

Particle spectrograph

Wave operator and propagator

$\sigma_{1+}^{\#1} \alpha\beta$	$\sigma_{1+}^{\#2} \alpha\beta$	$\tau_{1+}^{\#1} \alpha\beta$	$\sigma_{1-}^{\#1} \alpha$	$\sigma_{1-}^{\#2} \alpha$	$\tau_{1-}^{\#1} \alpha$	$\tau_{1-}^{\#2} \alpha$
$\sigma_{1+}^{\#1} \dagger \alpha\beta$	$\frac{2(t_1+t_2)}{3t_1t_2+2k^2r_5(t_1+t_2)}$	$\frac{\sqrt{2}(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2r_5(t_1+t_2))}$	0	0	0	0
$\sigma_{1+}^{\#2} \dagger \alpha\beta$	$\frac{\sqrt{2}(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2r_5(t_1+t_2))}$	$\frac{6k^2r_5+t_1+4t_2}{(1+k^2)^2(3t_1t_2+2k^2r_5(t_1+t_2))}$	0	0	0	0
$\tau_{1+}^{\#1} \dagger \alpha\beta$	$-\frac{i\sqrt{2}k(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2r_5(t_1+t_2))}$	$-\frac{k^2(6k^2r_5+t_1+4t_2)}{(1+k^2)^2(3t_1t_2+2k^2r_5(t_1+t_2))}$	0	0	0	0
$\sigma_{1-}^{\#1} \dagger \alpha$	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	0	$\frac{2ik}{t_1+2k^2t_1}$
$\sigma_{1-}^{\#2} \dagger \alpha$	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$-\frac{2k^2r_5+t_1}{(t_1+2k^2t_1)^2}$	0	$-\frac{i\sqrt{2}k(2k^2r_5t_1)}{(t_1+2k^2t_1)^2}$
$\tau_{1-}^{\#1} \dagger \alpha$	0	0	0	0	0	0
$\tau_{1-}^{\#2} \dagger \alpha$	0	0	$-\frac{2ik}{t_1+2k^2t_1}$	$\frac{i\sqrt{2}k(2k^2r_5t_1)}{(t_1+2k^2t_1)^2}$	0	$-\frac{4k^4r_5+2k^2t_1}{(t_1+2k^2t_1)^2}$

Quadratic (free) Lagrangian density

$$\begin{aligned} & -t_1\omega_{\kappa\alpha}^{\alpha'}\omega_{\kappa\alpha}^{\kappa}-\frac{1}{3}t_1\omega_{\kappa\lambda}^{\kappa\lambda}\omega_{\kappa\lambda}^{\prime}+\frac{2}{3}t_2\omega_{\kappa\lambda}^{\kappa\lambda}\omega_{\kappa\lambda}^{\prime}+\frac{1}{3}t_1\omega_{\kappa\lambda}^{\kappa\lambda}\omega_{\kappa\lambda}^{\prime}+\frac{1}{3}t_1\omega_{\kappa\lambda}^{\kappa\lambda}\omega_{\kappa\lambda}^{\prime} \\ & \frac{1}{3}t_2\omega_{\kappa\lambda}^{\kappa\lambda}\omega_{\kappa\lambda}^{\prime}+\omega_{\alpha\beta}^{\alpha\beta}\tau_{\alpha\beta}+\omega_{\alpha\beta}^{\alpha\beta}\tau_{\alpha\beta}+\omega_{\alpha\beta}^{\alpha\beta}\tau_{\alpha\beta}+\omega_{\alpha\beta}^{\alpha\beta}\tau_{\alpha\beta}+\omega_{\alpha\beta}^{\alpha\beta}\tau_{\alpha\beta} \\ & \frac{2}{3}r_2\partial^\beta\omega_{\kappa}^{\alpha}\partial_\theta\omega_{\alpha\beta}^{\kappa}-\frac{1}{3}r_2\partial_\theta\omega_{\alpha\beta}^{\kappa}\partial_\kappa\omega_{\alpha\beta}^{\alpha\beta}-\frac{2}{3}r_2\partial_\theta\omega_{\alpha\beta}^{\kappa}\partial_\kappa\omega_{\alpha\beta}^{\alpha\beta}-\frac{2}{3}r_2\partial_\theta\omega_{\alpha\beta}^{\kappa}\partial_\kappa\omega_{\alpha\beta}^{\alpha\beta} \\ & r_5\partial_\alpha\omega_{\lambda\theta}^{\alpha}\partial_\kappa\omega_{\lambda\theta}^{\theta\kappa\lambda}+r_5\partial_\theta\omega_{\lambda\alpha}^{\alpha}\partial_\kappa\omega_{\lambda\alpha}^{\theta\kappa\lambda}-r_5\partial_\alpha\omega_{\lambda\theta}^{\alpha}\partial_\kappa\omega_{\lambda\theta}^{\theta\kappa\lambda} \\ & 2r_5\partial_\theta\omega_{\lambda\alpha}^{\alpha}\partial_\kappa\omega_{\lambda\alpha}^{\kappa\lambda\theta}-\frac{1}{3}t_1\partial^\alpha f_{\theta\kappa}\partial^\kappa f_{\alpha}^{\theta}+\frac{1}{6}t_2\partial^\alpha f_{\theta\kappa}\partial^\kappa f_{\alpha}^{\theta}-\frac{2}{3}t_1\partial^\alpha f_{\kappa\theta}\partial^\kappa f_{\alpha}^{\theta}- \\ & \frac{1}{6}t_2\partial^\alpha f_{\kappa\theta}\partial^\kappa f_{\alpha}^{\theta}-\frac{1}{3}t_1\partial^\alpha f_{\kappa}^{\lambda}\partial^\kappa f_{\alpha\lambda}^{\lambda}+\frac{1}{6}t_2\partial^\alpha f_{\kappa}^{\lambda}\partial^\kappa f_{\alpha\lambda}^{\lambda}+t_1\omega_{\kappa\alpha}^{\alpha}\partial^\kappa f_{\lambda}^{\prime}+ \\ & t_1\omega_{\kappa\lambda}^{\lambda}\partial^\kappa f_{\lambda}^{\prime}+2t_1\partial^\alpha f_{\kappa\alpha}\partial^\kappa f_{\lambda}^{\prime}-t_1\partial_\kappa f_{\lambda}^{\lambda}\partial^\kappa f_{\lambda}^{\prime}+\frac{1}{3}t_1\omega_{\theta\kappa}\partial^\kappa f_{\lambda}^{\prime\theta}+ \\ & \frac{1}{3}t_2\omega_{\theta\kappa}\partial^\kappa f_{\lambda}^{\prime\theta}+\frac{4}{3}t_1\omega_{\lambda\kappa\theta}\partial^\kappa f_{\lambda}^{\prime\theta}-\frac{2}{3}t_2\omega_{\lambda\kappa\theta}\partial^\kappa f_{\lambda}^{\prime\theta}-\frac{1}{3}t_1\omega_{\theta\lambda\kappa}\partial^\kappa f_{\lambda}^{\prime\theta}- \\ & \frac{1}{3}t_2\omega_{\theta\lambda\kappa}\partial^\kappa f_{\lambda}^{\prime\theta}+\frac{2}{3}t_1\omega_{\theta\kappa\lambda}\partial^\kappa f_{\lambda}^{\prime\theta}+\frac{2}{3}t_2\omega_{\theta\kappa\lambda}\partial^\kappa f_{\lambda}^{\prime\theta}-t_1\omega_{\lambda\alpha}^{\alpha}\partial^\kappa f_{\lambda}^{\prime}- \\ & t_1\omega_{\lambda\lambda}^{\lambda}\partial^\kappa f_{\lambda}^{\prime}+\frac{1}{3}t_1\partial^\alpha f_{\kappa}^{\lambda}\partial^\kappa f_{\lambda\alpha}^{\lambda}-\frac{1}{6}t_2\partial^\alpha f_{\kappa}^{\lambda}\partial^\kappa f_{\lambda\alpha}^{\lambda}+\frac{1}{3}t_1\partial_\kappa f_{\lambda}^{\lambda}\partial^\kappa f_{\lambda}^{\theta}- \\ & \frac{1}{6}t_2\partial_\kappa f_{\lambda}^{\lambda}\partial^\kappa f_{\lambda}^{\theta}+\frac{2}{3}t_1\partial_\kappa f_{\lambda}^{\lambda}\partial^\kappa f_{\lambda}^{\theta}+\frac{1}{6}t_2\partial_\kappa f_{\lambda}^{\lambda}\partial^\kappa f_{\lambda}^{\theta}-t_1\partial^\alpha f_{\lambda}^{\lambda}\partial^\kappa f_{\lambda\kappa}^{\alpha}+ \\ & \frac{1}{3}r_2\partial_\kappa\omega_{\alpha\beta\theta}^{\alpha}\partial^\kappa\omega_{\alpha\beta\theta}^{\alpha}+\frac{2}{3}r_2\partial_\kappa\omega_{\alpha\beta\theta}^{\alpha}\partial^\kappa\omega_{\alpha\beta\theta}^{\alpha}-\frac{2}{3}r_2\partial^\beta\omega_{\alpha\beta\theta}^{\alpha}\partial_\lambda\omega_{\alpha\beta}^{\lambda\prime}+ \\ & \frac{2}{3}r_2\partial^\beta\omega_{\lambda\alpha}^{\lambda\alpha}\partial_\lambda\omega_{\alpha\beta}^{\lambda\prime}+r_5\partial_\alpha\omega_{\lambda\theta}^{\alpha}\partial^\lambda\omega_{\lambda\theta}^{\theta\kappa}-r_5\partial_\theta\omega_{\lambda\alpha}^{\alpha}\partial^\lambda\omega_{\lambda\alpha}^{\theta\kappa} \end{aligned}$$

	$\omega_{1+}^{\#1} \alpha\beta$	$\omega_{1+}^{\#2} \alpha\beta$	$f_{1+}^{\#1} \alpha\beta$	$\omega_{1-}^{\#1} \alpha$	$\omega_{1-}^{\#2} \alpha$	$f_{1-}^{\#1} \alpha$	$f_{1-}^{\#2} \alpha$
$\omega_{1+}^{\#1} \dagger \alpha\beta$	$\frac{1}{6}(6k^2r_5+t_1+4t_2)$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$-\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	0	0	0	0
$\omega_{1+}^{\#2} \dagger \alpha\beta$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{t_1+t_2}{3}$	$\frac{1}{3}ik(t_1+t_2)$	0	0	0	0
$f_{1+}^{\#1} \dagger \alpha\beta$	$\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	$-\frac{1}{3}ik(t_1+t_2)$	$\frac{1}{3}k^2(t_1+t_2)$	0	0	0	0
$\omega_{1-}^{\#1} \dagger \alpha$	0	0	0	$k^2r_5-\frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0	$ik t_1$
$\omega_{1-}^{\#2} \dagger \alpha$	0	0	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
$f_{1-}^{\#1} \dagger \alpha$	0	0	0	0	0	0	0
$f_{1-}^{\#2} \dagger \alpha$	0	0	0	$-ik t_1$	0	0	0

$\omega_0^{\#1} \dagger$	$f_0^{\#1} \dagger$	$\omega_0^{\#1}$
0	0	0
0	0	0
0	0	0
0	0	0

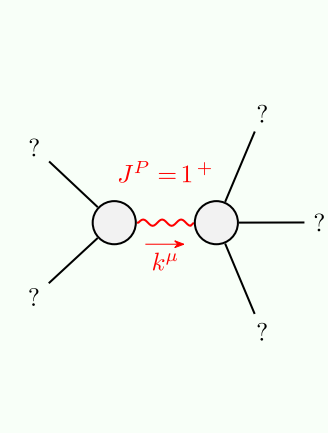
$\sigma_{0+}^{\#1} \dagger$	$\tau_{0+}^{\#1} \dagger$	$\tau_{0+}^{\#2} \dagger$	$\sigma_{0-}^{\#1} \dagger$
$-\frac{1}{(1+2k^2)^2t_1}$	$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_1}$	0	0
$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_1}$	$-\frac{2k^2}{(1+2k^2)^2t_1}$	0	0
0	0	0	0
0	0	0	$\frac{1}{k^2r_2+t_2}$

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

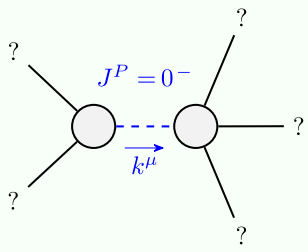
$\sigma_{2+}^{\#1} \dagger \alpha\beta$	$\tau_{2+}^{\#1} \alpha\beta$	$\sigma_{2-}^{\#1} \alpha\beta\chi$
$\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	0
$\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	$\frac{4k^2}{(1+2k^2)^2t_1}$	0
0	0	$\frac{2}{t_1}$

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

Massive and massless spectra



Massive particle	
Pole residue:	$\frac{-3t_1t_2(t_1+t_2)+3r_5(t_1^2+2t_2^2)}{r_5(t_1+t_2)(-3t_1t_2+2r_5(t_1+t_2))} > 0$
Polarisations:	3
Square mass:	$-\frac{3t_1t_2}{2r_5t_1+2r_5t_2} > 0$
Spin:	1
Parity:	Even



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

$r_2 < 0 \ \&\& \ r_5 > 0 \ \&\& \ t_1 < 0 \ \&\& \ t_2 > -t_1$