Particle spectrograph

Wave operator and propagator

Quadratic (free) Lagrangian density

$$
\begin{aligned}
&-t_1\,\omega_{\prime}^{\alpha\prime}\,\omega_{\kappa\alpha}{}^{\kappa}-\tfrac{1}{3}t_1\,\omega_{\kappa\lambda}{}^{\kappa\lambda\prime}+\tfrac{2}{3}t_2\,\omega_{\prime}^{\kappa\lambda}\,\omega_{\kappa\lambda}{}^{\prime}+\\
&\tfrac{1}{3}t_1\,\omega_{\kappa\lambda}{}^{\prime}\,\omega_{\prime}^{\kappa\lambda}+\tfrac{1}{3}t_2\,\omega_{\kappa\lambda}{}^{\prime}\,\omega_{\prime}^{\kappa\lambda}+f^{\alpha\beta}\,\tau_{\alpha\beta}+\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi}+\\
&2\,r_1\,\partial_{\prime}\omega^{\kappa\lambda}{}_{\lambda}{}^{\alpha}\,\partial\omega_{\kappa}{}^{\kappa}{}_{\alpha}-\tfrac{2}{3}r_1\,\partial^{\beta}\omega^{\kappa}{}_{\kappa}{}^{\alpha}\,\partial_{\theta}\omega_{\alpha\beta}+\tfrac{2}{3}r_2\,\partial^{\beta}\omega^{\kappa}{}_{\kappa}{}^{\alpha}\,\partial_{\theta}\omega_{\alpha\beta}-\\
&\tfrac{2}{3}r_1\,\partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\,\partial_{\kappa}\omega^{\alpha\beta\theta}-\tfrac{1}{3}r_2\,\partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\,\partial_{\kappa}\omega^{\alpha\beta\theta}+\tfrac{2}{3}r_1\,\partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\,\partial_{\kappa}\omega^{\theta\alpha\beta}-\\
&\tfrac{2}{3}r_2\,\partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\,\partial_{\kappa}\omega^{\theta\alpha\beta}+2\,r_1\,\partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\,\partial_{\kappa}\omega^{\theta\kappa\lambda}-2\,r_1\,\partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\,\partial_{\kappa}\omega^{\theta\kappa\lambda}+\\
&2\,r_1\,\partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\,\partial_{\kappa}\omega^{\kappa\lambda\theta}-4\,r_1\,\partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\,\partial_{\kappa}\omega^{\kappa\lambda\theta}-\tfrac{1}{3}t_1\,\partial^{\alpha}f_{\theta\kappa}\,\partial^{\kappa}f_{\alpha}{}^{\theta}+\\
&\tfrac{1}{6}t_2\,\partial^{\alpha}f_{\kappa\theta}\,\partial^{\kappa}f_{\alpha}{}^{\theta}-\tfrac{1}{6}t_2\,\partial^{\alpha}f_{\kappa\theta}\,\partial^{\kappa}f_{\alpha}{}^{\theta}-\tfrac{1}{3}t_1\,\partial^{\alpha}f_{\kappa\lambda}\,\partial^{\kappa}f_{\alpha}{}^{\lambda}+\\
&\tfrac{1}{6}t_2\,\partial^{\alpha}f_{\theta\kappa}\,\partial^{\kappa}f_{\alpha}{}^{\theta}+t_1\,\omega_{\kappa\alpha}{}^{\alpha}\,\partial^{\kappa}f_{\prime}{}^{\lambda}+t_1\,\omega_{\kappa\lambda}{}^{\lambda}\,\partial^{\kappa}f_{\prime}{}^{\lambda}+2\,t_1\,\partial^{\alpha}f_{\kappa\alpha}\,\partial^{\kappa}f_{\prime}{}^{\prime}-\\
&t_1\,\partial_{\kappa}f_{\lambda}{}^{\lambda}\,\partial^{\kappa}f_{\prime}{}^{\prime}+\tfrac{1}{3}t_1\,\omega_{\prime\theta\kappa}\,\partial^{\kappa}f^{\prime\theta}+\tfrac{4}{3}t_1\,\omega_{\iota\kappa\theta}\,\partial^{\kappa}f^{\iota\theta}-\\
&\tfrac{2}{3}t_2\,\omega_{\iota\kappa\theta}\,\partial^{\kappa}f^{\iota\theta}+\tfrac{2}{3}t_1\,\omega_{\theta\iota\kappa}\,\partial^{\kappa}f^{\iota\theta}-\tfrac{1}{3}t_2\,\omega_{\theta\iota\kappa}\,\partial^{\kappa}f^{\iota\theta}+\\
&\tfrac{2}{3}t_2\,\omega_{\theta\kappa\iota}\,\partial^{\kappa}f^{\iota\theta}-t_1\,\omega_{\iota\alpha}{}^{\alpha}\,\partial^{\kappa}f^{\prime}{}_{\kappa}-t_1\,\omega_{\iota\lambda}{}^{\lambda}\,\partial^{\kappa}f^{\prime}{}_{\kappa}+\tfrac{1}{3}t_1\,\partial^{\alpha}f^{\prime}{}_{\kappa}\,\partial^{\kappa}f_{\lambda\alpha}-\\
&\tfrac{1}{6}t_2\,\partial^{\alpha}f^{\lambda}{}_{\kappa}\,\partial^{\kappa}f_{\lambda\alpha}+\tfrac{1}{3}t_1\,\partial_{\kappa}f_{\theta}{}^{\lambda}\,\partial^{\kappa}f_{\lambda}{}^{\theta}-\tfrac{1}{6}t_2\,\partial_{\kappa}f_{\theta}{}^{\lambda}\,\partial^{\kappa}f_{\lambda}{}^{\theta}+\tfrac{2}{3}t_1\,\partial_{\kappa}f^{\lambda}{}_{\theta}\,\partial^{\kappa}f_{\lambda}{}^{\theta}+\\
&\tfrac{1}{6}t_2\,\partial_{\kappa}f^{\lambda}{}_{\theta}\,\partial^{\kappa}f_{\lambda}{}^{\theta}-t_1\,\partial_{\kappa}f^{\lambda}{}_{\theta}\,\partial^{\kappa}f_{\lambda}{}^{\theta}+\\
&\tfrac{1}{3}r_2\,\partial_{\kappa}\omega^{\alpha\beta\theta}\,\partial^{\kappa}\omega_{\alpha\beta\theta}+\tfrac{2}{3}r_1\,\partial_{\kappa}\omega^{\alpha\beta\theta}\,\partial^{\kappa}\omega_{\alpha\beta\theta}-\tfrac{2}{3}r_1\,\partial_{\kappa}\omega^{\theta\alpha\beta}\,\partial^{\kappa}\omega_{\alpha\beta\theta}+\\
&\tfrac{2}{3}r_2\,\partial_{\kappa}\omega^{\theta\alpha\beta}\,\partial^{\kappa}\omega_{\alpha\beta\theta}-\tfrac{2}{3}r_1\,\partial^{\beta}\omega_{\prime}^{\alpha\lambda}\,\partial_{\lambda}\omega_{\alpha\beta}{}^{\prime}-\tfrac{2}{3}r_1\,\partial^{\beta}\omega_{\prime}^{\lambda\alpha}\,\partial_{\lambda}\omega_{\alpha\beta}{}^{\prime}+\\
&\tfrac{2}{3}r_2\,\partial^{\beta}\omega_{\prime}^{\lambda\alpha}\,\partial_{\lambda}\omega_{\alpha\beta}{}^{\prime}-2\,r_1\,\partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\,\partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa}+2\,r_1\,\partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\,\partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa}
\end{aligned}
$$

$\sigma_{1^+}^{\#1}{}^{\alpha\beta}\dagger\sigma_{1^+}^{\#1}{}^{\alpha\beta}$

$\frac{\sqrt{2}\,(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$\frac{i\sqrt{2}\,k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	0	0	0	0
$\frac{t_1+4t_2}{3(1+k^2)^2t_1t_2}$	$\frac{ik(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	0	0	0	0
$-\frac{ik(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	$\frac{k^2(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	0	0	0	0
0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{2ik}{t_1+2k^2t_1}$	0	0
0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{2k^2r_1+t_1}{(t_1+2k^2t_1)^2}$	$\frac{i\sqrt{2}\,k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$	0
0	0	0	0	0	0
0	0	$-\frac{2ik}{t_1+2k^2t_1}$	$-\frac{i\sqrt{2}\,k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$	0	$\frac{2k^2(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$

$\omega_{1^+}^{\#1}{}^{\alpha\beta}\dagger\sigma_{1^+}^{\#1}{}^{\alpha\beta}$

$\frac{2(t_1+t_2)}{3t_1t_2}$	$\frac{\sqrt{2}\,(t_1-2t_2)}{3(1+k^2)t_1t_2}$	0	0	0	0
$\frac{\sqrt{2}\,(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$\frac{t_1+4t_2}{3(1+k^2)^2t_1t_2}$	0	0	0	0
$-\frac{i\sqrt{2}\,k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$-\frac{ik(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	0	0	0	0
0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{2ik}{t_1+2k^2t_1}$	0	0
0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{2k^2r_1+t_1}{(t_1+2k^2t_1)^2}$	$\frac{i\sqrt{2}\,k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$	0
0	0	0	0	0	0
0	0	$-\frac{2ik}{t_1+2k^2t_1}$	$-\frac{i\sqrt{2}\,k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$	0	$\frac{2k^2(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$

$\omega_{1^+}^{\#1}{}^{\alpha\beta}\dagger\omega_{1^+}^{\#1}{}^{\alpha\beta}$

$\frac{2(t_1+t_2)}{3t_1t_2}$	$\frac{\sqrt{2}\,(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$-\frac{i\sqrt{2}\,k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	0	0	0
$\frac{\sqrt{2}\,(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$\frac{t_1+4t_2}{3(1+k^2)^2t_1t_2}$	$-\frac{ik(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	0	0	0
$-\frac{i\sqrt{2}\,k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$-\frac{ik(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	$\frac{k^2(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	0	0	0
0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{2ik}{t_1+2k^2t_1}$	0
0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{2k^2r_1+t_1}{(t_1+2k^2t_1)^2}$	$\frac{i\sqrt{2}\,k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$
0	0	0	$-\frac{2ik}{t_1+2k^2t_1}$	$-\frac{i\sqrt{2}\,k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$	0

$\tau_{1^+}^{\#1}{}^{\alpha\beta}\dagger\tau_{1^+}^{\#1}{}^{\alpha\beta}$

$\frac{i\sqrt{2}\,k}{(1+2k^2)^2t_1}$	$-\frac{2k^2}{(1+2k^2)^2t_1}$	0	0	0	0
$-\frac{2k^2}{(1+2k^2)^2t_1}$	$-\frac{i\sqrt{2}\,k}{(1+2k^2)^2t_1}$	0	0	0	0
0	0	$\frac{1}{k^2r_2+t_2}$	$\frac{ik}{k^2r_2+t_2}$	0	0
0	0	$\frac{ik}{k^2r_2+t_2}$	$\frac{k^2}{k^2r_2+t_2}$	0	0
0	0	0	0	$\frac{1}{2}$	$\frac{t_1}{2}$
0	0	0	0	$\frac{t_1}{2}$	$\frac{t_1^2}{4}$

$\omega_{1^+}^{\#1}{}^{\alpha\beta}\dagger\tau_{1^+}^{\#1}{}^{\alpha\beta}$

$\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}\,k}{(1+2k^2)^2t_1}$	0	0	0	0
$\frac{2i\sqrt{2}\,k}{(1+2k^2)^2t_1}$	$\frac{4k^2}{(1+2k^2)^2t_1}$	0	0	0	0
0	0	$\frac{2}{2k^2r_1+t_1}$	$\frac{2k^2}{2k^2r_1+t_1}$	0	0
0	0	$\frac{2k^2}{2k^2r_1+t_1}$	$\frac{4k^4}{2k^2r_1+t_1}$	0	0
0	0	0	0	$\frac{2}{2k^2r_1+t_1}$	$\frac{2k^2}{2k^2r_1+t_1}$
0	0	0	0	$\frac{2k^2}{2k^2r_1+t_1}$	$\frac{4k^4}{2k^2r_1+t_1}$

$\omega_{1^+}^{\#1}{}^{\alpha\beta}\dagger f_{1^+}^{\#1}{}^{\alpha\beta}$

$\frac{1}{6}(t_1+4t_2)$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{i\,k\,(t_1-2t_2)}{3\sqrt{2}}$	0	0	0
$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{t_1+t_2}{3}$	$\frac{1}{3}i\,k\,(t_1+t_2)$	0	0	0
$\frac{i\,k\,(t_1-2t_2)}{3\sqrt{2}}$	$\frac{1}{3}i\,k\,(t_1+t_2)$	$\frac{1}{3}k^2\,(t_1+t_2)$	0	0	0
0	0	0	$-k^2\,r_1-\frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0
0	0	0	$\frac{t_1}{\sqrt{2}}$	0	0
0	0	0	0	0	0
0	0	0	$-i\,k\,t_1$	0	0
0	0	0	0	0	0

$\omega_{1^+}^{\#1}{}^{\alpha\beta}\dagger\omega_{1^-}^{\#1}{}^{\alpha}$

$\frac{1}{6}(t_1+4t_2)$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{i\,k\,(t_1-2t_2)}{3\sqrt{2}}$	0	0	0
$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{t_1+t_2}{3}$	$\frac{1}{3}i\,k\,(t_1+t_2)$	0	0	0
$\frac{i\,k\,(t_1-2t_2)}{3\sqrt{2}}$	$\frac{1}{3}i\,k\,(t_1+t_2)$	$\frac{1}{3}k^2\,(t_1+t_2)$	0	0	0
0	0	0	$-k^2\,r_1-\frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	$i\,k\,t_1$
0	0	0	$\frac{t_1}{\sqrt{2}}$	0	0
0	0	0	0	0	0
0	0	0	$-i\,k\,t_1$	0	0
0	0	0	0	0	0

$\sigma_{2^+}^{\#1}{}^{\alpha\beta}\dagger\sigma_{2^+}^{\#1}{}^{\alpha\beta}$

$\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}\,k}{(1+2k^2)^2t_1}$	0	0
$\frac{2i\sqrt{2}\,k}{(1+2k^2)^2t_1}$	$\frac{4k^2}{(1+2k^2)^2t_1}$	0	0
0	0	$\frac{2}{2k^2r_1+t_1}$	$\frac{2k^2}{2k^2r_1+t_1}$
0	0	$\frac{2k^2}{2k^2r_1+t_1}$	$\frac{4k^4}{2k^2r_1+t_1}$

$\omega_{0^+}^{\#1}\dagger f_{0^+}^{\#1}{}^{\alpha\beta}\dagger\omega_{0^-}^{\#1}$

$-t_1$	$i\sqrt{2}\,k\,t_1$	0
$-i\sqrt{2}\,k\,t_1$	$-2k^2\,t_1$	0
0	0	$k^2\,r_2+t_2$

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

$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	0
$\frac{ikt_1}{\sqrt{2}}$	$k^2\,t_1$	0
0	0	$k^2\,r_1+\frac{t_1}{2}$

$\tau_{0^+}^{\#1}\dagger\tau_{0^+}^{\#2}\dagger\sigma_{0^-}^{\#1}$

$\frac{i\sqrt{2}\,k}{(1+2k^2)^2t_1}$	0	0
$-\frac{2k^2}{(1+2k^2)^2t_1}$	0	0
0	0	$\frac{1}{k^2r_2+t_2}$

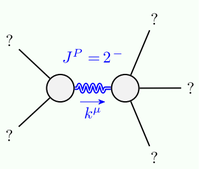
$\sigma_{0^+}^{\#1}\dagger\tau_{0^+}^{\#1}\dagger\tau_{0^+}^{\#2}\dagger\sigma_{0^-}^{\#1}$

$-\frac{i\sqrt{2}\,k}{(1+2k^2)^2t_1}$	$-\frac{2k^2}{(1+2k^2)^2t_1}$	0	0
$-\frac{2k^2}{(1+2k^2)^2t_1}$	$\frac{i\sqrt{2}\,k}{(1+2k^2)^2t_1}$	0	0
0	0	$\frac{1}{k^2r_2+t_2}$	$\frac{ik}{k^2r_2+t_2}$
0	0	$\frac{ik}{k^2r_2+t_2}$	$\frac{k^2}{k^2r_2+t_2}$

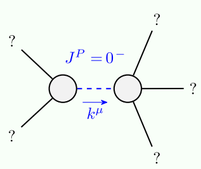
Source constraints/gauge generators

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
$\tau_{1^+}^{\#1\,\alpha\beta}+i\,k\,\sigma_{1^+}^{\#2\,\alpha\beta}==0$	3
$\tau_{2^+}^{\#1\,\alpha\beta}-2\,i\,k\,\sigma_{2^+}^{\#1\,\alpha\beta}==0$	5
Total constraints:	16

Massive and massless spectra



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



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

$r_1<0\;\&\&\;r_2<0\;\&\&\;t_1>0\;\&\&\;t_2>0$