_\beta \omega_{\iota\theta}^\theta + 9 \partial_\alpha \omega^{\alpha\beta\iota} \partial_\theta \omega_{\iota\beta}^\theta -$$
$$3 \partial_\alpha \omega^{\alpha\beta\iota} \partial_\theta \omega_{\beta\iota}^\theta - 6 \partial_{\iota\omega}^{\alpha\beta} \partial_\alpha \partial_\theta \omega_{\beta\iota}^\theta + 9 \partial_\alpha \omega^{\alpha\beta\iota} \partial_\theta \omega_{\iota\beta}^\theta -$$
$$18 \partial_{\iota\omega}^{\alpha\beta} \partial_\theta \omega_{\iota\beta}^\theta - 4 \partial_\beta \omega_{\alpha\iota\theta} \partial^\theta \omega^{\alpha\beta\iota} +$$
$$2 \partial_\beta \omega_{\alpha\theta\iota} \partial^\theta \omega^{\alpha\beta\iota} + 4 \partial_\beta \omega_{\iota\theta\alpha} \partial^\theta \omega^{\alpha\beta\iota} -$$
$$2 \partial_{\iota\omega}^{\alpha\beta\theta} \partial^\theta \omega^{\alpha\beta\iota} + 2 \partial_\theta \omega_{\alpha\beta\iota} \partial^\theta \omega^{\alpha\beta\iota} +$$
$$2 \partial_\theta \omega_{\alpha\iota\beta} \partial^\theta \omega^{\alpha\beta\iota}) [t, x, y, z] dz dy dx dt$$

$\sigma_1^{\#1+} \dagger^{\alpha\beta}$	$\sigma_1^{\#2+} \alpha\beta$	$\tau_1^{\#1+} \alpha\beta$	$\sigma_1^{\#1-} \alpha$	$\sigma_1^{\#2-} \alpha$	$\tau_1^{\#1-} \alpha$	$\tau_1^{\#2-} \alpha$
0	$-\frac{\sqrt{2}}{t_1+k^2}t_1$	$-\frac{i\sqrt{2}k}{t_1+k^2}t_1$	0	0	0	0
$\sigma_1^{\#2+} \dagger^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2}t_1$	$-\frac{i(2k^3r_1+kt_1)}{(1+k^2)^2t_1^2}$	0	0	0	0
$\tau_1^{\#1+} \dagger^{\alpha\beta}$	$\frac{i\sqrt{2}k}{t_1+k^2}t_1$	$\frac{-2k^4r_1+k^2t_1}{(1+k^2)^2t_1^2}$	0	0	0	0
$\sigma_1^{\#1-} \dagger^\alpha$	0	0	$\frac{6}{(3+4k^2)^2t_1}$	$\frac{6\sqrt{2}}{(3+4k^2)^2t_1}$	0	$\frac{12ik}{(3+4k^2)^2t_1}$
$\sigma_1^{\#2-} \dagger^\alpha$	0	0	0	$\frac{12}{(3+4k^2)^2t_1}$	0	$\frac{12i\sqrt{2}k}{(3+4k^2)^2t_1}$
$\tau_1^{\#1-} \dagger^\alpha$	0	0	0	0	0	0
$\tau_1^{\#2-} \dagger^\alpha$	0	0	0	$-\frac{12ik}{(3+4k^2)^2t_1}$	$-\frac{12i\sqrt{2}k}{(3+4k^2)^2t_1}$	$\frac{24k^2}{(3+4k^2)^2t_1}$

$\omega_1^{\#1+} \alpha\beta$	$\omega_1^{\#2+} \alpha\beta$	$f_1^{\#1+} \alpha\beta$	$\omega_1^{\#1-} \alpha$	$\omega_1^{\#2-} \alpha$	$f_1^{\#1-} \alpha$	$f_1^{\#2-} \alpha$
$k^2r_1-\frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{ikt_1}{\sqrt{2}}$	0	0	0	0
$\omega_1^{\#2+} \dagger^{\alpha\beta}$	0	0	0	0	0	0
$f_1^{\#1+} \dagger^{\alpha\beta}$	0	0	0	0	0	0
$\omega_1^{\#1-} \dagger^\alpha$	0	0	$\frac{t_1}{6}$	$\frac{t_1}{3\sqrt{2}}$	0	$\frac{ikt_1}{3}$
$\omega_1^{\#2-} \dagger^\alpha$	0	0	$\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	0	$\frac{1}{3}i\sqrt{2}kt_1$
$f_1^{\#1-} \dagger^\alpha$	0	0	0	0	0	0
$f_1^{\#2-} \dagger^\alpha$	0	0	$-\frac{1}{3}i\sqrt{2}kt_1$	$-\frac{1}{3}i\sqrt{2}kt_1$	0	$\frac{2k^2t_1}{3}$

	$\sigma_{2+}^{\#1\alpha\beta}$	$\tau_{2+}^{\#1\alpha\beta}$	$\sigma_{2-}^{\#1\alpha\beta\chi}$
$\sigma_{2+}^{\#1\dagger\alpha\beta}$	$\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	0
$\tau_{2+}^{\#1\dagger\alpha\beta}$	$\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	$\frac{4k^2}{(1+2k^2)^2t_1}$	0
$\sigma_{2-}^{\#1\dagger\alpha\beta\chi}$	0	0	$\frac{2}{2k^2r_1+t_1}$

	$\omega_0^{\#1}$	$f_0^{\#1}$	$f_0^{\#2}$	$\omega_0^{\#1}$
$\omega_0^{\#1} \dagger$	$6k^2(-r_1+r_3)$	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	$-t_1$

	$\omega_2^{\#1+} f_2^{\#1+} \alpha\beta$	$\omega_2^{\#1-} \alpha\beta\chi$	
$\omega_2^{\#1+} \dagger^{\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	0
$f_2^{\#1+} \dagger^{\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	$k^2 t_1$	0
$\omega_2^{\#1-} \dagger^{\alpha\beta\chi}$	0	0	$k^2 r_1 + \frac{t_1}{2}$

$\sigma_0^{\#1+}$	$\tau_0^{\#1+}$	$\tau_0^{\#2+}$	$\sigma_0^{\#1-}$
$\sigma_0^{\#1+}$	$\frac{1}{6k^2(-r_1+r_3)}$	0	0
$\tau_0^{\#1+}$	0	0	0
$\tau_0^{\#2+}$	0	0	0
$\sigma_0^{\#1-}$	0	0	$-\frac{1}{r_1}$

Massive and massless spectra

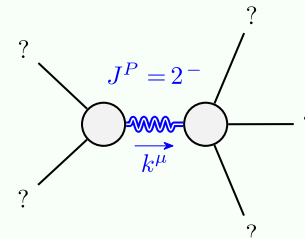


Diagram illustrating a massive particle exchange between two vertices. The internal line is a wavy line with momentum k^μ and $J^P = 2^-$.

Massive particle	
Pole residue:	$-\frac{1}{r_1} > 0$
Polarisations:	5
Square mass:	$-\frac{t_1}{2r_1} > 0$
Spin:	2
Parity:	Odd

(No massless particles)

Unitarity conditions

$r_1 < 0 \&\& t_1 > 0$