Particle spectrograph

Wave operator and propagator

SO(3) irreps	Fundamental fields	Multiplicities
$\tau_0^{\#2} == 0$	$\partial_{\beta}\partial_{\alpha}\tau^{\alpha\beta}==0$	1
$\tau_{0}^{\#1} == 0$	$\partial_{\beta}\partial_{\alpha}\tau^{\alpha\beta} == \partial_{\beta}\partial^{\beta}\tau^{\alpha}$	1
$t_{1}^{\#2}\alpha == 0$	$\partial_{\chi}\partial_{\beta}\partial^{\alpha}\tau^{\beta\chi} == \partial_{\chi}\partial^{\chi}\partial_{\beta}\tau^{\alpha\beta}$	8
$\tau_{1}^{\#1}{}^{\alpha}=0$	$\partial_{\chi}\partial_{\beta}\partial^{\alpha}\tau^{\beta\chi} == \partial_{\chi}\partial^{\chi}\partial_{\beta}\tau^{\beta\alpha}$	3
$\sigma_{1}^{\#2\alpha} == 0$	$\partial_{\chi}\partial_{\beta}\sigma^{\alpha\beta\chi}==0$	(F)
$\tau_{1+}^{\#1}\alpha\beta + ik \ \sigma_{1+}^{\#2}\alpha\beta == 0$	$\partial_{\chi}\partial^{\alpha}\tau^{\beta\chi} + \partial_{\chi}\partial^{\beta}\tau^{\chi\alpha} + \partial_{\chi}\partial^{\chi}\tau^{\alpha\beta} +$	3
	$2 \partial_{\delta} \partial_{\chi} \partial^{\alpha} \sigma^{\beta \chi \delta} + 2 \partial_{\delta} \partial^{\delta} \partial_{\chi} \sigma^{\alpha \beta \chi} = =$	
	$\partial_{\chi}\partial^{\alpha} \tau^{\chi\beta} + \partial_{\chi}\partial^{\beta} \tau^{\alpha\chi} +$	
	$\partial_{\chi}\partial^{\chi} t^{eta lpha} + 2 \partial_{\delta}\partial_{\chi}\partial^{eta} \sigma^{lpha \chi \delta}$	
$\sigma_{2^{-}}^{\#1}\alpha\beta\chi == 0$	$3 \partial_{\epsilon} \partial_{\delta} \partial^{\chi} \partial^{\alpha} \sigma^{\beta \delta \epsilon} + 3 \partial_{\epsilon} \partial^{\epsilon} \partial^{\chi} \partial^{\alpha} \sigma^{\beta \delta} \partial_{\delta} +$	5
	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\beta} \sigma^{\alpha \chi \delta} + 4 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\beta} \sigma^{\alpha \delta \chi} +$	
	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\beta} \sigma^{\chi \delta \alpha} + 4 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\chi} \sigma^{\alpha \beta \delta} +$	
	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\chi} \sigma^{\alpha \delta \beta} + 2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\delta} \sigma^{\beta \chi \alpha} +$	
	$3 \eta^{eta\chi} \partial_\phi \partial^\phi \partial_\epsilon \partial^\alpha \sigma^{\delta \epsilon}_{\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	
	$3 \eta^{lpha \chi} \partial_{\phi} \partial^{\phi} \partial_{\epsilon} \partial_{\delta} \sigma^{eta \delta \epsilon} +$	
	$3 \eta^{eta \chi} \partial_{\phi} \partial^{\phi} \partial_{\epsilon} \partial^{\epsilon} \sigma^{\alpha \delta}{}_{\delta} = =$	
	$3 \partial_{\epsilon} \partial_{\delta} \partial^{\chi} \partial^{\beta} \sigma^{\alpha \delta \epsilon} + 3 \partial_{\epsilon} \partial^{\epsilon} \partial^{\chi} \partial^{\beta} \sigma^{\alpha \delta}{}_{\delta} +$	
	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\alpha} \sigma^{\beta \chi \delta} + 4 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\alpha} \sigma^{\beta \delta \chi} +$	
	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\alpha} \sigma^{\chi \delta \beta} + 2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\chi} \sigma^{\beta \delta \alpha} +$	
	$4 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\delta} \sigma^{\alpha \beta \chi} + 2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\delta} \sigma^{\alpha \chi \beta} +$	
	$3 \eta^{lpha \chi} \partial_{\phi} \partial^{\phi} \partial_{\epsilon} \partial^{\beta} \sigma^{\delta \epsilon}_{\ \ \delta} +$	
	$3 \eta^{eta\chi} \partial_\phi \partial^\phi \partial_\epsilon \partial_\delta \sigma^{lpha\delta\epsilon} +$	
	$3~\eta^{lpha\chi}~\partial_{\phi}\partial^{\phi}\partial_{\epsilon}\partial^{\epsilon}\sigma^{eta\delta}{}_{\delta}$	
$\tau_{2+}^{\#1}\alpha\beta=0$	$4 \partial_{\delta} \partial_{\chi} \partial^{\beta} \partial^{\alpha} t^{\chi \delta} + 2 \partial_{\delta} \partial^{\delta} \partial^{\beta} \partial^{\alpha} t^{\chi}_{\chi} +$	5
	$3\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\chi}t^{\alpha\beta} + 3\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\chi}t^{\beta\alpha} +$	
	$2 \eta^{\alpha\beta} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial_{\chi} \tau^{\chi\delta} ==$	
	$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\alpha} \tau^{\beta \chi} + 3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\alpha} \tau^{\chi \beta} +$	
	$3\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\beta}\tau^{\alpha\chi} + 3\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\beta}\tau^{\chi\alpha} +$	
	$2 \eta^{lphaeta} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\delta} au_{\chi}^{\chi}$	
$\sigma_{2^+}^{\#1}\alpha\beta==0$	$3 \partial_{\delta} \partial_{\chi} \partial^{\alpha} \sigma^{\beta \chi \delta} + 3 \partial_{\delta} \partial_{\chi} \partial^{\beta} \sigma^{\alpha \chi \delta} +$	5
	$2 \eta^{\alpha\beta} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \sigma^{\chi\delta}_{\chi} == 2 \partial_{\delta} \partial^{\beta} \partial^{\alpha} \sigma^{\chi\delta}_{\chi} +$	
	$3 \left(\partial_{\delta} \partial^{\delta} \partial_{\chi} \sigma^{\alpha \chi \beta} + \partial_{\delta} \partial^{\delta} \partial_{\chi} \sigma^{\beta \chi \alpha} \right)$	
Total constraints/gauge generators:	ige generators:	29

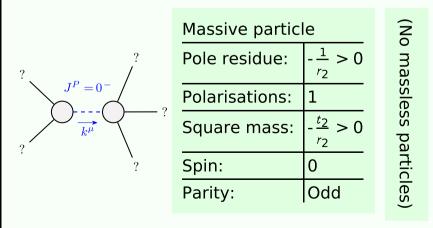
-
Quadratic (free) action
S== S
$\iiint (\frac{1}{6} \left(6 f^{\alpha \beta} \tau_{\alpha \beta} + 6 \mathcal{A}^{\alpha \beta \chi} \sigma_{\alpha \beta \chi} - 18 r_3 \partial_{\beta} \mathcal{A}_{, \ \theta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\prime} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}_{\beta}^{\ \theta} \partial^{\prime} \mathcal{A}^{\alpha \beta}_{\ \alpha} - 6 r_3 \partial_{\beta} \mathcal{A}^{\alpha \beta}_{\ \beta} - 6 r_3 \partial_{\beta} $
$6r_3\partial_lpha \mathcal{A}^{lphaeta\prime}\partial_ heta \mathcal{A}_eta^{\;\;eta}+12r_3\partial^\prime \mathcal{A}^{lphaeta}_{\;\;lpha}\partial_ heta \mathcal{A}_eta^{\;eta},$
$18 r_3 \partial_\alpha \mathcal{A}^{\alpha \beta'} \partial_\theta \mathcal{A}_{'}^{\ \theta} + 36 r_3 \partial' \mathcal{A}^{\alpha \beta}_{\ \alpha} \partial_\theta \mathcal{A}_{'}^{\ \theta} +$
$4t_2\mathcal{F}_{_{_{_{_{_{_{_{_{_{_{_{_{_{_{_{_{_{_$
$t_2\partial_{\scriptscriptstyle j} f_{\alpha\theta}\partial^{\theta} f^{\alpha\prime} + t_2\partial_{\theta} f_{\alpha\prime}\partial^{\theta} f^{\alpha\prime} - t_2\partial_{\theta} f_{\scriptscriptstyle 1\alpha}\partial^{\theta} f^{\alpha\prime} - 4t_2$
$\mathcal{A}_{lpha heta_{\prime}}\left(\mathcal{A}^{lpha heta}+\partial^{ heta}f^{lpha\prime} ight)+2t_{2}\mathcal{A}_{lpha heta}\left(\mathcal{A}^{lpha heta}+2\partial^{ heta}f^{lpha\prime} ight)+$
$8r_2\partial_eta \mathcal{A}_{lpha I heta}\partial^ heta \mathcal{A}^{lpha eta_I}$ - $4r_2\partial_eta \mathcal{A}_{lpha eta_I}\partial^ heta \mathcal{A}^{lpha eta_I}$ +
$4r_2\partial_eta \mathcal{H}_{_{I}etalpha}\partial^ heta \mathcal{H}^{lphaeta_I}$ - $24r_3\partial_eta \mathcal{H}_{_{I}etalpha}\partial^ heta \mathcal{H}^{lphaeta_I}$ -
$2r_2\partial_{arphi}\mathcal{R}_{lphaeta heta}\partial^{artheta}\mathcal{R}^{lphaeta\prime}+2r_2\partial_{artheta}\mathcal{R}_{lphaeta\prime}\partial^{artheta}\mathcal{R}^{lphaeta\prime}.$
$4r_2\partial_ heta \mathcal{R}_{lpha_Ieta}\partial^ heta \mathcal{R}^{lphaeta_I}))[t,x,y,z]d\! zd\! yd\! xd\! t$
$\sigma_{1}^{\#1}{}_{lphaeta} \qquad \sigma_{1}^{\#2}{}_{lphaeta} \qquad au_{1}^{\#1}{}_{lphaeta} \qquad \sigma_{1}^{\#1}{}_{lpha} \qquad \sigma_{1}^{\#2}{}_{lpha} \qquad au_{1}^{\#2}{}_{lpha} \qquad au_{1}^{\#2}{}_$

α															
t_1^{-1}	0	0	0	0	0	0	0	$f_{1^-}^{\#2}$	0	0	0	0	0	0	
t_{1}^{-}	0	0	0	0	0	0	0	$f_{1}^{\#1}{}_{lpha}$ f	0	0	0	0	0	0	
σ_{1}^{-}	0	0	0	0	0	0	0	χ							
$\sigma_{1}^{}\alpha$ (0	0	0	$\frac{1}{k^2 r_3}$	0	0	0	$\mathcal{A}_{1^{ o}}^{\#^2}$	0	0	0	0	0	0	
Q		$\frac{2}{t^2}$	2 2	۱٬۶۰				${\mathscr A}_{1^{\bar{-}}\alpha}^{\#1}$	0	0	0	$k^2 r_3$	0	0	
$^{l}1^{+}\alpha\beta$	- <u>i VZ</u> kr3+k³r3	$\frac{i(3k^2r_3+2t_2)}{k(1+k^2)^2r_3t_2}$	$\frac{3k^2r_3+2t_2}{(1+k^2)^2r_3t_2}$	0	0	0	0	$f_{1+lphaeta}^{\#1}$ 3	$i\sqrt{2} kt_2$	<u>i k t 2</u> 3	$\frac{k^2 t_2}{3}$	0	0	0	
$\sigma_{1}{}^{+}\alpha eta$	$\frac{\sqrt{2}}{k^2 r_3 + k^4 r_3}$	$\frac{3k^2r_3+2t_2}{(k+k^3)^2r_3t_2}$	$\frac{i (3k^2 r_3 + 2t_2)}{k (1 + k^2)^2 r_3 t_2}$	0	0	0	0	${\mathscr A}_{1}^{\#2}$	$\begin{array}{c c} \sqrt{2} \ t_2 \\ 3 \\ 3 \\ 4 \\ 1 \\ 1 \\ 1 \\ 1 \\ 2 \\ 3 \\ 4 \\ 1 \\ 2 \\ 3 \\ 3 \\ 3 \\ 4 \\ 1 \\ 3 \\ 3 \\ 4 \\ 3 \\ 4 \\ 5 \\ 5 \\ 5 \\ 5 \\ 5 \\ 5 \\ 5 \\ 5 \\ 5 \\ 5$	2 2 3	$-\frac{1}{3}$ ikt ₂	0	0	0	
$O_{1} + \alpha \beta$	$\frac{1}{k^2 r_3}$	$\frac{\sqrt{2}}{k^2 r_3 + k^4 r_3}$	$\frac{i\sqrt{2}}{kr_3+k^3r_3} - \frac{i}{k}$	0	0	0	0	${\mathscr A}_{1}^{\#1}_{\alpha\beta}$	$k^2 r_3 + \frac{2t_2}{3}$	$\frac{\sqrt{2}\ t_2}{3}$	$-\frac{1}{3}\bar{I}\sqrt{2}kt_2$	0	0	0	
	$\sigma_{1}^{\#1} + \alpha \beta$	$\sigma_{1}^{#2} + \alpha \beta$	$\tau_1^{\#1} + \alpha \beta$	$\sigma_{1}^{\#_1} +^{\alpha}$	$\sigma_{1}^{\#2} +^{lpha}$	$ au_{1}^{\#1} +^{lpha}$	$\tau_{1}^{\#2} + ^{\alpha}$		$\mathcal{A}_{1}^{\#1} + \tau^{lphaeta}$	$\mathcal{A}_{1}^{\#2} + \alpha^{\beta}$	$f_{1+}^{#1} +^{\alpha \beta}$	$\mathcal{A}_1^{\#1} \dotplus^\alpha$	$\mathcal{A}_1^{\#2} \dagger^{\alpha}$	$f_1^{\#1} + ^{lpha}$	7

, 11 -			72+1			,	U	U
$ au_{0}^{1}$		$\sigma_0^{\#1}$	$\mathcal{A}_2^{\#1}\dagger^{c}$	αβχ	C)	0	0
0	0+	00-		${\mathcal F}$	(#1 ₀ +	$f_{0}^{#1}$	$f_{0+}^{#2}$	${\cal A}_0^{\#}$
	U	U	${\cal R}_{0}^{\#1}\dagger$	6 k	$r^2 r_3$	0	0	0
0	0	0	$f_{0^{+}}^{#1}$ †		0	0	0	0
0	0	0						
		1	$f_{0+}^{#2}$ †		0	0	0	0
0	0	$\frac{-}{k^2 r_2 + t_2}$	$\mathcal{A}_0^{\sharp 1}$ †		0	0	0	$k^2 r_2 +$
			•					

 $\mathcal{A}_{2^{+}\alpha\beta}^{\#1} \, f_{2^{+}\alpha\beta}^{\#1} \, \mathcal{A}_{2^{-}\alpha\beta\chi}^{\#1}$

Massive and massless spectra



Unitarity conditions

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