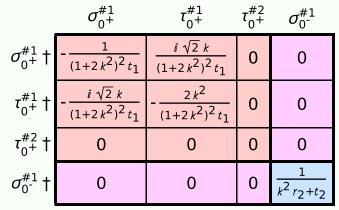
## Particle spectrograph

## Wave operator and propagator



_	$\sigma_{2}^{\#1}{}_{lphaeta}$	$ au_2^{\#1}_{lphaeta}$	$\sigma_{2}^{\#1}{}_{\alpha\beta\chi}$
$\sigma_{2}^{\#1}\dagger^{lphaeta}$	$\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	0
$ au_2^{\#1}\dagger^{lphaeta}$	$\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	$\frac{4k^2}{(1+2k^2)^2t_1}$	0
$\sigma_2^{\#1} \dagger^{lphaeta\chi}$	0	0	$\frac{2}{t_1}$

$\mathcal{A}_{0}^{\#1} + \begin{array}{c ccccccccccccccccccccccccccccccccccc$
v
a#2 .
$f_{0+}^{\#2}\dagger$ 0 0 0 0
$\mathcal{A}_{0}^{\#1} + 0 \qquad 0 \qquad k^2 r_2 + t_2$

Source constraints		
SO(3) irreps	Fundamental fields	Multiplicities
$\tau_{0+}^{\#2} == 0$	$\partial_{\beta}\partial_{\alpha}\tau^{\alpha\beta} == 0$	1
$\tau_{0+}^{\#1} - 2  \bar{\imath}  k  \sigma_{0+}^{\#1} == 0$	$\partial_{\beta}\partial_{\alpha}\tau^{\alpha\beta} = \partial_{\beta}\partial^{\beta}\tau^{\alpha}_{\alpha} + 2\partial_{\chi}\partial^{\chi}\partial_{\beta}\sigma^{\alpha\beta}_{\alpha}$	1
$\tau_{1}^{\#2\alpha} + 2  i  k  \sigma_{1}^{\#2\alpha} == 0$	$\partial_{\chi}\partial_{\beta}\partial^{\alpha}\tau^{\beta\chi} = \partial_{\chi}\partial^{\chi}\partial_{\beta}\tau^{\alpha\beta} + 2\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial_{\beta}\sigma^{\alpha\beta\chi}$	3
$\tau_{1}^{\#1}{}^{\alpha} == 0$	$\partial_{\chi}\partial_{\beta}\partial^{\alpha}\tau^{\beta\chi} == \partial_{\chi}\partial^{\chi}\partial_{\beta}\tau^{\beta\alpha}$	3
$\tau_{1+}^{\#1\alpha\beta} + i k \sigma_{1+}^{\#2\alpha\beta} == 0$	$\partial_{\chi}\partial^{\alpha}\tau^{\beta\chi} + \partial_{\chi}\partial^{\beta}\tau^{\chi\alpha} + \partial_{\chi}\partial^{\chi}\tau^{\alpha\beta} +$	3
	$2 \partial_{\delta} \partial_{\chi} \partial^{\alpha} \sigma^{\beta \chi \delta} + 2 \partial_{\delta} \partial^{\delta} \partial_{\chi} \sigma^{\alpha \beta \chi} = =$	
	$\partial_{\chi}\partial^{\alpha}\tau^{\chi\beta} + \partial_{\chi}\partial^{\beta}\tau^{\alpha\chi} +$	
	$\partial_{\chi}\partial^{\chi}\tau^{\beta\alpha} + 2\partial_{\delta}\partial_{\chi}\partial^{\beta}\sigma^{\alpha\chi\delta}$	
$\tau_{2^{+}}^{\#1\alpha\beta} - 2ik\sigma_{2^{+}}^{\#1\alpha\beta} == 0$	$-i \left(4 \partial_{\delta} \partial_{\chi} \partial^{\beta} \partial^{\alpha} \tau^{\chi \delta} + 2 \partial_{\delta} \partial^{\delta} \partial^{\beta} \partial^{\alpha} \tau^{\chi} \right)$	5
	$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\alpha} \tau^{\beta \chi} - 3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\alpha} \tau^{\chi \beta} -$	
	$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\beta} \tau^{\alpha \chi} - 3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\beta} \tau^{\chi \alpha} +$	
	$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\chi} \tau^{\alpha\beta} + 3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\chi} \tau^{\beta\alpha} +$	
	$4 i k^{X} \partial_{\epsilon} \partial_{\chi} \partial^{\beta} \partial^{\alpha} \sigma^{\delta \epsilon}_{\delta} -$	
	$6 i k^{\chi} \partial_{\epsilon} \partial_{\delta} \partial_{\chi} \partial^{\alpha} \sigma^{\beta \delta \epsilon} -$	
	$6 i k^{\chi} \partial_{\epsilon} \partial_{\delta} \partial_{\chi} \partial^{\beta} \sigma^{\alpha \delta \epsilon} +$	
	$2 \eta^{\alpha\beta} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial_{\chi} \tau^{\chi\delta} +$	
	$6 i k^{\chi} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial_{\chi} \sigma^{\alpha \delta \beta} +$	
	$6 i k^{X} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial_{X} \sigma^{\beta \delta \alpha} -$	
	$2 \eta^{\alpha\beta} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\delta} \tau^{\chi}_{\chi}$ -	
	$4 i \eta^{\alpha\beta} k^{\chi} \partial_{\phi} \partial^{\phi} \partial_{\epsilon} \partial_{\chi} \sigma^{\delta\epsilon} ) == 0$	
Total constraints/gau	ge generators:	16

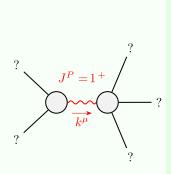
_	$\mathcal{A}_{2}^{\#1}{}_{lphaeta}$	$f_{2^{+}\alpha\beta}^{\#1}$	$\mathcal{A}_{2^{-}lphaeta\chi}^{\#1}$
$\mathcal{A}_{2}^{\sharp 1}\dagger^{lphaeta}$	<u>t</u> 1 2	$-\frac{ikt_1}{\sqrt{2}}$	0
$f_2^{#1}\dagger^{\alpha\beta}$	$\frac{i k t_1}{\sqrt{2}}$	$k^2 t_1$	0
${\mathscr H}_2^{\sharp_1}\!\dagger^{lphaeta\chi}$	0	0	<u>t</u> 1 2

$\tau_{1}^{\#2}{}_{\alpha}$	0	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	$\frac{-4k^4r_5 + 2k^2t_1}{(t_1 + 2k^2t_1)^2}$
$\tau_{1}^{\#1}{}_{\alpha}$	0	0	0	0	0	0	0
$\sigma_{1}^{\#2}{}_{lpha}$	0	0	0	$\frac{\sqrt{2}}{t_1 + 2k^2t_1}$	$\frac{-2 k^2 r_5 + t_1}{(t_1 + 2 k^2 t_1)^2}$	0	$\frac{i\sqrt{2} k(2k^2 r_5 - t_1)}{(t_1 + 2k^2 t_1)^2}$
$\sigma_{1^{\text{-}}\alpha}^{\#1}$	0	0	0	0	$\frac{\sqrt{2}}{t_1 + 2k^2t_1}$	0	$-\frac{2ik}{t_1+2k^2t_1}$
${\tau_1^{\#}}_1^1$	$\frac{i\sqrt{2}k(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2r_5(t_1+t_2))}$	$\frac{i k (6 k^2 r_5 + t_1 + 4 t_2)}{(1 + k^2)^2 (3 t_1 t_2 + 2 k^2 r_5 (t_1 + t_2))}$	$\frac{k^2 \left(6  k^2  r_5 + t_1 + 4  t_2\right)}{\left(1 + k^2\right)^2 \left(3  t_1  t_2 + 2  k^2  r_5 \left(t_1 + t_2\right)\right)}$	0	0	0	0
$\sigma_{1}^{\#2}{}_{\alpha\beta}$	$\frac{\sqrt{2} (t_1 - 2t_2)}{(1 + k^2) (3t_1 t_2 + 2k^2 r_5 (t_1 + t_2))}$	$\frac{6 k^2 r_5 + t_1 + 4 t_2}{(1 + k^2)^2 (3 t_1 t_2 + 2 k^2 r_5 (t_1 + t_2))}$	$-\frac{ik(6k^2r_5+t_1+4t_2)}{(1+k^2)^2(3t_1t_2+2k^2r_5(t_1+t_2))}$	0	0	0	0
$\sigma_{1}^{\#1}{}_{\alpha\beta}$	3t1t	$\frac{\sqrt{2} (t_1 - 2t_2)}{(1 + k^2) (3t_1 t_2 + 2k^2 r_5 (t_1 + t_2))}$	$-\frac{i\sqrt{2}k(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2r_5(t_1+t_2))}$	0	0	0	0
	$\sigma_{1}^{\#1} + \alpha^{eta}$	$\sigma_{1}^{\#2} + \alpha \beta$	$\tau_1^{#1} + \alpha \beta$	$\sigma_{1}^{\#1} +^{\alpha}$	$\sigma_1^{\#2} +^{\alpha}$	$t_{1}^{#1} + ^{\alpha}$	$t_1^{\#2} + ^{\alpha}$

	${\cal A}_{1}^{\sharp 1}{}_{lphaeta}$	${\cal A}_{1}^{\#2}{}_{lphaeta}$	$f_{1^{+}lphaeta}^{\#1}$	${\mathscr R}_{1^{-}\;lpha}^{\sharp 1}$	$\mathcal{A}_{1}^{\#2}{}_{lpha}$	$f_{1-\alpha}^{\#1}$	$f_{1-\alpha}^{#2}$
$(1^{+1}_{1} + \alpha \beta)$	$\frac{1}{6} \left( 6  k^2  r_5 + t_1 + 4  t_2 \right)$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$-\frac{i k (t_1 - 2 t_2)}{3 \sqrt{2}}$	0	0	0	0
$I_{1}^{\#2} + \alpha \beta$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{t_1+t_2}{3}$	$\frac{1}{3}\bar{l}k(t_1+t_2)$	0	0	0	0
$f_{1}^{#1} + \alpha \beta$	$\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	$-\frac{1}{3}ik(t_1+t_2)$	•		0	0	0
$\mathcal{A}_{1}^{\#1} + \alpha$	0	0	0	$k^2 r_5 - \frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0	ikt <sub>1</sub>
$\mathcal{A}_{1}^{\#2} + \alpha$	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	-	0	0	0

Quadratic (free) action
S==
$\iiint (\frac{1}{6} (6t_1 \mathcal{A}_{\alpha}^{\alpha_i} \mathcal{A}_{i\theta}^{\theta} + 6f^{\alpha\beta} \tau_{\alpha\beta} + 6\mathcal{A}^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - 12t_1 \mathcal{A}_{\alpha\theta}^{\theta} \partial_i f^{\alpha_i} + 12)$
$t_1  \mathcal{H}_{i  \theta}^{ \theta}  \partial^i f^{lpha}_{  lpha} - 6  t_1  \partial_i f^{  heta}_{    heta} \partial^i f^{ lpha}_{    lpha} - 6  t_1  \partial_i f^{ lpha i}  \partial_{ heta} f^{$
$12 t_1 \partial' f^{\alpha}_{\alpha} \partial_{\theta} f_{i}^{\theta} + 4 t_1 \mathcal{A}_{i\theta\alpha} \partial^{\theta} f^{\alpha i} + 4 t_2 \mathcal{A}_{i\theta\alpha} \partial^{\theta} f^{\alpha i} -$
$4t_1\partial_{\alpha}f_{i\theta}\partial^{\theta}f^{\alpha i} + 2t_2\partial_{\alpha}f_{i\theta}\partial^{\theta}f^{\alpha i} - 4t_1\partial_{\alpha}f_{\theta i}\partial^{\theta}f^{\alpha i} -$
$t_2  \partial_{\alpha} f_{\theta_i} \partial^{\theta} f^{\alpha_i} + 2  t_1  \partial_{i} f_{\alpha \theta} \partial^{\theta} f^{\alpha_i} - t_2  \partial_{i} f_{\alpha \theta} \partial^{\theta} f^{\alpha_i} +$
$4 t_1 \partial_{\theta} f_{\alpha_{I}} \partial^{\theta} f^{\alpha_{I}} + t_2 \partial_{\theta} f_{\alpha_{I}} \partial^{\theta} f^{\alpha_{I}} + 2 t_1 \partial_{\theta} f_{I\alpha} \partial^{\theta} f^{\alpha_{I}} -$
$t_2  \partial_{\theta} f_{i\alpha} \partial^{\theta} f^{\alpha i} + 2 (t_1 + t_2)  \mathcal{A}_{\alpha i \theta} (\mathcal{A}^{\alpha i \theta} + 2  \partial^{\theta} f^{\alpha i}) +$
$2 \mathcal{A}_{\alpha\theta \iota} ((t_1 - 2t_2) \mathcal{A}^{\alpha\iota\theta} + 2 (2t_1 - t_2) \partial^{\theta} f^{\alpha\iota}) +$
$8r_2\partial_\beta\mathcal{A}_{\alpha_I\theta}\partial^\theta\mathcal{A}^{\alpha\beta_I}-4r_2\partial_\beta\mathcal{A}_{\alpha\theta_I}\partial^\theta\mathcal{A}^{\alpha\beta_I}+$
$4r_2\partial_\beta\mathcal{A}_{_I\theta\alpha}\partial^\theta\mathcal{A}^{\alpha\beta_I}-2r_2\partial_\iota\mathcal{A}_{\alpha\beta\theta}\partial^\theta\mathcal{A}^{\alpha\beta_I}+$
$2r_2\partial_\theta\mathcal{A}_{\alpha\beta_l}\partial^\theta\mathcal{A}^{\alpha\beta_l}-4r_2\partial_\theta\mathcal{A}_{\alpha_l\beta}\partial^\theta\mathcal{A}^{\alpha\beta_l}+6r_5\partial_\iota\mathcal{A}_\theta^{\ \ \kappa}$
$\partial^{\theta}\mathcal{A}^{\alpha_{l}}_{\alpha} - 6r_{5}\partial_{\theta}\mathcal{A}_{l\kappa}^{\kappa}\partial^{\theta}\mathcal{A}^{\alpha_{l}}_{\alpha} - 6r_{5}\partial_{\alpha}\mathcal{A}^{\alpha_{l}\theta}\partial_{\kappa}\mathcal{A}_{l\theta}^{\kappa} +$
$12 r_5 \partial^{\theta} \mathcal{A}^{\alpha_{l}}{}_{\alpha} \partial_{\kappa} \mathcal{A}_{l}{}_{\theta}^{\kappa} + 6 r_5 \partial_{\alpha} \mathcal{A}^{\alpha_{l} \theta} \partial_{\kappa} \mathcal{A}_{\theta}{}_{l}^{\kappa} -$
$12 r_5 \partial^{\theta} \mathcal{A}^{\alpha_l}_{\alpha} \partial_{\kappa} \mathcal{A}_{\theta_l}^{\kappa}))[t, x, y, z] dz dy dx dt$

## 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		

?	$J^P = 0^-$ $k^{\mu}$	?
ţ		?

Massive particle				
$-\frac{1}{r_2} > 0$				
1				
$-\frac{t_2}{r_2} > 0$				
0				
Odd				

(No massless particles)

## Unitarity conditions

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