## Particle spectrograph

## Wave operator and propagator

Source constraints		
SO(3) irreps	Fundamental fields	Multiplicities
$\tau_{0}^{#2} == 0$	$\partial_{\beta}\partial_{\alpha}\tau^{\alpha\beta} == 0$	1
$t_0^{#1} == 0$	$\partial_{\beta}\partial_{\alpha}\tau^{\alpha\beta} == \partial_{\beta}\partial^{\beta}\tau^{\alpha}$	1
$t_1^{\#2}\alpha + 2ik \ \sigma_1^{\#1}\alpha == 0$	$\partial_{\chi}\partial_{\beta}\partial^{\alpha}t^{\beta\chi}+$	3
	$_{2}$ ( $\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\alpha}\sigma^{eta\chi}_{}$ , $\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial_{eta}\sigma^{lphaeta\chi}$ +	
	$\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\chi}\sigma^{\alpha\beta}$ ) == $\partial_{\chi}\partial^{\chi}\partial^{\beta}\tau^{\alpha\beta}$	
$\tau_{1}^{\#1}{}^{\alpha} == 0$	$\partial_{\chi}\partial_{\beta}\partial^{\alpha}\tau^{\beta\chi} == \partial_{\chi}\partial^{\chi}\partial_{\beta}\tau^{\beta\alpha}$	3
$\sigma_{1}^{\#1}{}^{\alpha} := \sigma_{1}^{\#2}{}^{\alpha}$	$\partial_{\chi}\partial^{\alpha}\sigma^{\beta\chi}_{\beta} + \partial_{\chi}\partial^{\chi}\sigma^{\alpha\beta}_{\beta} == 0$	3
$\tau_{1}^{\#1}\alpha\beta + ik \ \sigma_{1}^{\#2}\alpha\beta == 0$	$\partial_{\chi}\partial^{\alpha}\tau^{\beta\chi} + \partial_{\chi}\partial^{\beta}\tau^{\chi\alpha} + \partial_{\chi}\partial^{\chi}\tau^{\alpha\beta} +$	3
	$2 \partial_{\delta} \partial_{\chi} \partial^{\alpha} \sigma^{\beta \chi \delta} + 2 \partial_{\delta} \partial^{\delta} \partial_{\chi} \sigma^{\alpha \beta \chi} = =$	
	$\partial_{\chi}\partial^{\alpha}\tau^{\chi\beta} + \partial_{\chi}\partial^{\beta}\tau^{\alpha\chi} +$	
	$\partial_{\chi}\partial^{\chi}\tau^{etalpha}+2\partial_{\delta}\partial_{\chi}\partial^{eta}\sigma^{lpha\chi\delta}$	
$\tau_{2}^{\#1}\alpha\beta - 2ik \ \sigma_{2}^{\#1}\alpha\beta == 0$	$-2ik \sigma_{2+}^{\#1}\alpha\beta == 0 -i(4\partial_{\delta}\partial_{\chi}\partial^{\beta}\partial^{\alpha}\tau^{\chi\delta} + 2\partial_{\delta}\partial^{\delta}\partial^{\alpha}\tau^{\chi}_{\chi} -$	5
	$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\alpha} \tau^{\beta \chi} - 3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\alpha} \tau^{\chi \beta} -$	
	$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\beta} \tau^{\alpha \chi} - 3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\beta} \tau^{\chi \alpha} +$	
	$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\chi} \tau^{\alpha \beta} + 3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\chi} \tau^{\beta \alpha} +$	
	$4\ ^{ec{l}}\ k^{\chi}\ \partial_{\epsilon}\partial_{\chi}\partial^{eta}\partial^{lpha}\sigma^{\delta\epsilon}_{\ \ \delta}$ -	
	$6 i k^{\chi} \partial_{\epsilon} \partial_{\delta} \partial_{\chi} \partial^{\alpha} \sigma^{\beta \delta \epsilon}$ -	
	$6 i k^{\chi} \partial_{\epsilon} \partial_{\delta} \partial_{\chi} \partial^{\beta} \sigma^{\alpha \delta \epsilon} +$	
	$2 \eta^{\alpha\beta} \partial_{\epsilon} \partial_{\epsilon} \partial_{\delta} \partial_{\chi} \tau^{\chi\delta} +$	
	$6 i k^{\chi} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial_{\chi} \sigma^{\alpha \delta \beta} +$	
	$6$ $i$ $k^{\chi}$ $\partial_{\epsilon}\partial^{\epsilon}\partial_{\delta}\partial_{\chi}\sigma^{eta\deltalpha}$ -	
	$2 \eta^{\alpha\beta} \partial_{\epsilon} \partial_{\delta} \partial_{\delta} \partial^{\zeta} \chi_{\chi}^{-}$	
	$4  \bar{l}  \eta^{\alpha\beta}  k^{\chi}  \partial_{\phi} \partial^{\phi} \partial_{\epsilon} \partial_{\chi} \sigma^{\delta \epsilon}_{\delta}) = 0$	
Total constraints/gauge generators:	ge generators:	19

		+	- <sub>12</sub>										
+	$\partial'\omega^{\alpha\beta}$	$^{3'}\partial_{ heta}\omega_{_{}}^{ heta}$	$^{\prime}_{i\thetalpha}\partial_{\theta}f_{\epsilon}$	- <sub>1</sub> ω <sub>f</sub>	+	<i>f</i> α′ -	+ (,,,						
$\omega_{\alpha}^{\theta}\partial_{}f$	r $_3\partial_eta\omega_{_{_{_{_{_{_{_{_{_{_{_{_{_{_{_{_{_{_{$	$\Gamma_3  \partial_{\alpha} \omega^{\alpha \beta}$	$'+4t_2 \omega$	$_{1}\partial_{\alpha}f_{ heta},\partial^{\epsilon}$	$f_{\alpha\theta}\partial^{\theta}f^{\alpha\prime}$	$\partial_{\theta} f_{I\alpha} \partial^{\theta}_{J}$	$\theta + 2 \partial^{\theta} f$	$+(_{\alpha}f_{\alpha'})+$	+ '8	αβι_	- ιθχ	ı dix dit	
$\alpha \beta \chi^{-} 4 t_1$	$f^{\alpha}$ - 24,	<sub>θ</sub> , θ - 24	$^{1  heta lpha} \partial_{ heta} f_{lpha}$	$^{artheta}f^{lpha\prime}$ - 4 $t$	$f^{\alpha\prime}$ - $t_2  \partial_{ij}$	$f^{\alpha\prime} + 2 t_1$	$_{lpha^{\prime} heta}$ ( $\omega^{lpha^{\prime}}$	$2t_1-t_2)$	$_{lpha  heta ^{\prime }}^{lpha } \partial _{ heta }^{lpha } \omega _{lpha ^{\prime }}^{lpha }$	$\omega_{, \theta lpha} \partial^{ heta} \omega$	$ u_{\alpha\beta_{l}}\partial^{\theta}\omega^{c}$	z] d z d  ı	
$\omega^{\alpha p \chi} \ \sigma$	$_{1}\partial_{i}f^{\theta}{}_{\theta}\partial_{i}$	$t_1  \partial' f^{lpha}_{\ \ lpha} \dot{\epsilon}$	$+4t_1 \alpha$	$t_2  \partial_{\alpha} f_{I \theta} \hat{c}$	$\partial_i f_{\alpha\theta} \partial^{\theta_j}$	$\partial_{\theta} f_{\alpha_{I}} \partial^{\theta_{J}}$	$_1+t_2)$ $\omega$	$a^{\alpha \theta} + 2$ (	$4 r_2 \partial_{\beta} \omega_{\beta}$	$24 r_3 \partial_{\beta} c$	$+2r_2\partial_{\theta}u$	][t, x, y,	
$^{3} \tau_{\alpha\beta} + 6$	$f^{\alpha}_{\alpha}$ -2t	$_{\theta}f_{\alpha}^{\ \ \theta}+4$	$^3_{\alpha}\partial_{\theta}\omega_{,\beta}^{$	$^{10}f^{\alpha\prime}+2$	$t^{\alpha\prime} + 2 t_1$	$^{artheta}f^{lpha\prime}+t_{2}$	$t^{\alpha\prime} + 2 (t)$	$-2t_2$ ) $\omega$	$, \partial^{\theta}\omega^{\alpha\beta\prime}$ -	$^{\prime}\partial^{\theta}\omega^{\alpha\beta\prime}$ -	$^{,}\partial^{ heta}\omega^{lphaeta_{'}}$	$\partial^{\theta}\omega^{lphaeta_{\prime}}))$	:
$\theta + e^{f_{\alpha b}}$	$\theta^{\theta}$ $\theta^{1}$	$f_1 \partial_i f^{\alpha i} \partial_i$	$3 r_3 \partial' \omega^{\alpha l}$	$\beta_{1} \partial_{\alpha} f_{1\theta} \partial_{\beta}$	$\partial_{\alpha}f_{\theta},\partial^{\theta}f$	$i_1 \partial_{\theta} f_{\alpha_I} \partial_{\alpha_I}$	$\partial_{\theta} f_{\prime\alpha} \partial^{\theta} f_{}$	$\omega_{lpha  heta_{\prime}}$ (( $t_1$	$^{'2}\partial_{eta}\omega_{lpha_{eta}}$	$^{'2}\partial_{eta}\omega_{_{I}\Thetalpha}$	'2 $\partial_{i}\omega_{\alphaeta \epsilon}$	$\gamma_2 \partial_{\theta} \omega_{lpha i eta}$	
$\omega^{\alpha\prime}_{\alpha} \omega^{\theta}_{\prime}$	4	2 t	48	4	$t_2$	4	<i>t</i> <sub>2</sub>	2	8	4	27	4	:
$\frac{1}{6} (2t_1 a)$													:
= ]]]][(													
	$S == \iiint_{\theta} (2t_1  \omega^{\alpha}_{\alpha}  \omega^{\theta}_{\beta} + 6  f^{\alpha \rho}  \tau_{\alpha \beta} + 6  \omega^{\alpha \rho \chi}  \sigma_{\alpha \beta \chi} - 4  t_1  \omega^{\theta}_{\alpha  \theta}  \partial_{\beta} f^{\alpha \prime} +$	$= \iiint (\frac{1}{6} (2t_1 \ \omega^{\alpha_{\prime}} \ \omega_{\prime}^{\prime  \theta} + 6 \ f^{\mu \rho} \ \tau_{\alpha \beta} + 6 \ \omega^{\mu \rho \lambda} \ \sigma_{\alpha \beta \chi} - 4t_1 \ \omega_{\alpha}^{\ \theta} \ \partial_{\prime} f^{\alpha \prime} + \\ 4t_1 \ \omega_{\prime}^{\ \theta} \ \partial^{\prime} f^{\alpha} - 2t_1 \ \partial_{\prime} f^{\theta} \ \partial^{\prime} f^{\alpha} - 24 \ r_3 \ \partial_{\beta} \omega_{\prime}^{\ \theta} \ \partial^{\prime} \omega^{\alpha \beta} \ -$	$= \iiint \left(\frac{1}{6} \left(2t_1 \ \omega^{\alpha_l} \ \omega^{ \beta}_{l} + 6 \ f^{\mu \rho} \ \tau_{\alpha \beta} + 6 \ \omega^{\mu \rho \chi} \ \sigma_{\alpha \beta \chi} - 4t_1 \ \omega^{ \beta}_{\alpha} \ \partial_{l} f^{\alpha_{l}} + \right. $ $\left. 4t_1 \ \omega^{ \beta}_{l} \ \partial_{l} f^{\alpha}_{\alpha} - 2t_1 \partial_{l} f^{ \beta}_{\theta} \ \partial^{l} f^{\alpha}_{\alpha} - 24 r_3 \partial_{\beta} \omega^{ \beta}_{l} \partial_{\beta} \omega^{\alpha \beta}_{\alpha} - \right. $ $\left. 2t_1 \partial_{l} f^{\alpha l} \partial_{\theta} f^{ \beta}_{\alpha} + 4t_1 \partial^{l} f^{\alpha}_{\alpha} \partial_{\theta} f^{ \beta}_{l} - 24 r_3 \partial_{\alpha} \omega^{\alpha \beta l} \partial_{\theta} \omega^{ \beta}_{l} + \right. $	$= \iiint \left(\frac{1}{6} \left(2 t_1 \ \omega^{\alpha_l} \ \omega_{_l}^{\ \theta} + 6 \ f^{\alpha p} \ t_{\alpha \beta} + 6 \ \omega^{\alpha p \chi} \ \sigma_{\alpha \beta \chi} - 4 t_1 \ \omega_{_{\alpha}}^{\ \theta} \ \partial_{l} f^{\alpha_{l}} + \right. $ $\left. 4 t_1 \ \omega_{_{_l}}^{\ \theta} \ \partial^{l} f^{\alpha} - 2 t_1 \partial_{l} f^{\theta} \ \partial^{l} f^{\alpha} - 24 r_3 \partial_{\beta} \omega_{_{_l}}^{\ \theta} \partial^{l} \omega^{\alpha \beta} - \right. $ $\left. 2 t_1 \partial_{l} f^{\alpha_{l}} \partial_{\theta} f^{\alpha} + 4 t_1 \partial^{l} f^{\alpha} \partial_{\theta} f^{\beta} - 24 r_3 \partial_{\alpha} \omega^{\alpha \beta l} \partial_{\theta} \omega_{_{_l}}^{\ \theta} + \right. $ $\left. 48 r_3 \partial^{l} \omega^{\alpha \beta} \partial_{\theta} \omega_{_{_l}}^{\ \theta} + 4 t_1 \ \omega_{_{_l} \theta \alpha} \partial^{\theta} f^{\alpha_{l}} + 4 t_2 \ \omega_{_l} \partial_{\alpha} \partial_{\theta} f^{\alpha_{l}} - \right. $	$= \iiint \left(\frac{1}{6} \left(2 t_1 \ \omega^{\alpha_{l}} \ \omega_{l}^{\ \theta} + 6 \ f^{\mu \rho} \ t_{\alpha \beta} + 6 \ \omega^{\mu \rho \chi} \ \sigma_{\alpha \beta \chi} - 4 t_1 \ \omega_{\alpha}^{\ \theta} \ \partial_{l} f^{\mu l} + \right. \right. $ $\left. 4 t_1 \ \omega_{l}^{\ \theta} \ \partial^{l} f^{\alpha} - 2 t_1 \partial_{l} f^{\theta} \ \partial^{l} f^{\alpha} - 24 r_3 \partial_{\beta} \omega_{l}^{\ \theta} \partial^{l} \omega^{\alpha \beta} - \right. $ $\left. 2 t_1 \partial_{l} f^{\alpha l} \partial_{\theta} f^{\alpha} + 4 t_1 \partial^{l} f^{\alpha} \partial_{\theta} f^{\beta} - 24 r_3 \partial_{\alpha} \omega^{\alpha \beta l} \partial_{\theta} \omega_{l}^{\ \theta} + \right. $ $\left. 48 r_3 \partial^{l} \omega^{\alpha \beta} \partial_{\theta} \omega_{l}^{\ \theta} + 4 t_1 \ \omega_{l \theta \alpha} \partial^{\theta} f^{\alpha l} + 4 t_2 \ \omega_{l \theta \alpha} \partial^{\theta} f^{\alpha l} - \right. $ $\left. 4 t_1 \partial_{\alpha} f_{l \theta} \partial^{\theta} f^{\alpha l} + 2 t_2 \partial_{\alpha} f_{l \theta} \partial^{\theta} f^{\alpha l} - 4 t_1 \partial_{\alpha} f_{\theta l} \partial^{\theta} f^{\alpha l} - \right. $	$= \iiint \left( \frac{1}{6} \left( 2 t_1 \ \omega^{\alpha_{i}} \ \omega_{i}^{\ \theta} + 6 \ f^{\mu \rho} \ t_{\alpha \beta} + 6 \ \omega^{\mu \rho \chi} \ \sigma_{\alpha \beta \chi} - 4 t_1 \ \omega_{\alpha}^{\ \theta} \ \partial_{i} f^{\mu i} + \right. \right. \\ \left. 4 t_1 \ \omega_{i}^{\ \theta} \ \partial^{i} f^{\alpha}_{\ \alpha} - 2 t_1 \partial_{i} f^{\theta}_{\ \theta} \partial^{j} f^{\alpha}_{\ \alpha} - 24 r_3 \partial_{\beta} \omega_{i}^{\ \theta} \partial^{j} \omega^{\alpha \beta}_{\ \alpha} - \right. \\ \left. 2 t_1 \partial_{i} f^{\alpha i} \partial_{\theta} f^{\alpha}_{\ \alpha} + 4 t_1 \partial_{i} f^{\alpha}_{\ \alpha} \partial_{\theta} f^{i}_{\ i} - 24 r_3 \partial_{\alpha} \omega^{\alpha \beta i} \partial_{\theta} \omega_{i}^{\ \theta} + \right. \\ \left. 4 8 r_3 \partial^{i} \omega^{\alpha \beta}_{\ \alpha} \partial_{\theta} \omega_{i}^{\ \theta} + 4 t_1 \ \omega_{i \theta \alpha} \partial^{\theta} f^{\alpha i} + 4 t_2 \ \omega_{i \theta \alpha} \partial^{\theta} f^{\alpha i} - \right. \\ \left. 4 t_1 \partial_{\alpha} f_{i \theta} \partial^{\theta} f^{\alpha i} + 2 t_2 \partial_{\alpha} f_{i \theta} \partial^{\theta} f^{\alpha i} - 4 t_1 \partial_{\alpha} f_{\theta i} \partial^{\theta} f^{\alpha i} - \right. \\ \left. t_2 \partial_{\alpha} f_{\theta i} \partial^{\theta} f^{\alpha i} + 2 t_1 \partial_{i} f_{\alpha \theta} \partial^{\theta} f^{\alpha i} - t_2 \partial_{i} f_{\alpha \theta} \partial^{\theta} f^{\alpha i} + \right.$	$ = \iiint_{6}^{\pm} (2t_{1}  \omega^{\alpha'}_{\alpha}  \omega_{r}^{\theta} + 6  f^{\alpha \beta}  t_{\alpha \beta} + 6  \omega^{\alpha \beta \chi}  \sigma_{\alpha \beta \chi} - 4t_{1}  \omega_{\alpha}^{\theta}  \partial_{r} f^{\alpha'} + \\ 4t_{1}  \omega_{r}^{\theta}  \partial_{r} f^{\alpha}_{\alpha} - 2t_{1} \partial_{r} f^{\theta}_{\theta}  \partial^{r} f^{\alpha}_{\alpha} - 24  r_{3}  \partial_{\theta} \omega_{r}^{\theta}  \partial^{\theta} \omega_{\alpha}^{\theta} - \\ 2t_{1}  \partial_{r} f^{\alpha l}  \partial_{\theta} f^{\alpha}_{\alpha} + 4t_{1}  \partial^{r} f^{\alpha}_{\alpha}  \partial_{\theta} f^{\beta}_{r} - 24  r_{3}  \partial_{\alpha} \omega^{\alpha \beta l}  \partial_{\theta} \omega_{r}^{\theta} + \\ 48  r_{3}  \partial^{r} \omega^{\alpha \beta}_{\alpha}  \partial_{\theta} \omega_{r}^{\theta} + 4t_{1}  \omega_{r \theta \alpha}  \partial^{\theta} f^{\alpha'} + 4t_{2}  \omega_{r \theta \alpha}  \partial^{\theta} f^{\alpha'} - \\ 4t_{1}  \partial_{\alpha} f_{r \theta}  \partial^{\theta} f^{\alpha'} + 2t_{2}  \partial_{\alpha} f_{r \theta}  \partial^{\theta} f^{\alpha'} - 4t_{1}  \partial_{\alpha} f_{\theta}  \partial^{\theta} f^{\alpha'} - \\ t_{2}  \partial_{\alpha} f_{\theta}  \partial^{\theta} f^{\alpha'} + 2t_{1}  \partial_{r} f_{\alpha \theta}  \partial^{\theta} f^{\alpha'} + 2t_{1}  \partial_{\theta} f_{r \alpha} + 2t_{1}  \partial_{\theta} f_{\alpha'} + 2t_{1}  \partial_{\theta} f_{\alpha'} + 2t_{1}  \partial_{\theta} f_{\alpha'} - 4t_{1}  \partial_{\theta} f^{\alpha'} - 4t_{1}  \partial_{\theta} f^{\alpha'} + 2t_{1}  \partial_{\theta} f^{\alpha'} + 2t_{1}  \partial_{\theta} f^{\alpha'} + 2t_{1}  \partial_{\theta} f^{\alpha'} - 4t_{1}  \partial_{\theta} $	$ = J J J J \Big( \frac{1}{6} \left( 2 t_1 \ \omega_{\alpha}^{\alpha} \ \omega_{r}^{\rho} + 6 \ f^{\alpha \rho} \ t_{\alpha \beta} + 6 \ \omega^{\alpha \rho \lambda} \ \sigma_{\alpha \beta \chi} - 4 t_1 \ \omega_{\alpha}^{\rho} \ \partial_{r} f^{\alpha r} + 4 t_1 \ \omega_{r}^{\rho} \ \partial_{r} f^{\alpha} - 2 t_1 \partial_{r} f^{\theta} \ \partial^{\rho} f^{\alpha} - 2 t_1 \partial_{r} f^{\theta} \ \partial^{\rho} f^{\alpha} - 2 t_1 \partial_{r} g^{\theta} \ \partial^{\rho} f^{\alpha} - 2 t_1 \partial_{\rho} f^{\alpha \rho} \ \partial_{\rho} f^{\alpha} - 2 t_1 \partial_{\rho} f^{\alpha \rho} \ \partial_{\rho} f^{\alpha} - 2 t_1 \partial_{\rho} g^{\theta} \partial_{\rho} g^{\rho} - 2 t_1 \partial_{\rho} g^{\rho} \partial_{\rho} g^{$	$= \iiint_{6}^{\pm} (2t_{1} \ \omega^{\alpha'}_{\alpha} \ \omega_{r}^{\theta} + 6 \ f^{\alpha \beta} \ t_{\alpha \beta} + 6 \ \omega^{\alpha \beta \chi} \ \sigma_{\alpha \beta \chi} - 4t_{1} \ \omega_{\alpha}^{\theta} \ \partial_{r} f^{\alpha'} + \\ + 4t_{1} \ \omega_{r}^{\theta} \ \partial^{r} f^{\alpha}_{\alpha} - 2t_{1} \partial_{r} f^{\theta}_{\theta} \partial^{r} f^{\alpha}_{\alpha} - 24 r_{3} \partial_{\beta} \omega_{r}^{\theta} \partial^{r} \omega^{\alpha}_{\alpha} - \\ + 2t_{1} \partial_{r} f^{\alpha'} \partial_{\theta} f^{\alpha}_{\alpha} + 4t_{1} \partial^{r} f^{\alpha}_{\alpha} \partial_{\theta} f^{r}_{r} - 24 r_{3} \partial_{\alpha} \omega^{\alpha \beta l} \partial_{\theta} \omega_{r}^{\theta} + \\ + 48 r_{3} \partial^{r} \omega^{\alpha \beta}_{\alpha} \partial_{\theta} \omega_{r}^{\theta} + 4t_{1} \omega_{r} \partial_{\theta} f^{\alpha'} + 4t_{2} \omega_{r} \partial_{\theta} f^{\alpha'} - \\ + 4t_{1} \partial_{\alpha} f_{r,\theta} \partial^{\theta} f^{\alpha'} + 2t_{2} \partial_{\alpha} f_{r,\theta} \partial^{\theta} f^{\alpha'} - 4t_{1} \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha'} - \\ + 2t_{2} \partial_{\alpha} f_{\theta_{1}} \partial^{\theta} f^{\alpha'} + 2t_{1} \partial_{r} f_{\alpha \theta} \partial^{\theta} f^{\alpha'} + 2t_{1} \partial_{\theta} f_{\alpha} \partial^{\theta} f^{\alpha'} + \\ + 4t_{1} \partial_{\theta} f_{\alpha_{1}} \partial^{\theta} f^{\alpha'} + 2t_{1} \partial_{r} f^{\alpha} \partial^{\theta} f^{\alpha'} + 2t_{1} \partial_{\theta} f_{r,\alpha} \partial^{\theta} f^{\alpha'} - \\ + 2t_{2} \partial_{\theta} f_{r,\alpha} \partial^{\theta} f^{\alpha'} + 2(t_{1} + t_{2}) \omega_{\alpha'} \partial^{\theta} f^{\alpha'} + 2 \partial^{\theta} f^{\alpha'} \partial^{\theta} f^{\alpha'} + \\ + 2t_{2} \partial_{\theta} f_{r,\alpha} \partial^{\theta} f^{\alpha'} + 2(t_{1} + t_{2}) \omega_{\alpha'} \partial^{\theta} f^{\alpha'} + 2 \partial^{\theta} f^{\alpha'} \partial^{\theta} f^{\alpha'} + \\ + 2t_{2} \partial_{\theta} f_{r,\alpha} \partial^{\theta} f^{\alpha'} + 2(t_{1} + t_{2}) \omega_{\alpha'} \partial^{\theta} f^{\alpha'} + 2 \partial^{\theta} f^{\alpha'} \partial^{\theta} f^{\alpha'} + \\ + 2t_{2} \partial_{\theta} f_{r,\alpha} \partial^{\theta} f^{\alpha'} + 2(t_{1} + t_{2}) \omega_{\alpha'} \partial^{\theta} f^{\alpha'} + 2 \partial^{\theta} f^{\alpha'} \partial^{\theta} f^{\alpha'} + \\ + 2t_{2} \partial_{\theta} f_{r,\alpha} \partial^{\theta} f^{\alpha'} + 2(t_{1} + t_{2}) \omega_{\alpha'} \partial^{\theta} f^{\alpha'} + 2 \partial^{\theta} f^{\alpha'} \partial^{\theta} f^{\alpha'} + \\ + 2t_{2} \partial_{\theta} f_{r,\alpha} \partial^{\theta} f^{\alpha'} + 2(t_{1} + t_{2}) \partial^{\theta} f^{\alpha'} + 2 \partial^{\theta} f^{\alpha'} \partial^{\theta} f^{\alpha'$	$= \iiint_{\frac{1}{6}} (2t_{1}  \omega^{\alpha}_{\alpha}  \omega^{\beta}_{r} + 6  f^{\alpha \beta}_{\alpha}  t_{\alpha\beta} + 6  \omega^{\alpha \beta \chi}_{\alpha\beta} - 4t_{1}  \omega^{\beta}_{\alpha}  \theta^{\beta}_{r} f^{\alpha r}_{r} + 4t_{1}  \omega^{\beta}_{r}  \theta^{\beta}_{r} f^{\alpha}_{r} - 24  t_{3}  \partial_{\beta} \omega^{\beta}_{r}  \theta^{\beta}_{r} \omega^{\alpha \beta}_{r} - 24  t_{3}  \partial_{\beta} \omega^{\beta}_{r}  \theta^{\beta}_{r} + 4t_{1}  \omega^{\beta}_{r}  \theta^{\beta}_{r} f^{\alpha}_{r} - 24  t_{3}  \partial_{\beta} \omega^{\beta}_{r}  \theta^{\beta}_{r} + 4t_{2}  \omega^{\beta}_{r}  \theta^{\beta}$	$= \iiint \left( \frac{1}{6} \left( 2t_1 \ \omega^{\alpha'}_{\alpha} \ \omega^{\rho}_{\beta} + 6 \ f^{\mu \rho} \ t_{\alpha \beta} + 6 \ \omega^{\mu \rho \lambda} \ \sigma_{\alpha \beta \chi} - 4t_1 \ \omega^{\rho}_{\alpha} \ \theta^{\rho} f^{\mu \nu}_{\alpha} + 4t_1 \ \omega^{\rho}_{\beta} \theta^{\rho} f^{\alpha}_{\alpha} - 2t_1 \partial_{\beta} f^{\theta}_{\beta} \partial^{\rho} f^{\alpha}_{\alpha} - 24 r_3 \partial_{\beta} \omega^{\rho}_{\beta} \theta^{\rho} \partial^{\rho}_{\alpha} - 2t_1 \partial_{\beta} f^{\theta}_{\beta} \partial^{\rho} f^{\alpha}_{\alpha} - 24 r_3 \partial_{\beta} \omega^{\rho}_{\beta} \theta^{\rho}_{\beta} \partial^{\rho}_{\alpha} - 2t_1 \partial_{\beta} f^{\alpha}_{\alpha} \partial^{\rho} f^{\alpha}_{\alpha} - 4t_1 \partial_{\beta} f^{\alpha}_{\beta} \partial^{\rho}_{\alpha} \partial^{\rho}_{\beta} \partial^{\rho}_{\alpha} \partial^{\rho}_{\beta} \partial^{\rho}_{\alpha} - 4t_1 \partial_{\beta} f^{\alpha}_{\beta} \partial^{\rho}_{\alpha} \partial^{\rho}_{\beta} \partial^{\rho}_{\alpha} - 4t_1 \partial_{\beta} f^{\alpha}_{\beta} \partial^{\rho}_{\alpha} \partial^{\rho}_{\beta} \partial^{\rho}_{\beta$	$ = \int \int \int \int \int \frac{1}{6} (2t_1  \omega^{\alpha l}_{\alpha}  \omega^{\beta}_{l} + 6  f^{\mu \nu}  t_{\alpha \beta} + 6  \omega^{\mu \nu \lambda}  \alpha_{\alpha \beta \chi} - 4t_1  \omega^{\alpha}_{\alpha}  \theta_{l} f^{\mu l} + 4t_1  \omega^{\beta}_{l}  \theta_{l} f^{\alpha}_{\alpha} - 2t_1  \delta_{l} f^{\beta}_{\alpha}  \theta_{l} f^{\alpha}_{\alpha} - 2t_1  \delta_{l} f^{\beta}_{\alpha}  \theta_{l} f^{\beta}_{\alpha} - 2t_1  \delta_{l} f^{\alpha}_{\alpha}  \theta_{l} f^{\alpha}_{\alpha} - 2t_1  \delta_{l} f^{\alpha}_{\alpha} + 2t_1  \delta_{l} f^{\alpha}_{\alpha} + 2t_1  \delta_{l} f^{\alpha}_{\alpha} + 2t_1  \delta_{l} f^{\alpha}_{\alpha} - 2t_1  \delta_{l} f^{\alpha}_{\alpha} - 2t_1  \delta_{l} f^{\alpha}_{\alpha} + 2t_1  \delta_{l}$	$ \begin{aligned} & = \int \partial u  du  du  du  du  du  du  du $

				1 -	-		1	
$ au_1^{\#2}$	0	0	0	$\frac{12ik}{(3+4k^2)^2t_1}$	$\frac{12 i \sqrt{2} k}{(3+4 k^2)^2 t_1}$	0	$\frac{24 k^2}{(3+4 k^2)^2 t_1}$	f#2
$\tau_{1^-}^{\#1}\alpha$	0	0	0	0	0	0	0	$f_{\#1}^{\#1}$
$\sigma_{1}^{\#2}{}_{lpha}$	0	0	0	$\frac{6\sqrt{2}}{(3+4k^2)^2t_1}$	$\frac{12}{(3+4k^2)^2t_1}$	0	$-\frac{12i\sqrt{2}k}{(3+4k^2)^2t_1}$	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
$\sigma_{1}^{\#1}{}_{\alpha}$	0	0	0	$\frac{6}{(3+4 k^2)^2 t_1}$	$\frac{6\sqrt{2}}{(3+4k^2)^2t_1}$	0	$-\frac{12 i k}{(3+4 k^2)^2 t_1}$	(,) <u>#</u> 1
$\tau_{1}^{\#1}{}_{\alpha\beta}$	$\frac{i\sqrt{2}k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$\frac{i k (t_1 + 4 t_2)}{3 (1 + k^2)^2 t_1 t_2}$	$\frac{k^2 (t_1 + 4t_2)}{3 (1 + k^2)^2 t_1 t_2}$	0	0	0	0	$f^{#}_{1}^{1}$
$\sigma_{1}^{\#2}{}_{+}\alpha_{\beta}$	$\frac{\sqrt{2} (t_1 - 2t_2)}{3(1 + k^2) t_1 t_2}$	$\frac{t_1+4t_2}{3(1+k^2)^2t_1t_2}$	$-\frac{ik(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	0	0	0	0	2#(1)
$\sigma_{1}^{\#1}{}_{\!\!\!\!+}\alpha\beta$		$\frac{\sqrt{2} (t_1 - 2t_2)}{3(1 + k^2) t_1 t_2}$	$-\frac{i\sqrt{2}k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	0	0	0	0	$\omega^{*1}$
	$\sigma_{1}^{\#1} + ^{lphaeta}$	$\sigma_1^{\#2} + \alpha^{\beta}$	$\tau_{1}^{#1} + \alpha \beta$	$\sigma_{1}^{\#1} +^{\alpha}$	$\sigma_1^{\#2} +^{lpha}$	$\tau_{1}^{\#1} +^{\alpha}$	$\tau_1^{\#2} + \alpha$	

						_		
$\frac{1-2t_2)}{\sqrt{2}}$	$t_1 + t_2$	$t_1 + t_2$	0	0	0	0	$\sigma_{0^{+}}^{\sharp 1}$ $\tau_{0^{+}}^{\sharp 1}$ $\tau_{0^{+}}^{\sharp 2}$ $\sigma_{0^{-}}^{\sharp 1}$	
$-\frac{ik(t)}{3}$	$\frac{1}{3}\bar{l}k(t$	$\frac{1}{3} k^2 (t)$				)	L1	_
		(2)						
$\frac{-2t_2}{\sqrt{2}}$	+ <i>t</i> 2	$(t_1 + i_1)$	0	0	0	0		)
- <u>t1</u>	<u>7</u> 7	$-\frac{1}{3}\bar{l}k$					$\sigma_{0}^{\#1} \dagger 0 0 0 \frac{1}{k^2 r_2 + t_2} 0$	
4 t <sub>2</sub> )	$\frac{t_2}{2}$	<u>t2)</u>					$\sigma_{2^{+}\alpha\beta}^{\sharp 1}$ $\sigma_{2^{+}\alpha\beta}^{\sharp 1}$ $\sigma_{2^{-}}^{\sharp 1}$	α
( <i>t</i> <sub>1</sub> +	$-\frac{t_1-2}{3}$	$\frac{i k (t_1 - 2)}{3 \sqrt{2}}$	0	0	0	0	$\sigma_{2+}^{\#1} \dagger^{\alpha\beta} \frac{\frac{2}{(1+2k^2)^2 t_1} - \frac{2i\sqrt{2}k}{(1+2k^2)^2 t_1}}{\sigma_{2+}^{\#1}} = 0$	)
$+^{\alpha\beta}$	$+^{\alpha\beta}$	$+^{\alpha\beta}$	1 +α	$^{2}$ $^{+}$	$^{1}$ $^{+}$	2 +α	$\tau_{2+}^{\#1} + \alpha \beta \frac{2 i \sqrt{2} k}{(1+2k^2)^2 t_1} \frac{4k^2}{(1+2k^2)^2 t_1} $	)
$\omega_1^{\#1}$	$\omega_1^{\#2}$	$f_1^{\#1}$	$\omega_{1^{\bar{-}}}^{\#}$	$\omega_{1^{\bar{-}}}^{\#}$	$f_1^\#$	$f_{1}^{\#}$	$\sigma_2^{\#1} \dagger^{\alpha\beta\chi} = 0$ 0 $\frac{2}{t_2}$	<u>}</u> - 1
	$\omega_1^{\#1} +  ag{4} \left[ rac{1}{6} \left( t_1 + 4  t_2  ight)  ight] - rac{t_1 - 2  t_2}{3  \sqrt{2}} \qquad - rac{i  k \left( t_1 - 2  t_2  ight)}{3  \sqrt{2}} $	$\frac{1}{6} (t_1 + 4t_2) - \frac{t_1 - 2t_2}{3\sqrt{2}}$ $- \frac{t_1 - 2t_2}{3\sqrt{2}}$ $\frac{t_1 + t_2}{3}$ $\frac{1}{3}$	$\frac{1}{6} (t_1 + 4t_2) - \frac{t_1 - 2t_2}{3\sqrt{2}} - \frac{t_1 - 2t_2}{3\sqrt{2}}$ $- \frac{t_1 - 2t_2}{3\sqrt{2}} - \frac{t_1 + t_2}{3} \frac{1}{3}$ $\frac{ik(t_1 - 2t_2)}{3\sqrt{2}} - \frac{1}{3} \vec{l} k(t_1 + t_2) \frac{1}{3}$	$\frac{1}{6} (t_1 + 4t_2) - \frac{t_1 - 2t_2}{3\sqrt{2}} - \frac{t_1 - 2t_2}{3\sqrt{2}}$ $- \frac{t_1 - 2t_2}{3\sqrt{2}} - \frac{t_1 + t_2}{3} \frac{1}{3} \frac{1}{3}$ $\frac{ik(t_1 - 2t_2)}{3\sqrt{2}} - \frac{1}{3} \vec{i} k(t_1 + t_2) \frac{1}{3}$ $0 \qquad 0$	$ \frac{1}{6} (t_1 + 4t_2) - \frac{t_1 - 2t_2}{3\sqrt{2}} - \frac{t_1 - 2t_2}{3\sqrt{2}} - \frac{t_1 + t_2}{3\sqrt{2}} = \frac{1}{3} $ $ \frac{i k(t_1 - 2t_2)}{3\sqrt{2}} - \frac{1}{3} \vec{i} k(t_1 + t_2) = \frac{1}{3} $ $ 0 \qquad 0 \qquad 0 $	$ \frac{1}{6} (t_1 + 4t_2) - \frac{t_1 - 2t_2}{3\sqrt{2}} - \frac{t_1 - 2t_2}{3\sqrt{2}} - \frac{t_1 + t_2}{3\sqrt{2}} \frac{1}{3} $ $ \frac{i k (t_1 - 2t_2)}{3\sqrt{2}} - \frac{1}{3} \vec{i} k (t_1 + t_2) \frac{1}{3} $ $ 0 0 0 $ $ 0 0 $	$ \frac{\frac{1}{6}(t_1 + 4t_2)}{-\frac{t_1 - 2t_2}{3\sqrt{2}}} - \frac{\frac{t_1 - 2t_2}{3\sqrt{2}}}{\frac{t_1 + t_2}{3\sqrt{2}}} - \frac{\frac{1}{3}}{\frac{i}{3}} \frac{k}{k} \frac{t_1 + t_2}{t_1 + t_2}) \frac{1}{3} \frac{1}{3} \\ 0 0 0 0 \\ 0 0 0 \\ 0 0 0 $	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$

0 0 0

 $\begin{array}{c|c}
0 \\
\frac{i\,kt_1}{3} \\
\frac{1}{3}\,\bar{l}\,\sqrt{2}\,kt_1 \\
0 \\
0 \\
\frac{2\,k^2\,t_1}{3}
\end{array}$ 

0 0

0

0

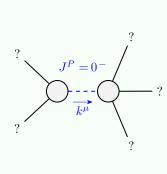
0

0

 $\begin{array}{c|c}
0 & \frac{t_1}{3} \\
\frac{t_1}{3} & \frac{t_1}{3}
\end{array}$ 

 $\begin{bmatrix} t_1 \\ 0 \\ 0 \end{bmatrix}$ 

## Massive and massless spectra



	Massive particl	e	
?	Pole residue:	$-\frac{1}{r_2} > 0$	HIGOSIESS
	Polarisations:	1	<u>0</u>
	Square mass:	$-\frac{t_2}{r_2} > 0$	
	Spin:	0	hai ticies,
	Parity:	Odd	<u>(</u>

## Unitarity conditions

 $r_2 < 0 \&\& t_2 > 0$