

# Particle spectrograph

## Wave operator and propagator

	$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1-}^{\#1} \dagger^{\alpha}$	$\sigma_{1-}^{\#2} \dagger^{\alpha}$	$\tau_{1-}^{\#1} \dagger^{\alpha}$	$\tau_{1-}^{\#2} \dagger^{\alpha}$
$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	0	$\frac{2\sqrt{2}}{\alpha_0 + \alpha_0 k^2}$	$\frac{2i\sqrt{2}k}{\alpha_0 + \alpha_0 k^2}$	0	0	0	0
$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$\frac{2\sqrt{2}}{\alpha_0 + \alpha_0 k^2}$	$-\frac{2}{\alpha_0(1+k^2)^2}$	$-\frac{2ik}{\alpha_0(1+k^2)^2}$	0	0	0	0
$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{2i\sqrt{2}k}{\alpha_0 + \alpha_0 k^2}$	$\frac{2ik}{\alpha_0(1+k^2)^2}$	$-\frac{2k^2}{\alpha_0(1+k^2)^2}$	0	0	0	0
$\sigma_{1-}^{\#1} \dagger^{\alpha}$	0	0	0	0	$-\frac{2\sqrt{2}}{\alpha_0 + 2\alpha_0 k^2}$	0	$-\frac{4ik}{\alpha_0 + 2\alpha_0 k^2}$
$\sigma_{1-}^{\#2} \dagger^{\alpha}$	0	0	0	$-\frac{2\sqrt{2}}{\alpha_0 + 2\alpha_0 k^2}$	$-\frac{2}{\alpha_0(1+2k^2)^2}$	0	$-\frac{2i\sqrt{2}k}{\alpha_0(1+2k^2)^2}$
$\tau_{1-}^{\#1} \dagger^{\alpha}$	0	0	0	0	0	0	0
$\tau_{1-}^{\#2} \dagger^{\alpha}$	0	0	0	$\frac{4ik}{\alpha_0 + 2\alpha_0 k^2}$	$\frac{2i\sqrt{2}k}{\alpha_0(1+2k^2)^2}$	0	$-\frac{4k^2}{\alpha_0(1+2k^2)^2}$

Quadratic (free) Lagrangian density
 
$$\begin{aligned}
 &-\frac{1}{2}\alpha_0\,\omega_{\alpha\zeta\beta}\,\omega^{\alpha\beta\zeta}-\frac{1}{2}\alpha_0\,\omega^{\alpha\beta}{}_{\alpha}\,\omega_{\beta}{}^{\zeta}{}_{\zeta}+f^{\alpha\beta}\,\tau_{\alpha\beta}+\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi}- \\
 &\alpha_0\,f^{\alpha\beta}\,\partial_{\beta}\omega_{\alpha}{}^{\zeta}{}_{\zeta}+\alpha_0\,\partial_{\beta}\omega^{\alpha\beta}{}_{\alpha}+\alpha_0\,f^{\alpha\beta}\,\partial_{\zeta}\omega_{\alpha}{}^{\zeta}{}_{\beta}-\alpha_0\,f^{\alpha}{}_{\alpha}\,\partial_{\zeta}\omega^{\beta\zeta}{}_{\beta}
 \end{aligned}$$

	$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1-}^{\#1} \dagger^{\alpha}$	$\omega_{1-}^{\#2} \dagger^{\alpha}$	$f_{1-}^{\#1} \dagger^{\alpha}$	$f_{1-}^{\#2} \dagger^{\alpha}$
$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{\alpha_0}{4}$	$\frac{\alpha_0}{2\sqrt{2}}$	$-\frac{i\alpha_0 k}{2\sqrt{2}}$	0	0	0	0
$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$\frac{\alpha_0}{2\sqrt{2}}$	0	0	0	0	0	0
$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{i\alpha_0 k}{2\sqrt{2}}$	0	0	0	0	0	0
$\omega_{1-}^{\#1} \dagger^{\alpha}$	0	0	0	$\frac{\alpha_0}{4}$	$-\frac{\alpha_0}{2\sqrt{2}}$	0	$-\frac{1}{2}i\alpha_0 k$
$\omega_{1-}^{\#2} \dagger^{\alpha}$	0	0	0	$-\frac{\alpha_0}{2\sqrt{2}}$	0	0	0
$f_{1-}^{\#1} \dagger^{\alpha}$	0	0	0	0	0	0	0
$f_{1-}^{\#2} \dagger^{\alpha}$	0	0	0	$\frac{i\alpha_0 k}{2}$	0	0	0

	$\omega_{0+}^{\#1} \dagger$	$f_{0+}^{\#1} \dagger$	$f_{0+}^{\#2} \dagger$	$\omega_{0-}^{\#1} \dagger$
$\omega_{0+}^{\#1} \dagger$	$\frac{\alpha_0}{2}$	$-\frac{i\alpha_0 k}{\sqrt{2}}$	0	0
$f_{0+}^{\#1} \dagger$	$\frac{i\alpha_0 k}{\sqrt{2}}$	0	0	0
$f_{0+}^{\#2} \dagger$	0	0	0	0
$\omega_{0-}^{\#1} \dagger$	0	0	0	$\frac{\alpha_0}{2}$

	$\sigma_{0+}^{\#1} \dagger$	$\tau_{0+}^{\#1} \dagger$	$\tau_{0+}^{\#2} \dagger$	$\sigma_{0-}^{\#1} \dagger$
$\sigma_{0+}^{\#1} \dagger$	0	$-\frac{i\sqrt{2}}{\alpha_0 k}$	0	0
$\tau_{0+}^{\#1} \dagger$	$\frac{i\sqrt{2}}{\alpha_0 k}$	$-\frac{1}{\alpha_0 k^2}$	0	0
$\tau_{0+}^{\#2} \dagger$	0	0	0	0
$\sigma_{0-}^{\#1} \dagger$	0	0	0	$\frac{2}{\alpha_0}$

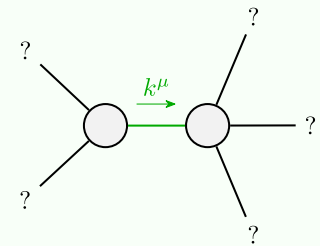
	$\sigma_{2+}^{\#1} \dagger^{\alpha\beta}$	$\tau_{2+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{2-}^{\#1} \dagger^{\alpha\beta\chi}$
$\sigma_{2+}^{\#1} \dagger^{\alpha\beta}$	0	$\frac{2i\sqrt{2}}{\alpha_0 k}$	0
$\tau_{2+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{2i\sqrt{2}}{\alpha_0 k}$	$\frac{2}{\alpha_0 k^2}$	0
$\sigma_{2-}^{\#1} \dagger^{\alpha\beta\chi}$	0	0	$-\frac{4}{\alpha_0}$

	$\omega_{2+}^{\#1} \dagger^{\alpha\beta}$	$f_{2+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2-}^{\#1} \dagger^{\alpha\beta\chi}$
$\omega_{2+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{\alpha_0}{4}$	$\frac{i\alpha_0 k}{2\sqrt{2}}$	0
$f_{2+}^{\#1} \dagger^{\alpha\beta}$	$\frac{i\alpha_0 k}{2\sqrt{2}}$	0	0
$\omega_{2-}^{\#1} \dagger^{\alpha\beta\chi}$	0	0	$-\frac{\alpha_0}{4}$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau_{0+}^{\#2} == 0$	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
Total constraints:	10

## Massive and massless spectra



Quadratic pole	
Pole residue:	$\frac{1}{\alpha_0} > 0$
Polarisations:	2

(No massive particles)

## Unitarity conditions

$\alpha_0 > 0$