

Particle spectrograph

Wave operator and propagator

	$\sigma_{1+}^{\#1\alpha\beta}$	$\sigma_{1+}^{\#2\alpha\beta}$	$\tau_{1+}^{\#1\alpha\beta}$	$\sigma_{1-}^{\#1\alpha}$	$\sigma_{1-}^{\#2\alpha}$	$\tau_{1-}^{\#1\alpha}$	$\tau_{1-}^{\#2\alpha}$
$\sigma_{1+}^{\#1\alpha\beta} \dagger$	0	$-\frac{\sqrt{2}}{t_1+k^2t_1}$	$-\frac{i\sqrt{2}k}{t_1+k^2t_1}$	0	0	0	0
$\sigma_{1+}^{\#2\alpha\beta} \dagger$	$-\frac{\sqrt{2}}{t_1+k^2t_1}$	$\frac{-2k^2(2r_1+r_5)+t_1}{(1+k^2)^2t_1^2}$	$\frac{-2ik^3(2r_1+r_5)+ikt_1}{(1+k^2)^2t_1^2}$	0	0	0	0
$\tau_{1+}^{\#1\alpha\beta} \dagger$	$\frac{i\sqrt{2}k}{t_1+k^2t_1}$	$\frac{i(2k^3(2r_1+r_5)-kt_1)}{(1+k^2)^2t_1^2}$	$\frac{-2k^4(2r_1+r_5)+k^2t_1}{(1+k^2)^2t_1^2}$	0	0	0	0
$\sigma_{1-}^{\#1\alpha} \dagger$	0	0	0	$\frac{2(t_1+t_3)}{3t_1t_3+2k^2(r_1+r_5)(t_1+t_3)}$	$-\frac{\sqrt{2}(t_1-2t_3)}{(1+2k^2)(3t_1t_3+2k^2(r_1+r_5)(t_1+t_3))}$	0	$-\frac{2ik(t_1-2t_3)}{(1+2k^2)(3t_1t_3+2k^2(r_1+r_5)(t_1+t_3))}$
$\sigma_{1-}^{\#2\alpha} \dagger$	0	0	0	0	$-\frac{\sqrt{2}}{(1+2k^2)^2(3t_1t_3+2k^2(r_1+r_5)(t_1+t_3))}$	0	$\frac{6k^2(r_1+r_5)+t_1+4t_3}{(1+2k^2)^2(3t_1t_3+2k^2(r_1+r_5)(t_1+t_3))}$
$\tau_{1-}^{\#1\alpha} \dagger$	0	0	0	0	0	0	0
$\tau_{1-}^{\#2\alpha} \dagger$	0	0	0	$\frac{2ik(t_1-2t_3)}{(1+2k^2)(3t_1t_3+2k^2(r_1+r_5)(t_1+t_3))}$	$-\frac{i\sqrt{2}k(6k^2(r_1+r_5)+t_1+4t_3)}{(1+2k^2)^2(3t_1t_3+2k^2(r_1+r_5)(t_1+t_3))}$	0	$\frac{2k^2(6k^2(r_1+r_5)+t_1+4t_3)}{(1+2k^2)^2(3t_1t_3+2k^2(r_1+r_5)(t_1+t_3))}$

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

	$\omega_{0+}^{\#1}$	$f_{0+}^{\#1}$	$f_{0+}^{\#2}$	$\omega_{0-}^{\#1}$
$\omega_{0+}^{\#1} \dagger$	t_3	$-i\sqrt{2}kt_3$	0	0
$f_{0+}^{\#1} \dagger$	$i\sqrt{2}kt_3$	$2k^2t_3$	0	0
$f_{0+}^{\#2} \dagger$	0	0	0	0
$\omega_{0-}^{\#1} \dagger$	0	0	0	$-t_1$

Quadratic (free) Lagrangian density

$$\begin{aligned} &-\frac{1}{3}t_1\omega_{\kappa\alpha}^{\alpha'}\omega_{\kappa\alpha}^{\kappa}+\frac{2}{3}t_3\omega_{\kappa\alpha}^{\alpha'}\omega_{\kappa\alpha}^{\kappa}-t_1\omega_{\kappa\alpha}^{\kappa\lambda}\omega_{\kappa\lambda}^{\alpha'}+f_{\alpha\beta}^{\alpha\beta}\tau_{\alpha\beta}+ \\ &\omega^{\alpha\beta\chi}\sigma_{\alpha\beta\chi}-r_5\partial_{\lambda}\omega_{\kappa\lambda}^{\kappa\lambda}\partial'_{\kappa}\omega_{\lambda\alpha}^{\alpha}-\frac{2}{3}r_1\partial^{\beta}\omega_{\kappa}^{\theta\alpha}\partial_{\theta}\omega_{\alpha\beta}^{\kappa}-\frac{2}{3}r_1\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}-r_5\partial_{\alpha}\omega_{\lambda\theta}^{\alpha}\partial_{\kappa}\omega^{\theta\kappa\lambda}+r_5\partial_{\theta}\omega_{\lambda\alpha}^{\alpha}\partial_{\kappa}\omega^{\theta\kappa\lambda}-r_5\partial_{\alpha}\omega_{\lambda\theta}^{\alpha}\partial_{\kappa}\omega^{\kappa\lambda\theta}+ \\ &2r_5\partial_{\theta}\omega_{\lambda\alpha}^{\alpha}\partial_{\kappa}\omega^{\kappa\lambda\theta}-\frac{1}{2}t_1\partial^{\alpha}f_{\theta\kappa}^{\kappa}\partial^{\kappa}f_{\alpha}^{\theta}-\frac{1}{2}t_1\partial^{\alpha}f_{\kappa\theta}^{\kappa}\partial^{\theta}f_{\alpha}^{\kappa}-\frac{1}{2}t_1\partial^{\alpha}f_{\lambda}^{\kappa}\partial^{\kappa}f_{\alpha}^{\lambda}+ \\ &\frac{1}{3}t_1\omega_{\kappa\alpha}^{\alpha}\partial^{\kappa}f_{\lambda}^{\lambda}-\frac{2}{3}t_3\omega_{\kappa\alpha}^{\alpha}\partial^{\kappa}f_{\lambda}^{\lambda}+\frac{1}{3}t_1\omega_{\kappa\lambda}^{\lambda}\partial^{\kappa}f_{\lambda}^{\lambda}-\frac{2}{3}t_3\omega_{\kappa\lambda}^{\lambda}\partial^{\kappa}f_{\lambda}^{\lambda}+ \\ &\frac{2}{3}t_1\partial^{\alpha}f_{\kappa\alpha}^{\kappa}\partial^{\kappa}f_{\lambda}^{\lambda}-\frac{4}{3}t_3\partial^{\alpha}f_{\kappa\alpha}^{\kappa}\partial^{\kappa}f_{\lambda}^{\lambda}-\frac{1}{3}t_1\partial_{\kappa}f_{\lambda}^{\lambda}\partial^{\kappa}f_{\lambda}^{\lambda}+\frac{2}{3}t_3\partial_{\kappa}f_{\lambda}^{\lambda}\partial^{\kappa}f_{\lambda}^{\lambda}+ \\ &2t_1\omega_{\kappa\theta}^{\theta}\partial^{\kappa}f_{\lambda}^{\lambda}-\frac{1}{3}t_1\omega_{\lambda\alpha}^{\alpha}\partial^{\kappa}f_{\kappa}^{\kappa}+\frac{2}{3}t_3\omega_{\lambda\alpha}^{\alpha}\partial^{\kappa}f_{\kappa}^{\kappa}-\frac{1}{3}t_1\omega_{\lambda\kappa}^{\kappa}\partial^{\kappa}f_{\kappa}^{\kappa}+ \\ &\frac{2}{3}t_3\omega_{\lambda\kappa}^{\kappa}\partial^{\kappa}f_{\lambda}^{\lambda}+\frac{1}{2}t_1\partial^{\alpha}f_{\lambda}^{\lambda}\partial^{\kappa}f_{\alpha}^{\theta}+\frac{1}{2}t_1\partial_{\kappa}f_{\lambda}^{\lambda}\partial^{\kappa}f_{\theta}^{\theta}+\frac{1}{2}t_1\partial_{\kappa}f_{\lambda}^{\lambda}\partial^{\kappa}f_{\theta}^{\theta}- \\ &\frac{1}{3}t_1\partial^{\alpha}f_{\alpha}^{\lambda}\partial^{\kappa}f_{\lambda\kappa}^{\kappa}+\frac{2}{3}t_3\partial^{\alpha}f_{\alpha}^{\lambda}\partial^{\kappa}f_{\lambda\kappa}^{\kappa}+\frac{2}{3}r_1\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_1\partial^{\theta}\omega_{\lambda}^{\alpha\lambda}\partial_{\lambda}\omega_{\alpha\beta}^{\kappa}-\frac{8}{3}r_1\partial^{\beta}\omega_{\lambda}^{\lambda\alpha}\partial_{\lambda}\omega_{\alpha\beta}^{\kappa}+r_5\partial_{\alpha}\omega_{\lambda}^{\alpha}\partial^{\lambda}\omega_{\kappa}^{\theta\kappa}-r_5\partial_{\theta}\omega_{\lambda}^{\alpha}\partial^{\lambda}\omega_{\alpha}^{\theta\kappa} \end{aligned}$$

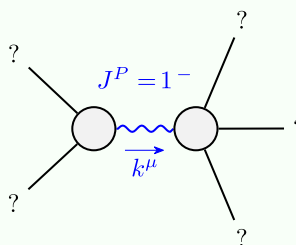
	$\omega_{2+}^{\#1\alpha\beta}$	$f_{2+}^{\#1\alpha\beta}$	$\omega_{2-}^{\#1\alpha\beta\chi}$
$\omega_{2+}^{\#1\alpha\beta} \dagger$	$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	0
$f_{2+}^{\#1\alpha\beta} \dagger$	$\frac{ikt_1}{\sqrt{2}}$	k^2t_1	0
$\omega_{2-}^{\#1\alpha\beta\chi} \dagger$	0	0	$k^2r_1+\frac{t_1}{2}$

	$\sigma_{0+}^{\#1}$	$\tau_{0+}^{\#1}$	$\tau_{0+}^{\#2}$	$\sigma_{0-}^{\#1}$
$\sigma_{0+}^{\#1} \dagger$	$\frac{1}{(1+2k^2)^2t_3}$	$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_3}$	0	0
$\tau_{0+}^{\#1} \dagger$	$\frac{i\sqrt{2}k}{(1+2k^2)^2t_3}$	$\frac{2k^2}{(1+2k^2)^2t_3}$	0	0
$\tau_{0+}^{\#2} \dagger$	0	0	0	0
$\sigma_{0-}^{\#1} \dagger$	0	0	0	$-\frac{1}{t_1}$

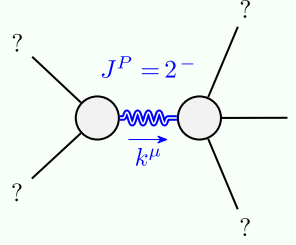
Source constraints/gauge generators	
SO(3) irreps	Multiplicities
$\tau_{0+}^{\#2} == 0$	1
$\tau_{0+}^{\#1}-2ik\sigma_{0+}^{\#1} == 0$	1
$\tau_{1-}^{\#2\alpha}+2ik\sigma_{1-}^{\#2\alpha} == 0$	3
$\tau_{1-}^{\#1\alpha} == 0$	3
$\tau_{1+}^{\#1\alpha\beta}+ik\sigma_{1+}^{\#2\alpha\beta} == 0$	3
$\tau_{2+}^{\#1\alpha\beta}-2ik\sigma_{2+}^{\#1\alpha\beta} == 0$	5
Total constraints:	16

	$\omega_{1+}^{\#1\alpha\beta}$	$\omega_{1+}^{\#2\alpha\beta}$	$f_{1+}^{\#1\alpha\beta}$	$\omega_{1-}^{\#1\alpha}$	$\omega_{1-}^{\#2\alpha}$	$f_{1-}^{\#1\alpha}$	$f_{1-}^{\#2\alpha}$
$\omega_{1+}^{\#1\alpha\beta} \dagger$	$k^2(2r_1+r_5)-\frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{ikt_1}{\sqrt{2}}$	0	0	0	0
$\omega_{1+}^{\#2\alpha\beta} \dagger$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$f_{1+}^{\#1\alpha\beta} \dagger$	$\frac{ikt_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega_{1-}^{\#1\alpha} \dagger$	0	0	0	$\frac{1}{6}(6k^2(r_1+r_5)+t_1+4t_3)$	$\frac{t_1-2t_3}{3\sqrt{2}}$	0	$\frac{1}{3}ik(t_1-2t_3)$
$\omega_{1-}^{\#2\alpha} \dagger$	0	0	0	$\frac{t_1-2t_3}{3\sqrt{2}}$	$\frac{t_1+t_3}{3}$	0	$\frac{1}{3}i\sqrt{2}k(t_1+t_3)$
$f_{1-}^{\#1\alpha} \dagger$	0	0	0	0	0	0	0
$f_{1-}^{\#2\alpha} \dagger$	0	0	0	$-\frac{1}{3}ik(t_1-2t_3)$	$-\frac{1}{3}i\sqrt{2}k(t_1+t_3)$	0	$\frac{2}{3}k^2(t_1+t_3)$

Massive and massless spectra



Massive particle	
Pole residue:	$-\frac{3(-2t_1t_3(t_1+t_3)+r_1(t_1^2+2t_3^2))+r_5(t_1^2+2t_3^2))}{2(r_1+r_5)(t_1+t_3)(-3t_1t_3+r_1(t_1+t_3)+r_5(t_1+t_3))} > 0$
Polarisations:	3
Square mass:	$-\frac{3t_1t_3}{2(r_1+r_5)(t_1+t_3)} > 0$
Spin:	1
Parity:	Odd



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

(No massless particles)

Unitarity conditions

$r_1 < 0 \ \&\& \ r_5 < -r_1 \ \&\& \ t_1 > 0 \ \&\& \ t_3 < -t_1 \ || \ t_3 > 0$