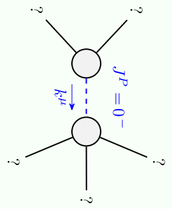
Particle spectrograph

Wave operator and propagator

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

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

Quadratic (free) Lagrangian density

$$\frac{2}{3} t_3\, \omega_{\iota}^{\alpha\iota}\, \omega_{\kappa\alpha}{}^{\kappa} + \frac{2}{3} t_2\, \omega_{\iota}^{\kappa\lambda}\, \omega_{\kappa\lambda}{}' + \frac{1}{3} t_2\, \omega_{\kappa\lambda}{}'\, \omega^{\kappa\lambda}{}_{\iota}' + f^{\alpha\beta}\, \tau_{\alpha\beta} + \omega^{\alpha\beta\chi}\, \sigma_{\alpha\beta\chi} +$$
$$2 r_1\, \partial_{\iota}\omega^{\kappa\lambda}{}_{\kappa}\, \partial'\omega_{\lambda}{}^{\alpha}{}_{\alpha} - \frac{2}{3} r_1\, \partial^{\beta}\omega^{\theta\alpha}{}_{\kappa}\, \partial_{\theta}\omega_{\alpha\beta}{}^{\kappa} + \frac{2}{3} r_2\, \partial^{\beta}\omega^{\theta\alpha}{}_{\kappa}\, \partial_{\theta}\omega_{\alpha\beta}{}^{\kappa} -$$
$$\frac{2}{3} r_1\, \partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\, \partial_{\kappa}\omega^{\alpha\beta\theta} - \frac{1}{3} r_2\, \partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\, \partial_{\kappa}\omega^{\alpha\beta\theta} + \frac{2}{3} r_1\, \partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\, \partial_{\kappa}\omega^{\theta\alpha\beta} -$$
$$\frac{2}{3} r_2\, \partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\, \partial_{\kappa}\omega^{\theta\alpha\beta} + 2 r_1\, \partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\, \partial_{\kappa}\omega^{\theta\kappa\lambda} - 2 r_1\, \partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\, \partial_{\kappa}\omega^{\theta\kappa\lambda} +$$
$$2 r_1\, \partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\, \partial_{\kappa}\omega^{\kappa\lambda\theta} - 4 r_1\, \partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\, \partial_{\kappa}\omega^{\kappa\lambda\theta} + \frac{1}{6} t_2\, \partial^{\alpha} f_{\theta\kappa}\, \partial^{\kappa} f_{\alpha}{}^{\theta} - \frac{1}{6} t_2\, \partial^{\alpha} f_{\kappa\theta}\, \partial^{\kappa} f_{\alpha}{}^{\theta} +$$
$$\frac{1}{6} t_2\, \partial^{\alpha} f^{\lambda}{}_{\kappa}\, \partial^{\kappa} f_{\alpha\lambda} - \frac{2}{3} t_3\, \omega_{\kappa\alpha}{}^{\alpha}\, \partial^{\kappa} f'_{\iota} - \frac{2}{3} t_3\, \omega_{\kappa\lambda}{}^{\lambda}\, \partial^{\kappa} f'_{\iota} - \frac{4}{3} t_3\, \partial^{\alpha} f_{\kappa\alpha}\, \partial^{\kappa} f'_{\iota} +$$
$$\frac{2}{3} t_3\, \partial_{\kappa} f^{\lambda}{}_{\lambda}\, \partial^{\kappa} f'_{\iota} + \frac{1}{3} t_2\, \omega_{\iota\theta\kappa}\, \partial^{\kappa} f'^{\iota\theta} - \frac{2}{3} t_2\, \omega_{\iota\kappa\theta}\, \partial^{\kappa} f'^{\iota\theta} - \frac{1}{3} t_2\, \omega_{\theta\iota\kappa}\, \partial^{\kappa} f'^{\iota\theta} +$$
$$\frac{2}{3} t_2\, \omega_{\theta\kappa\iota}\, \partial^{\kappa} f'^{\iota\theta} + \frac{2}{3} t_3\, \omega_{\iota\alpha}{}^{\alpha}\, \partial^{\kappa} f'_{\kappa} + \frac{2}{3} t_3\, \omega_{\iota\lambda}{}^{\lambda}\, \partial^{\kappa} f'_{\kappa} - \frac{1}{6} t_2\, \partial^{\alpha} f^{\lambda}{}_{\kappa}\, \partial^{\kappa} f_{\lambda\alpha} -$$
$$\frac{1}{6} t_2\, \partial_{\kappa} f_{\theta}{}^{\lambda}\, \partial^{\kappa} f_{\lambda}{}^{\theta} + \frac{1}{6} t_2\, \partial_{\kappa} f^{\lambda}{}_{\theta}\, \partial^{\kappa} f_{\lambda}{}^{\theta} + \frac{2}{3} t_3\, \partial^{\alpha} f^{\lambda}{}_{\alpha}\, \partial^{\kappa} f_{\lambda\kappa} + \frac{2}{3} r_1\, \partial_{\kappa}\omega^{\alpha\beta\theta}\, \partial^{\kappa}\omega_{\alpha\beta\theta} +$$
$$\frac{1}{3} r_2\, \partial_{\kappa}\omega^{\alpha\beta\theta}\, \partial^{\kappa}\omega_{\alpha\beta\theta} - \frac{2}{3} r_1\, \partial_{\kappa}\omega^{\theta\alpha\beta}\, \partial^{\kappa}\omega_{\alpha\beta\theta} + \frac{2}{3} r_2\, \partial_{\kappa}\omega^{\theta\alpha\beta}\, \partial^{\kappa}\omega_{\alpha\beta\theta} +$$
$$\frac{2}{3} r_1\, \partial^{\beta}\omega_{\iota}^{\alpha\lambda}\, \partial_{\lambda}\omega_{\alpha\beta}{}' - \frac{2}{3} r_2\, \partial^{\beta}\omega_{\iota}^{\alpha\lambda}\, \partial_{\lambda}\omega_{\alpha\beta}{}' - \frac{8}{3} r_1\, \partial^{\beta}\omega_{\iota}^{\lambda\alpha}\, \partial_{\lambda}\omega_{\alpha\beta}{}' +$$
$$\frac{2}{3} r_2\, \partial^{\beta}\omega_{\iota}^{\lambda\alpha}\, \partial_{\lambda}\omega_{\alpha\beta}{}' - 2 r_1\, \partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\, \partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa} + 2 r_1\, \partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\, \partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa}$$

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

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}\,\dagger$	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	$k^2 r_1$

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

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