Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$
\begin{aligned}
S = =\\
&\int\int\int (\tfrac{1}{3} (3\, t_1\, \omega^{\alpha\prime}{}_{\alpha}\, \omega_{\prime}{}^{\theta}{}_{\theta} + 3\, f^{\alpha\beta}\, \tau_{\alpha\beta} + 3\, \omega^{\alpha\beta\chi}\, \sigma_{\alpha\beta\chi} - 6\, t_1\, \omega_{\alpha}{}^{\theta}{}_{\theta}\, \partial_{\prime} f^{\alpha\prime} + 6\, t_1\, \omega_{\prime}{}^{\theta}{}_{\theta}\\
&\partial^{\prime} f^{\alpha}{}_{\alpha} - 6\, r_1\, \partial_{\beta} \omega_{\prime}{}^{\theta}{}_{\theta}\, \partial^{\prime} \omega^{\alpha\beta}{}_{\alpha} + 6\, r_1\, \partial_{\prime} \omega_{\beta}{}^{\theta}{}_{\theta}\, \partial^{\prime} \omega^{\alpha\beta}{}_{\alpha} -\\
&3\, t_1\, \partial^{\prime} f^{\alpha}{}_{\alpha} - 3\, t_1\, \partial_{\prime} f^{\theta}{}_{\theta}\, \partial^{\prime} f^{\alpha}{}_{\alpha} + 6\, t_1\, \partial_{\theta} f^{\alpha\prime}{}_{\alpha}\, \partial^{\theta} f_{\prime}{}^{\alpha} + 6\, r_1\, \partial_{\alpha} \omega^{\alpha\beta\prime}\, \partial_{\theta} \omega_{\beta}{}^{\theta}{}_{\prime} - 12\, r_1\, \partial^{\prime} \omega^{\alpha\beta}{}_{\alpha}\, \partial_{\theta} \omega_{\beta}{}^{\theta}{}_{\prime} -\\
&6\, r_1\, \partial_{\alpha} \omega^{\alpha\beta\prime}\, \partial_{\theta} \omega_{\prime}{}^{\theta}{}_{\beta} + 12\, r_1\, \partial^{\prime} \omega^{\alpha\beta}{}_{\alpha}\, \partial_{\theta} \omega_{\prime}{}^{\theta}{}_{\beta} + 2\, t_1\, \omega_{\prime\theta\alpha}\, \partial^{\theta} f^{\alpha\prime} -\\
&2\, t_1\, \partial_{\alpha} f_{\prime\theta}\, \partial^{\theta} f^{\alpha\prime} - 2\, t_1\, \partial_{\alpha} f_{\theta\prime}\, \partial^{\theta} f^{\alpha\prime} + 2\, t_1\, \partial_{\theta} f_{\alpha\prime}\, \partial^{\theta} f^{\alpha\prime} +\\
&t_1\, \partial_{\theta} f_{\prime\alpha}\, \partial^{\theta} f^{\alpha\prime} + t_1\, \omega_{\alpha\prime\theta}\, \partial^{\theta} \omega^{\alpha\beta\prime} + 4\, r_1\, \partial_{\beta} \omega_{\alpha\prime\theta}\, \partial^{\theta} \omega^{\alpha\beta\prime} + 2\, r_1\, \partial_{\beta} \omega_{\alpha\theta\prime}\, \partial^{\theta} \omega^{\alpha\beta\prime} + 2\, r_1\, \partial_{\beta} \omega_{\prime\theta\alpha}\, \partial^{\theta} \omega^{\alpha\beta\prime} -\\
&2\, r_2\, \partial_{\beta} \omega_{\alpha\theta\prime}\, \partial^{\theta} \omega^{\alpha\beta\prime} - 8\, r_1\, \partial_{\beta} \omega_{\prime\theta\alpha}\, \partial^{\theta} \omega^{\alpha\beta\prime} + 2\, r_2\, \partial_{\beta} \omega_{\prime\theta\alpha}\, \partial^{\theta} \omega^{\alpha\beta\prime} -\\
&2\, r_1\, \partial_{\prime} \omega_{\alpha\beta\theta}\, \partial^{\theta} \omega^{\alpha\beta\prime} - r_2\, \partial_{\prime} \omega_{\alpha\beta\theta}\, \partial^{\theta} \omega^{\alpha\beta\prime} + 2\, r_1\, \partial_{\theta} \omega_{\alpha\beta\prime}\, \partial^{\theta} \omega^{\alpha\beta\prime} + r_2\, \partial_{\theta} \omega_{\alpha\beta\prime}\, \partial^{\theta} \omega^{\alpha\beta\prime} +\\
&2\, r_1\, \partial_{\theta} \omega_{\alpha\beta}\, \partial^{\theta} \omega^{\alpha\beta\prime} - 2\, r_2\, \partial_{\theta} \omega_{\alpha\beta}\, \partial^{\theta} \omega^{\alpha\beta\prime}))[t, x, y, z]\, dz\, dy\, dx\, dt
\end{aligned}
$$

	$\sigma_{1^+}^{\#1\,\alpha\beta}$	$\tau_{1^+}^{\#1\,\alpha\beta}$	$\sigma_{1^-}^{\#1\,\alpha}$	$\sigma_{1^-}^{\#2\,\alpha}$	$\tau_{1^-}^{\#1\,\alpha}$	$\tau_{1^-}^{\#2\,\alpha}$
$\sigma_{1^+}^{\#1\,\alpha\beta}\,\dagger$	$\frac{6}{(3+2k^2)^2 t_1}$	$-\frac{6i\sqrt{2}\,k}{(3+2k^2)^2 t_1}$	0	0	0	0
$\sigma_{1^+}^{\#2\,\alpha\beta}\,\dagger$	$-\frac{6\sqrt{2}}{(3+2k^2)^2 t_1}$	$\frac{12ik}{(3+2k^2)^2 t_1}$	0	0	0	0
$\tau_{1^+}^{\#1\,\alpha\beta}\,\dagger$	$\frac{6i\sqrt{2}\,k}{(3+2k^2)^2 t_1}$	$\frac{12k^2}{(3+2k^2)^2 t_1}$	0	0	0	0
$\sigma_{1^-}^{\#1\,\alpha}\,\dagger$	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2 t_1}$	0	$\frac{2ik}{t_1+2k^2 t_1}$
$\sigma_{1^-}^{\#2\,\alpha}\,\dagger$	0	0	$\frac{\sqrt{2}}{t_1+2k^2 t_1}$	$\frac{2k^2 r_1+t_1}{(t_1+2k^2 t_1)^2}$	0	$\frac{i\sqrt{2}\,k(2k^2 r_1+t_1)}{(t_1+2k^2 t_1)^2}$
$\tau_{1^-}^{\#1\,\alpha}\,\dagger$	0	0	0	0	0	0
$\tau_{1^-}^{\#2\,\alpha}\,\dagger$	0	0	$-\frac{i\sqrt{2}\,k(2k^2 r_1+t_1)}{(t_1+2k^2 t_1)^2}$	0	$\frac{2k^2(2k^2 r_1+t_1)}{(t_1+2k^2 t_1)^2}$	0

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1}\,\dagger$	$-\frac{1}{(1+2k^2)^2 t_1}$	$\frac{i\sqrt{2}\,k}{(1+2k^2)^2 t_1}$	0	0
$\tau_{0^+}^{\#1}\,\dagger$	$-\frac{i\sqrt{2}\,k}{(1+2k^2)^2 t_1}$	$-\frac{2k^2}{(1+2k^2)^2 t_1}$	0	0
$\tau_{0^+}^{\#2}\,\dagger$	0	0	0	0
$\sigma_{0^-}^{\#1}\,\dagger$	0	0	0	$\frac{1}{k^2 r_2}$

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

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}\,\dagger$	$-t_1$	$i\sqrt{2}\,k\,t_1$	0	0
$f_{0^+}^{\#1}\,\dagger$	$-i\sqrt{2}\,k\,t_1$	$-2k^2 t_1$	0	0
$f_{0^+}^{\#2}\,\dagger$	0	0	0	$k^2 r_2$
$\omega_{0^-}^{\#1}\,\dagger$	0	0	0	0

	$f_{1^+}^{\#1\,\alpha\beta}$	$\omega_{1^-}^{\#1\,\alpha}$	$\omega_{1^-}^{\#2\,\alpha}$	$f_{1^-}^{\#1\,\alpha}$	$f_{1^-}^{\#2\,\alpha}$
$\omega_{1^+}^{\#1\,\alpha\beta}\,\dagger$	$-\frac{ikt_1}{3\sqrt{2}}$	0	0	0	0
$\omega_{1^+}^{\#2\,\alpha\beta}\,\dagger$	$\frac{ikt_1}{3}$	0	0	0	0
$f_{1^+}^{\#1\,\alpha\beta}\,\dagger$	$\frac{k^2 t_1}{3}$	0	0	0	0
$\omega_{1^-}^{\#1\,\alpha}\,\dagger$	0	$-k^2 r_1 - \frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0	$i k t_1$
$\omega_{1^-}^{\#2\,\alpha}\,\dagger$	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
$f_{1^-}^{\#1\,\alpha}\,\dagger$	0	0	0	0	0
$f_{1^-}^{\#2\,\alpha}\,\dagger$	0	$-i k t_1$	0	0	0

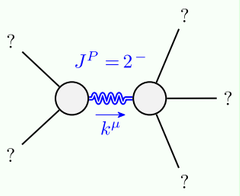
	$\omega_{1^+}^{\#1\,\alpha\beta}$	$\omega_{1^+}^{\#2\,\alpha\beta}$	$f_{1^+}^{\#1\,\alpha\beta}$	$\omega_{1^-}^{\#1\,\alpha}$	$\omega_{1^-}^{\#2\,\alpha}$	$f_{1^-}^{\#1\,\alpha}$	$f_{1^-}^{\#2\,\alpha}$
$\omega_{1^+}^{\#1\,\alpha\beta}\,\dagger$	$\frac{t_1}{6}$	$-\frac{t_1}{3\sqrt{2}}$	$\frac{ikt_1}{3\sqrt{2}}$	0	0	0	0
$\omega_{1^+}^{\#2\,\alpha\beta}\,\dagger$	$-\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	$-\frac{1}{3} i k t_1$	0	0	0	0
$f_{1^+}^{\#1\,\alpha\beta}\,\dagger$	$\frac{ikt_1}{3\sqrt{2}}$	$-\frac{1}{3} i k t_1$	0	0	0	0	0
$\omega_{1^-}^{\#1\,\alpha}\,\dagger$	0	0	0	0	0	0	0
$\omega_{1^-}^{\#2\,\alpha}\,\dagger$	0	0	0	0	0	0	0
$f_{1^-}^{\#1\,\alpha}\,\dagger$	0	0	0	0	0	0	0
$f_{1^-}^{\#2\,\alpha}\,\dagger$	0	0	0	0	0	0	0

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

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau_{0^+}^{\#2} == 0$	1
$\tau_{0^+}^{\#1} - 2\,i\,k\,\sigma_{0^+}^{\#1} == 0$	1
$\tau_{1^-}^{\#2\,\alpha} + 2\,i\,k\,\sigma_{1^-}^{\#2\,\alpha} == 0$	3
$\tau_{1^-}^{\#1\,\alpha} == 0$	3
$\tau_{1^+}^{\#1\,\alpha\beta} - 2\,i\,k\,\sigma_{1^+}^{\#1\,\alpha\beta} == 0$	3
$2\,\sigma_{1^+}^{\#1\,\alpha\beta} + \sigma_{1^+}^{\#2\,\alpha\beta} == 0$	3
$\tau_{2^+}^{\#1\,\alpha\beta} - 2\,i\,k\,\sigma_{2^+}^{\#1\,\alpha\beta} == 0$	5
Total constraints:	19

Massive and massless spectra



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

(No massless particles)

Unitarity conditions

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