Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$
\begin{aligned}
&S_F == \\
&\iiiint \Big(\tfrac{1}{6}\,(4 t_3\, \omega_I{}^{\alpha I}\, \omega_{\kappa\alpha}{}^{\kappa} + 4 t_2\, \omega_I{}^{\kappa\lambda}\, \omega_{\kappa\lambda}{}' + 2 t_2\, \omega_{\kappa\lambda}{}'\, \omega^{\kappa\lambda}{}_I + 6\, f^{\alpha\beta}\, \tau_{\alpha\beta} + 6\, \omega^{\alpha\beta\chi} \\
&\sigma_{\alpha\beta\chi} + 4 r_2\, \partial^\beta \omega^{\theta\alpha}{}_\kappa\, \partial_\theta \omega_{\alpha\beta}{}^{\kappa} - 2 r_2\, \partial_\theta \omega_{\alpha\beta}{}^{\kappa}\, \partial_\kappa \omega^{\alpha\beta\theta} - 4 r_2\, \partial_\theta \omega_{\alpha\beta}{}^{\kappa}\, \partial_\kappa \omega^{\theta\alpha\beta} + \\
&6 r_3\, \partial_\alpha \omega_\lambda{}^{\alpha}{}_\theta\, \partial_\kappa \omega^{\theta\kappa\lambda} - 6 r_3\, \partial_\theta \omega_\lambda{}^{\alpha}{}_\alpha\, \partial_\kappa \omega^{\theta\kappa\lambda} + t_2\, \partial^\alpha f_{\theta\kappa}\, \partial^\kappa f_\alpha{}^{\theta} - t_2\, \partial^\alpha f_{\kappa\theta}\, \partial^\kappa f_\alpha{}^{\theta} + \\
&t_2\, \partial^\alpha f^\lambda{}_\kappa\, \partial^\kappa f_{\alpha\lambda} - 4 t_3\, \omega_{\kappa\alpha}{}^{\alpha}\, \partial^\kappa f'_I - 4 t_3\, \omega_{\kappa\lambda}{}^{\lambda}\, \partial^\kappa f'_I - 8 t_3\, \partial^\alpha f_{\kappa\alpha}\, \partial^\kappa f'_I + \\
&4 t_3\, \partial_\kappa f^\lambda{}_\lambda\, \partial^\kappa f'_I + 2 t_2\, \omega_{I\theta\kappa}\, \partial^\kappa f'^{I\theta} - 4 t_2\, \omega_{I\kappa\theta}\, \partial^\kappa f'^{I\theta} - 2 t_2\, \omega_{\theta I\kappa}\, \partial^\kappa f'^{I\theta} + \\
&4 t_2\, \omega_{\theta\kappa I}\, \partial^\kappa f'^{I\theta} + 4 t_3\, \omega_{I\alpha}{}^{\alpha}\, \partial^\kappa f'_\kappa + 4 t_3\, \omega_{I\lambda}{}^{\lambda}\, \partial^\kappa f'_\kappa - t_2\, \partial^\alpha f^\lambda{}_\kappa\, \partial^\kappa f_{\lambda\alpha} - \\
&t_2\, \partial_\kappa f_\theta{}^\lambda\, \partial^\kappa f_\lambda{}^\theta + t_2\, \partial_\kappa f^\lambda{}_\theta\, \partial^\kappa f_\lambda{}^\theta + 4 t_3\, \partial^\alpha f^\lambda{}_\alpha\, \partial^\kappa f_{\lambda\kappa} + 2 r_2\, \partial_\kappa \omega^{\alpha\beta\theta}\, \partial^\kappa \omega_{\alpha\beta\theta} + \\
&4 r_2\, \partial_\kappa \omega^{\theta\alpha\beta}\, \partial^\kappa \omega_{\alpha\beta\theta} - 4 r_2\, \partial^\beta \omega_I{}^{\alpha\lambda}\, \partial_\lambda \omega_{\alpha\beta}{}' + 4 r_2\, \partial^\beta \omega_I{}^{\lambda\alpha}\, \partial_\lambda \omega_{\alpha\beta}{}' - 24 r_3\, \partial^\beta \omega_I{}^{\lambda\alpha} \\
&\partial_\lambda \omega_{\alpha\beta}{}' - 6 r_3\, \partial_\alpha \omega_\lambda{}^{\alpha}{}_\theta\, \partial^\lambda \omega^{\theta\kappa}{}_\kappa + 6 r_3\, \partial_\theta \omega_\lambda{}^{\alpha}{}_\alpha\, \partial^\lambda \omega^{\theta\kappa}{}_\kappa)\Big)[t, x, y, z]\, dz\, dy\, dx\, dt
\end{aligned}
$$

	$\sigma_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^+}^{\#2}{}_{\alpha\beta}$	$\tau_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^-}^{\#1}{}_{\alpha}$	$\sigma_{1^-}^{\#2}{}_{\alpha}$	$\tau_{1^-}^{\#1}{}_{\alpha}$	$\tau_{1^-}^{\#2}{}_{\alpha}$
$\sigma_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{2}{3k^2 r_3}$	$-\frac{2\sqrt{2}}{3k^2 r_3+3k^4 r_3}$	$-\frac{2i\sqrt{2}}{3k r_3+3k^3 r_3}$	0	0	0	0
$\sigma_{1^+}^{\#2}{}^{\dagger\alpha\beta}$	$-\frac{2\sqrt{2}}{3k^2 r_3+3k^4 r_3}$	$\frac{9k^2 r_3+4t_2}{3(k+k^3)^2 r_3 t_2}$	$\frac{i(9k^2 r_3+4t_2)}{3k(1+k^2)^2 r_3 t_2}$	0	0	0	0
$\tau_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{2i\sqrt{2}}{3k r_3+3k^3 r_3}$	$-\frac{i(9k^2 r_3+4t_2)}{3k(1+k^2)^2 r_3 t_2}$	$\frac{9k^2 r_3+4t_2}{3(1+k^2)^2 r_3 t_2}$	0	0	0	0
$\sigma_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	$\frac{6}{(3+2k^2)^2 t_3}$	$-\frac{3\sqrt{2}}{(3+2k^2)^2 t_3}$	0	$-\frac{6ik}{(3+2k^2)^2 t_3}$
$\sigma_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$-\frac{3\sqrt{2}}{(3+2k^2)^2 t_3}$	$\frac{3}{(3+2k^2)^2 t_3}$	0	$\frac{3i\sqrt{2}\,k}{(3+2k^2)^2 t_3}$
$\tau_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	0	0	0	0
$\tau_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$\frac{6ik}{(3+2k^2)^2 t_3}$	$-\frac{3i\sqrt{2}\,k}{(3+2k^2)^2 t_3}$	0	$\frac{6k^2}{(3+2k^2)^2 t_3}$

	$\omega_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^+}^{\#2}{}_{\alpha\beta}$	$f_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^-}^{\#1}{}_{\alpha}$	$\omega_{1^-}^{\#2}{}_{\alpha}$	$f_{1^-}^{\#1}{}_{\alpha}$	$f_{1^-}^{\#2}{}_{\alpha}$
$\omega_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{1}{6}(9k^2 r_3+4t_2)$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{1}{3}i\sqrt{2}\,k t_2$	0	0	0	0
$\omega_{1^+}^{\#2}{}^{\dagger\alpha\beta}$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{t_2}{3}$	$\frac{ik t_2}{3}$	0	0	0	0
$f_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$-\frac{1}{3}i\sqrt{2}\,k t_2$	$-\frac{1}{3}ik t_2$	$\frac{k^2 t_2}{3}$	0	0	0	0
$\omega_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	$\frac{2t_3}{3}$	$-\frac{\sqrt{2}\,t_3}{3}$	0	$-\frac{2}{3}ik t_3$
$\omega_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$-\frac{\sqrt{2}\,t_3}{3}$	$\frac{t_3}{3}$	0	$\frac{1}{3}i\sqrt{2}\,k t_3$
$f_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	0	0	0	0
$f_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$\frac{2ik t_3}{3}$	$-\frac{1}{3}i\sqrt{2}\,k t_3$	0	$\frac{2k^2 t_3}{3}$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau_{0^+}^{\#2} == 0$	1
$\tau_{0^+}^{\#1} - 2ik\,\sigma_{0^+}^{\#1} == 0$	1
$\tau_{1^-}^{\#2\alpha} - ik\,\sigma_{1^-}^{\#1\alpha} == 0$	3
$\tau_{1^-}^{\#1\alpha} == 0$	3
$\sigma_{1^-}^{\#1\alpha} + 2\,\sigma_{1^-}^{\#2\alpha} == 0$	3
$\tau_{1^+}^{\#1\alpha\beta} + ik\,\sigma_{1^+}^{\#2\alpha\beta} == 0$	3
$\sigma_{2^-}^{\#1\alpha\beta\chi} == 0$	5
$\tau_{2^+}^{\#1\alpha\beta} == 0$	5
Total constraints:	24

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1}{}^{\dagger}$	$\frac{1}{(1+2k^2)^2 t_3}$	$-\frac{i\sqrt{2}\,k}{(1+2k^2)^2 t_3}$	0	0
$\tau_{0^+}^{\#1}{}^{\dagger}$	$\frac{i\sqrt{2}\,k}{(1+2k^2)^2 t_3}$	$\frac{2k^2}{(1+2k^2)^2 t_3}$	0	0
$\tau_{0^+}^{\#2}{}^{\dagger}$	0	0	0	0
$\sigma_{0^-}^{\#1}{}^{\dagger}$	0	0	0	$\frac{1}{k^2 r_2+t_2}$

	$\sigma_{2^+}^{\#1}{}_{\alpha\beta}$	$\tau_{2^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{2^-}^{\#1}{}_{\alpha\beta\chi}$
$\sigma_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$-\frac{2}{3k^2 r_3}$	0	0
$\tau_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	0	0	0
$\sigma_{2^-}^{\#1}{}^{\dagger\alpha\beta\chi}$	0	0	0

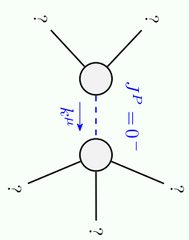
	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}{}^{\dagger}$	t_3	$-i\sqrt{2}\,k t_3$	0	0
$f_{0^+}^{\#1}{}^{\dagger}$	$i\sqrt{2}\,k t_3$	$2k^2 t_3$	0	0
$f_{0^+}^{\#2}{}^{\dagger}$	0	0	0	0
$\omega_{0^-}^{\#1}{}^{\dagger}$	0	0	0	$k^2 r_2 + t_2$

	$\omega_{2^+}^{\#1}{}_{\alpha\beta}$	$f_{2^+}^{\#1}{}_{\alpha\beta}$	$\omega_{2^-}^{\#1}{}_{\alpha\beta\chi}$
$\omega_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$-\frac{3k^2 r_3}{2}$	0	0
$f_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	0	0	0
$\omega_{2^-}^{\#1}{}^{\dagger\alpha\beta\chi}$	0	0	0

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

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