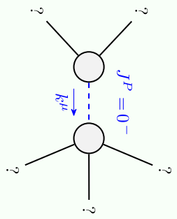
Particle spectrograph

Wave operator and propagator

Massive and massless spectra

Unitarity conditions

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



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)

Quadratic (free) action

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

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

	$\omega_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^+}^{\#2}{}_{\alpha\beta}$	$f_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^-}^{\#1}{}_{\alpha}$	$\omega_{1^-}^{\#2}{}_{\alpha}$	$f_{1^-}^{\#1}{}_{\alpha}$	$f_{1^-}^{\#2}{}_{\alpha}$
$\omega_{1^+}^{\#1}\dagger^{\alpha\beta}$	$\frac{2t_2}{3}$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{1}{3}i\sqrt{2}\,k t_2$	0	0	0	0
$\omega_{1^+}^{\#2}\dagger^{\alpha\beta}$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{t_2}{3}$	$\frac{ikt_2}{3}$	0	0	0	0
$f_{1^+}^{\#1}\dagger^{\alpha\beta}$	$-\frac{1}{3}i\sqrt{2}\,k t_2$	$-\frac{1}{3}ikt_2$	$\frac{k^2 t_2}{3}$	0	0	0	0
$\omega_{1^-}^{\#1}\dagger^{\alpha}$	0	0	0	$-k^2 r_1 + \frac{2t_3}{3}$	$-\frac{\sqrt{2}\,t_3}{3}$	0	$-\frac{2}{3}ikt_3$
$\omega_{1^-}^{\#2}\dagger^{\alpha}$	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	$\frac{2ikt_3}{3}$	$-\frac{1}{3}i\sqrt{2}\,k t_3$	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
$\tau_{1^-}^{\#2\alpha} + 2ik\,\sigma_{1^-}^{\#2\alpha} == 0$	3
$\tau_{1^-}^{\#1\alpha} == 0$	3
$\tau_{1^+}^{\#1\alpha\beta} + ik\,\sigma_{1^+}^{\#1\alpha\beta} == 0$	3
$\sigma_{1^+}^{\#1\alpha\beta} == \sigma_{1^+}^{\#2\alpha\beta}$	3
$\tau_{2^+}^{\#1\alpha\beta} == 0$	5
$\sigma_{2^+}^{\#1\alpha\beta} == 0$	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	$\frac{1}{k^2 r_2 + t_2}$

	$\sigma_{2^+}^{\#1}{}_{\alpha\beta}$	$\tau_{2^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{2^-}^{\#1}{}_{\alpha\beta\chi}$
$\sigma_{2^+}^{\#1}\dagger^{\alpha\beta}$	0	0	0
$\tau_{2^+}^{\#1}\dagger^{\alpha\beta}$	0	0	0
$\sigma_{2^-}^{\#1}\dagger^{\alpha\beta\chi}$	0	0	$\frac{1}{k^2 r_1}$

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

	$\omega_{2^+}^{\#1}{}_{\alpha\beta}$	$f_{2^+}^{\#1}{}_{\alpha\beta}$	$\omega_{2^-}^{\#1}{}_{\alpha\beta\chi}$
$\omega_{2^+}^{\#1}\dagger^{\alpha\beta}$	0	0	0
$f_{2^+}^{\#1}\dagger^{\alpha\beta}$	0	0	0
$\omega_{2^-}^{\#1}\dagger^{\alpha\beta\chi}$	0	0	$k^2 r_1$