Particle spectrograph

Wave operator and propagator

	$\omega_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^+}^{\#2}{}_{\alpha\beta}$	$f_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^-}^{\#1}{}_{\alpha}$	$\omega_{1^-}^{\#2}{}_{\alpha}$	$f_{1^-}^{\#1}{}_{\alpha}$	$f_{1^-}^{\#2}{}_{\alpha}$
$\omega_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$k^2 (2 r_3 + r_5) + \frac{2 t_2}{3}$	$\frac{\sqrt{2}\, t_2}{3}$	$\frac{1}{3} i \sqrt{2}\, k t_2$	0	0	0	0
$\omega_{1^+}^{\#2}{}^{\dagger\alpha\beta}$	$\frac{\sqrt{2}\, t_2}{3}$	$\frac{t_2}{3}$	$\frac{i k t_2}{3}$	0	0	0	0
$f_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$-\frac{1}{3} i \sqrt{2}\, k t_2$	$-\frac{1}{3} i k t_2$	$\frac{k^2 t_2}{3}$	0	0	0	0
$\omega_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	$k^2 (\frac{r_3}{2} + r_5) + \frac{2 t_3}{3}$	$-\frac{\sqrt{2}\, t_3}{3}$	0	$-\frac{2}{3} i k t_3$
$\omega_{1^-}^{\#2}{}^{\dagger\alpha}$	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	$\frac{2 i k t_3}{3}$	$-\frac{1}{3} i \sqrt{2}\, k t_3$	0	$\frac{2 k^2 t_3}{3}$

	$\sigma_{2^+}^{\#1}{}_{\alpha\beta}$	$\tau_{2^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{2^-}^{\#1}{}_{\alpha\beta\chi}$
$\sigma_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$-\frac{2}{3 k^2 r_3}$	0	0
$\tau_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	0	0	0
$\sigma_{2^-}^{\#1}{}^{\dagger\alpha\beta\chi}$	0	0	0

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}{}^{\dagger}$	t_3	$-i \sqrt{2}\, k t_3$	0	0
$f_{0^+}^{\#1}{}^{\dagger}$	$i \sqrt{2}\, k t_3$	$2 k^2 t_3$	0	0
$f_{0^+}^{\#2}{}^{\dagger}$	0	0	0	0
$\omega_{0^-}^{\#1}{}^{\dagger}$	0	0	0	$k^2 r_2 + t_2$

	$\omega_{2^+}^{\#1}{}_{\alpha\beta}$	$f_{2^+}^{\#1}{}_{\alpha\beta}$	$\omega_{2^-}^{\#1}{}_{\alpha\beta\chi}$
$\omega_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$-\frac{3 k^2 r_3}{2}$	0	0
$f_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	0	0	0
$\omega_{2^-}^{\#1}{}^{\dagger\alpha\beta\chi}$	0	0	0

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

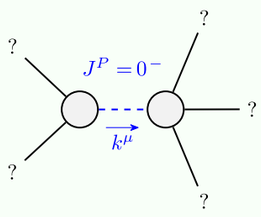
	$\sigma_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^+}^{\#2}{}_{\alpha\beta}$	$\tau_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^-}^{\#1}{}_{\alpha}$	$\sigma_{1^-}^{\#2}{}_{\alpha}$	$\tau_{1^-}^{\#1}{}_{\alpha}$	$\tau_{1^-}^{\#2}{}_{\alpha}$
$\sigma_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{1}{k^2 (2 r_3 + r_5)}$	$-\frac{\sqrt{2}}{k^2 (1+k^2) (2 r_3 + r_5)}$	$-\frac{i \sqrt{2}}{k (1+k^2) (2 r_3 + r_5)}$	0	$\frac{2 \sqrt{2}}{k^2 (1+2 k^2) (r_3 + 2 r_5)}$	0	$\frac{4 i}{k (1+2 k^2) (r_3 + 2 r_5)}$
$\sigma_{1^+}^{\#2}{}^{\dagger\alpha\beta}$	$-\frac{\sqrt{2}}{k^2 (1+k^2) (2 r_3 + r_5)}$	$\frac{3 k^2 (2 r_3 + r_5) + 2 t_2}{(k+k^3)^2 (2 r_3 + r_5) t_2}$	$\frac{i (3 k^2 (2 r_3 + r_5) + 2 t_2)}{k (1+k^2)^2 (2 r_3 + r_5) t_2}$	0	$\frac{3 k^2 (r_3 + 2 r_5) + 4 t_3}{(k+2 k^3)^2 (r_3 + 2 r_5) t_3}$	0	$-\frac{i \sqrt{2}\, (3 k^2 (r_3 + 2 r_5) + 4 t_3)}{k (1+2 k^2)^2 (r_3 + 2 r_5) t_3}$
$\tau_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{i \sqrt{2}}{k (1+k^2) (2 r_3 + r_5)}$	$-\frac{i (3 k^2 (2 r_3 + r_5) + 2 t_2)}{k (1+k^2)^2 (2 r_3 + r_5) t_2}$	$\frac{3 k^2 (2 r_3 + r_5) + 2 t_2}{(1+k^2)^2 (2 r_3 + r_5) t_2}$	0	0	0	0
$\sigma_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	$\frac{2}{k^2 (r_3 + 2 r_5)}$	$\frac{2 \sqrt{2}}{k^2 (1+2 k^2) (r_3 + 2 r_5)}$	0	$-\frac{4 i}{k (1+2 k^2) (r_3 + 2 r_5)}$
$\sigma_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$\frac{2 \sqrt{2}}{k^2 (1+2 k^2) (r_3 + 2 r_5)}$	$\frac{3 k^2 (r_3 + 2 r_5) + 4 t_3}{(k+2 k^3)^2 (r_3 + 2 r_5) t_3}$	0	$-\frac{i \sqrt{2}\, (3 k^2 (r_3 + 2 r_5) + 4 t_3)}{k (1+2 k^2)^2 (r_3 + 2 r_5) t_3}$
$\tau_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	0	0	0	0
$\tau_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$-\frac{4 i}{k (1+2 k^2) (r_3 + 2 r_5)}$	0	0	$\frac{6 k^2 (r_3 + 2 r_5) + 8 t_3}{(1+2 k^2)^2 (r_3 + 2 r_5) t_3}$

Quadratic (free) action

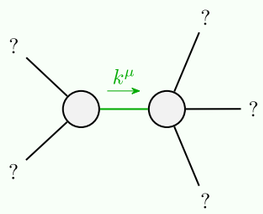
$$S = \iiint \Big(\frac{1}{6} (-4 t_3\, \omega^{\alpha\prime I}{}_{\alpha}\, \omega_{I}{}^{\kappa}{}_{\kappa} + 6\, f^{\alpha\beta}\, \tau_{\alpha\beta} + 6\, \omega^{\alpha\beta\chi}\, \sigma_{\alpha\beta\chi} + 8 t_3\, \omega_{\alpha}{}^{\kappa}{}_{\kappa}\, \partial_{I} f^{\alpha I} - 8 t_3\, \omega_{I}{}^{\kappa}{}_{\kappa}\, \partial^{I} f^{\alpha}{}_{\alpha} + 6\, \partial^{\prime} f^{\alpha}{}_{\alpha} + 4 t_3\, \partial_{I} f^{\kappa}{}_{\kappa}\, \partial^{\prime} f^{\alpha}{}_{\alpha} - 3 r_3\, \partial_{I} \omega_{\beta}{}^{\theta}{}_{\theta}\, \partial^{\prime} \omega^{\alpha\beta}{}_{\alpha} - 3 r_3\, \partial_{\alpha} \omega^{\alpha\beta I}\, \partial_{\theta} \omega_{I}{}^{\theta}{}_{\beta} + 3 r_3\, \partial_{\alpha} \omega^{\alpha\beta}{}_{\alpha}{}^{\theta}\, \partial_{\theta} \omega_{I}{}^{\theta}{}_{\beta} + 6 r_3\, \partial^{\prime} \omega^{\alpha\beta}{}_{\alpha}\, \partial_{\theta} \omega_{I}{}^{\theta}{}_{\beta} + 4 t_2\, \omega_{I\theta\alpha}\, \partial^{\theta} f^{\alpha I} + 2 t_2\, \partial_{\alpha} f_{I\theta}\, \partial^{\theta} f^{\alpha I} - t_2\, \partial_{\alpha} f_{\theta I}\, \partial^{\theta} f^{\alpha I} - t_2\, \partial_{I} f_{\alpha\theta}\, \partial^{\theta} f^{\alpha I} + t_2\, \partial_{\theta} f_{\alpha I}\, \partial^{\theta} f^{\alpha I} - t_2\, \partial_{\theta} f_{I\alpha}\, \partial^{\theta} f^{\alpha I} - 4 t_2\, \omega_{\alpha\theta I}\, (\omega^{\alpha I\theta} + \partial^{\theta} f^{\alpha I}) + 2 t_2\, \omega_{\alpha I\theta}\, (\omega^{\alpha I\theta} + 2\, \partial^{\theta} f^{\alpha I}) + 8 r_2\, \partial_{\beta} \omega_{\alpha\theta I}\, \partial^{\theta} \omega^{\alpha\beta I} + 4 r_2\, \partial_{\beta} \omega_{I\theta\alpha}\, \partial^{\theta} \omega^{\alpha\beta I} - 24 r_3\, \partial_{\beta} \omega_{I\theta\alpha}\, \partial^{\theta} \omega^{\alpha\beta I} - 2 r_2\, \partial_{I} \omega_{\alpha\beta\theta}\, \partial^{\theta} \omega^{\alpha\beta I} + 2 r_2\, \partial_{\theta} \omega_{\alpha\beta I} + \partial^{\theta} \omega^{\alpha\beta I}\, \partial_{\theta} \omega_{\alpha\beta I} - 4 r_2\, \partial_{\theta} \omega_{\alpha\beta I}\, \partial^{\theta} \omega^{\alpha\beta I} - 6 r_5\, \partial_{\theta} \omega_{I}{}^{\kappa}\, \partial^{\theta} \omega^{\alpha I}{}_{\alpha} + 6 r_5\, \partial_{\theta} \omega_{\alpha\beta I}\, \partial^{\theta} \omega^{\alpha\beta I} + 6 r_5\, \partial_{I} \omega_{\theta}{}^{\kappa}\, \partial^{\theta} \omega^{\alpha I}{}_{\alpha} + 4 t_3\, \partial_{I} f^{\alpha I}\, \partial_{\kappa} f_{\alpha}{}^{\kappa} - 8 t_3\, \partial^{\prime} f^{\alpha}{}_{I}\, \partial_{\kappa} f_{\alpha}{}^{\kappa} - 6 r_5\, \partial_{\alpha} \omega^{\alpha I\theta}\, \partial_{\kappa} \omega_{I}{}^{\kappa}{}_{\theta} + 12 r_5\, \partial^{\theta} \omega^{\alpha I}{}_{\alpha}\, \partial_{\kappa} \omega_{I}{}^{\kappa}{}_{\theta} + 6 r_5\, \partial_{\alpha} \omega^{\alpha I\theta}\, \partial_{\kappa} \omega_{\theta}{}^{\kappa}{}_{I} - 12 r_5\, \partial^{\theta} \omega^{\alpha I}{}_{\alpha}\, \partial_{\kappa} \omega_{\theta}{}^{\kappa}{}_{I}) \Big)[t, x, y, z]\, dz\, dy\, dx\, dt$$

Source constraints/gauge generators	Multiplicities
SO(3) irreps	
$\tau_{0^+}^{\#2} == 0$	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
$\sigma_{2^-}^{\#1\alpha\beta\chi} == 0$	5
$\tau_{2^+}^{\#1\alpha\beta} == 0$	5
Total constraints:	21

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



Quadratic pole	
Pole residue:	$-\frac{1}{r_3 (2 r_3 + r_5) (r_3 + 2 r_5) p^2} > 0$
Polarisations:	2

Unitarity conditions

$$r_2 < 0 \,\&\&\, r_3 < 0 \,\&\&\, r_5 < -\frac{r_3}{2} \,\&\&\, t_2 > 0 \,\|\, r_2 < 0 \,\&\&\, r_3 < 0 \,\&\&\, r_5 > -2 r_3 \,\&\&\, t_2 > 0 \,\|\, r_2 < 0 \,\&\&\, r_3 > 0 \,\&\&\, -2 r_3 < r_5 < -\frac{r_3}{2} \,\&\&\, t_2 > 0$$