Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$
\begin{aligned}
&S_F == \\
&\iiiint \Big(\tfrac{1}{6}\,(4\,t_3\;\omega_{\iota}{}^{\alpha\iota}\;\omega_{\kappa\alpha}{}^{\kappa} + 4\,t_2\;\omega_{\iota}{}^{\kappa\lambda}\;\omega_{\kappa\lambda}{}' + 2\,t_2\;\omega_{\kappa\lambda}{}'\;\omega^{\kappa\lambda}{}_{\iota} + 6\,f^{\alpha\beta}\;\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi} \\
&\sigma_{\alpha\beta\chi} + 12\,r_1\,\partial_\iota\omega^{\kappa\lambda}{}_{\kappa}\,\partial'\omega_{\lambda}{}^{\alpha}{}_{\alpha} - 4\,r_1\,\partial^\beta\omega^{\theta\alpha}{}_{\kappa}\,\partial_\theta\omega_{\alpha\beta}{}^{\kappa} + 4\,r_2\,\partial^\beta\omega^{\theta\alpha}{}_{\kappa}\,\partial_\theta\omega_{\alpha\beta}{}^{\kappa} - \\
&4\,r_1\,\partial_\theta\omega_{\alpha\beta}{}^{\kappa}\,\partial_\kappa\omega^{\alpha\beta\theta} - 2\,r_2\,\partial_\theta\omega_{\alpha\beta}{}^{\kappa}\,\partial_\kappa\omega^{\alpha\beta\theta} + 4\,r_1\,\partial_\theta\omega_{\alpha\beta}{}^{\kappa}\,\partial_\kappa\omega^{\theta\alpha\beta} - \\
&4\,r_2\,\partial_\theta\omega_{\alpha\beta}{}^{\kappa}\,\partial_\kappa\omega^{\theta\alpha\beta} + 12\,r_1\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\,\partial_\kappa\omega^{\theta\kappa\lambda} - 12\,r_1\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\,\partial_\kappa\omega^{\theta\kappa\lambda} + \\
&12\,r_1\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\,\partial_\kappa\omega^{\kappa\lambda\theta} - 24\,r_1\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\,\partial_\kappa\omega^{\kappa\lambda\theta} + 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'_{\iota} - 4\,t_3\;\omega_{\kappa\lambda}{}^{\lambda}\,\partial^\kappa f'_{\iota} - 8\,t_3\,\partial^\alpha f_{\kappa\alpha}\,\partial^\kappa f'_{\iota} + \\
&4\,t_3\,\partial_\kappa f^{\lambda}{}_{\lambda}\,\partial^\kappa f'_{\iota} + 2\,t_2\;\omega_{\iota\theta\kappa}\,\partial^\kappa f^{\iota\theta} - 4\,t_2\;\omega_{\iota\kappa\theta}\,\partial^\kappa f^{\iota\theta} - 2\,t_2\;\omega_{\theta\iota\kappa}\,\partial^\kappa f^{\iota\theta} + \\
&4\,t_2\;\omega_{\theta\kappa\iota}\,\partial^\kappa f^{\iota\theta} + 4\,t_3\;\omega_{\iota\alpha}{}^{\alpha}\,\partial^\kappa f'_{\kappa} + 4\,t_3\;\omega_{\iota\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} + 4\,r_1\,\partial_\kappa\omega^{\alpha\beta\theta}\,\partial^\kappa\omega_{\alpha\beta\theta} + \\
&2\,r_2\,\partial_\kappa\omega^{\alpha\beta\theta}\,\partial^\kappa\omega_{\alpha\beta\theta} - 4\,r_1\,\partial_\kappa\omega^{\theta\alpha\beta}\,\partial^\kappa\omega_{\alpha\beta\theta} + 4\,r_2\,\partial_\kappa\omega^{\theta\alpha\beta}\,\partial^\kappa\omega_{\alpha\beta\theta} + 4\,r_1\,\partial^\beta\omega_{\iota}{}^{\alpha\lambda} \\
&\partial_\lambda\omega_{\alpha\beta}{}' - 4\,r_2\,\partial^\beta\omega_{\iota}{}^{\alpha\lambda}\,\partial_\lambda\omega_{\alpha\beta}{}' - 16\,r_1\,\partial^\beta\omega_{\iota}{}^{\lambda\alpha}\,\partial_\lambda\omega_{\alpha\beta}{}' + 4\,r_2\,\partial^\beta\omega_{\iota}{}^{\lambda\alpha}\,\partial_\lambda\omega_{\alpha\beta}{}' - \\
&12\,r_1\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\,\partial^\lambda\omega^{\theta\kappa}{}_{\kappa} + 12\,r_1\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\,\partial^\lambda\omega^{\theta\kappa}{}_{\kappa}\Big)[t,\,x,\,y,\,z]\,dz\,dy\,dx\,dt
\end{aligned}
$$

	$\sigma^{\#1}_{1^+\,\alpha\beta}$	$\sigma^{\#2}_{1^+\,\alpha\beta}$	$\tau^{\#1}_{1^+\,\alpha\beta}$	$\sigma^{\#1}_{1^-\,\alpha}$	$\sigma^{\#2}_{1^-\,\alpha}$	$\tau^{\#1}_{1^-\,\alpha}$	$\tau^{\#2}_{1^-\,\alpha}$
$\sigma^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{6}{(3+k^2)^2\,t_2}$	$\frac{3\sqrt{2}}{(3+k^2)^2\,t_2}$	$\frac{3i\sqrt{2}\,k}{(3+k^2)^2\,t_2}$	0	0	0	0
$\sigma^{\#2}_{1^+}\dagger^{\alpha\beta}$	$\frac{3\sqrt{2}}{(3+k^2)^2\,t_2}$	$\frac{3}{(3+k^2)^2\,t_2}$	$\frac{3ik}{(3+k^2)^2\,t_2}$	0	0	0	0
$\tau^{\#1}_{1^+}\dagger^{\alpha\beta}$	$-\frac{3i\sqrt{2}\,k}{(3+k^2)^2\,t_2}$	$-\frac{3ik}{(3+k^2)^2\,t_2}$	$\frac{3k^2}{(3+k^2)^2\,t_2}$	0	0	0	0
$\sigma^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	$-\frac{1}{k^2\,r_1}$	$-\frac{\sqrt{2}}{k^2\,r_1+2\,k^4\,r_1}$	0	$-\frac{2i}{k\,r_1+2\,k^3\,r_1}$
$\sigma^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$-\frac{\sqrt{2}}{k^2\,r_1+2\,k^4\,r_1}$	$\frac{3k^2\,r_1-2\,t_3}{(k+2\,k^3)^2\,r_1\,t_3}$	0	$\frac{i\sqrt{2}\,(3k^2\,r_1-2\,t_3)}{k\,(1+2\,k^2)^2\,r_1\,t_3}$
$\tau^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	0	0	0	0
$\tau^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{2i}{k\,r_1+2\,k^3\,r_1}$	$-\frac{i\sqrt{2}\,(3k^2\,r_1-2\,t_3)}{k\,(1+2\,k^2)^2\,r_1\,t_3}$	0	$\frac{6k^2\,r_1-4\,t_3}{(1+2\,k^2)^2\,r_1\,t_3}$

	$\omega^{\#1}_{1^+\,\alpha\beta}$	$\omega^{\#2}_{1^+\,\alpha\beta}$	$f^{\#1}_{1^+\,\alpha\beta}$	$\omega^{\#1}_{1^-\,\alpha}$	$\omega^{\#2}_{1^-\,\alpha}$	$f^{\#1}_{1^-\,\alpha}$	$f^{\#2}_{1^-\,\alpha}$
$\omega^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{2\,t_2}{3}$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{1}{3}\,i\sqrt{2}\,k\,t_2$	0	0	0	0
$\omega^{\#2}_{1^+}\dagger^{\alpha\beta}$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{t_2}{3}$	$\frac{ik\,t_2}{3}$	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	$-k^2\,r_1+\frac{2\,t_3}{3}$	$-\frac{\sqrt{2}\,t_3}{3}$	0	$-\frac{2}{3}\,ik\,t_3$
$\omega^{\#2}_{1^-}\dagger^{\alpha}$	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
$f^{\#2}_{1^-}\dagger^{\alpha}$	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
$\tau^{\#2}_{0^+} == 0$	1
$\tau^{\#1}_{0^+} - 2\,ik\,\sigma^{\#1}_{0^+} == 0$	1
$\tau^{\#2\,\alpha}_{1^-} + 2\,ik\;\sigma^{\#2\,\alpha}_{1^-} == 0$	3
$\tau^{\#1\,\alpha}_{1^-} == 0$	3
$\tau^{\#1\,\alpha\beta}_{1^+} + ik\;\sigma^{\#1\,\alpha\beta}_{1^+} == 0$	3
$\sigma^{\#1\,\alpha\beta}_{1^+} == \sigma^{\#2\,\alpha\beta}_{1^+}$	3
$\tau^{\#1\,\alpha\beta}_{2^+} == 0$	5
$\sigma^{\#1\,\alpha\beta}_{2^+} == 0$	5
Total constraints:	24

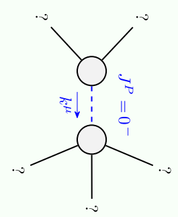
	$\sigma^{\#1}_{0^+}$	$\tau^{\#1}_{0^+}$	$\tau^{\#2}_{0^+}$	$\sigma^{\#1}_{0^-}$
$\sigma^{\#1}_{0^+}\dagger$	$\frac{1}{(1+2\,k^2)^2\,t_3}$	$-\frac{i\sqrt{2}\,k}{(1+2\,k^2)^2\,t_3}$	0	0
$\tau^{\#1}_{0^+}\dagger$	$\frac{i\sqrt{2}\,k}{(1+2\,k^2)^2\,t_3}$	$\frac{2\,k^2}{(1+2\,k^2)^2\,t_3}$	0	0
$\tau^{\#2}_{0^+}\dagger$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

	$\omega^{\#1}_{2^+\,\alpha\beta}$	$f^{\#1}_{2^+\,\alpha\beta}$	$\omega^{\#1}_{2^-\,\alpha\beta\chi}$
$\omega^{\#1}_{2^+}\dagger^{\alpha\beta}$	0	0	0
$f^{\#1}_{2^+}\dagger^{\alpha\beta}$	0	0	0
$\omega^{\#1}_{2^-}\dagger^{\alpha\beta\chi}$	0	0	$k^2\,r_1$

	$\omega^{\#1}_{0^+}$	$f^{\#1}_{0^+}$	$f^{\#2}_{0^+}$	$\omega^{\#1}_{0^-}$
$\omega^{\#1}_{0^+}\dagger$	t_3	$-i\sqrt{2}\,k\,t_3$	0	0
$f^{\#1}_{0^+}\dagger$	$i\sqrt{2}\,k\,t_3$	$2\,k^2\,t_3$	0	0
$f^{\#2}_{0^+}\dagger$	0	0	0	0
$\omega^{\#1}_{0^-}\dagger$	0	0	0	$k^2\,r_2+t_2$

	$\sigma^{\#1}_{2^+\,\alpha\beta}$	$\tau^{\#1}_{2^+\,\alpha\beta}$	$\sigma^{\#1}_{2^-\,\alpha\beta\chi}$
$\sigma^{\#1}_{2^+}\dagger^{\alpha\beta}$	0	0	0
$\tau^{\#1}_{2^+}\dagger^{\alpha\beta}$	0	0	0
$\sigma^{\#1}_{2^-}\dagger^{\alpha\beta\chi}$	0	0	$\frac{1}{k^2\,r_1}$

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

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