Particle spectrograph

Wave operator and propagator

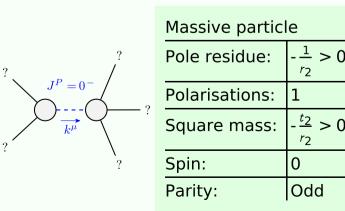
SO(3) irreps	Fundamental fields	Multiplicities
$\tau_{0}^{#2} == 0$	$\partial_{\beta}\partial_{\alpha}\tau^{\alpha\beta} == 0$	1
$\tau_{0+}^{\#1} - 2 i k \sigma_{0+}^{\#1} == 0$	$\partial_{\beta}\partial_{\alpha}t^{\alpha\beta} == \partial_{\beta}\partial^{\beta}t^{\alpha}_{\ \alpha} + 2\partial_{\chi}\partial^{\chi}\partial_{\beta}\sigma^{\alpha\beta}_{\ \alpha}$	П
$\tau_1^{\#2}{}^{\alpha} - ik \ \sigma_1^{\#1}{}^{\alpha} == 0$	$\partial_{\chi}\partial_{\beta}\partial^{\alpha}\tau^{\beta\chi} + \partial_{\delta}\partial^{\delta}\partial_{\chi}\partial_{\beta}\sigma^{\alpha\beta\chi} == \partial_{\chi}\partial^{\chi}\partial_{\beta}\tau^{\alpha\beta} + \partial_{\delta}\partial^{\delta}\partial_{\gamma}\partial^{\chi}\partial^{\alpha\beta}\partial^{\alpha}\partial^{\beta}\partial^{\alpha}\partial^{\beta}\partial^{\alpha}\partial^{\alpha}\partial^{\beta}\partial^{\alpha}\partial^{\alpha}\partial^{\alpha}\partial^{\alpha}\partial^{\alpha}\partial^{\alpha}\partial^{\alpha}\partial^{\alpha$	Е
$\tau_{1}^{\#1}\alpha == 0$	$\partial_{x}\partial_{\beta}\partial^{\alpha}\tau^{\beta X} == \partial_{x}\partial^{X}\partial_{\beta}\tau^{\beta \alpha}$	е
$\sigma_{1}^{\#1}{}^{\alpha} + 2 \ \sigma_{1}^{\#2}{}^{\alpha} = 0$	$\partial_{\chi}\partial^{\alpha}\sigma^{\beta\chi}_{\beta} + \partial_{\chi}\partial^{\chi}\sigma^{\alpha\beta}_{\beta} = 3 \partial_{\chi}\partial_{\beta}\sigma^{\alpha\beta\chi}$	8
$\tau_{1+}^{\#1}\alpha\beta + ik \ \sigma_{1+}^{\#2}\alpha\beta == 0$	$\partial_{\chi}\partial^{\alpha}\tau^{\beta\chi} + \partial_{\chi}\partial^{\beta}\tau^{\chi\alpha} +$	8
	$2 \partial_{\delta} \partial_{\chi} \partial^{\alpha} \sigma^{\beta \chi \delta} + 2 \partial_{\delta} \partial^{\delta} \partial_{\chi} \sigma^{\alpha \beta \chi} = =$ $\partial_{\nu} \partial^{\alpha} \chi^{\chi \beta} + \partial_{\nu} \partial^{\beta} \tau^{\alpha \chi} +$	
	$\hat{\partial}_{\chi}\partial^{\chi}\tau^{\beta\alpha} + 2\partial_{\delta}\partial_{\chi}\partial^{\beta}\sigma^{\alpha\chi\delta}$	
$\sigma_{2^{-1}}^{\#1}\alpha\beta\chi==0$	$3 \partial_{\epsilon} \partial_{\delta} \partial^{\chi} \partial^{\alpha} \sigma^{\beta \delta \epsilon} + 3 \partial_{\epsilon} \partial^{\epsilon} \partial^{\chi} \partial^{\alpha} \sigma^{\beta \delta} +$	5
	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\beta} \sigma^{\alpha \chi \delta} + 4 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\beta} \sigma^{\alpha \delta \chi} +$	
	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\beta} \sigma^{\chi \delta \alpha} + 4 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\chi} \sigma^{\alpha \beta \delta} +$	
	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\chi} \sigma^{\alpha \delta \beta} + 2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\delta} \sigma^{\beta \chi \alpha} +$	
	$3 \eta^{\beta \chi} \partial_{\phi} \partial^{\phi} \partial_{\varepsilon} \partial^{\alpha} \sigma^{\delta \varepsilon} +$	
	$3 \eta^{\alpha\chi} \partial_{\phi} \partial^{\phi} \partial_{\epsilon} \partial_{\delta} \sigma^{\beta \delta \epsilon} +$	
	$3 \eta^{\beta \chi} \partial_{\phi} \partial_{\phi} \partial_{\epsilon} \partial^{\epsilon} \sigma^{\alpha \delta}{}_{\delta} ==$	
	$3 \partial_{\epsilon} \partial_{\delta} \partial^{\chi} \partial^{\beta} \sigma^{\alpha \delta \epsilon} + 3 \partial_{\epsilon} \partial^{\epsilon} \partial^{\chi} \partial^{\beta} \sigma^{\alpha \delta} \partial_{\delta} +$	
	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\alpha} \sigma^{\beta X \delta} + 4 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\alpha} \sigma^{\beta \delta X} +$	
	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\alpha} \sigma^{\chi \delta \beta} + 2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\chi} \sigma^{\beta \delta \alpha} +$	
	$4 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\delta} \sigma^{\alpha \beta \chi} + 2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\delta} \sigma^{\alpha \chi \beta} +$	
	$3 \eta^{\alpha\chi} \partial_{\phi} \partial^{\phi} \partial_{\varepsilon} \partial^{\beta} \sigma^{\delta \varepsilon} +$	
	$3 \eta^{\beta \chi} \partial_{\phi} \partial^{\phi} \partial_{\varepsilon} \partial_{\delta} \sigma^{\alpha \delta \varepsilon} +$	
	$3 \eta^{\alpha\chi} \partial_{\phi} \partial^{\phi} \partial_{\epsilon} \partial^{\epsilon} \sigma^{\beta\delta}{}_{\delta}$	
$\tau_2^{\#1}\alpha\beta == 0$	$4 \partial_{\delta} \partial_{\chi} \partial^{\beta} \partial^{\alpha} \tau^{\chi \delta} + 2 \partial_{\delta} \partial^{\delta} \partial^{\beta} \partial^{\alpha} \tau^{\chi}_{\chi} +$	2
	$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\chi} \tau^{\alpha\beta} + 3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\chi} \tau^{\beta\alpha} +$	
	$2 \eta^{\alpha\beta} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial_{\chi} t^{\chi\delta} ==$	
	$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\alpha} \tau^{\beta \chi} + 3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\alpha} \tau^{\chi \beta} +$	
	$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\beta} \tau^{\alpha \chi} + 3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\beta} \tau^{\chi \alpha} +$	
	$2 \eta^{\alpha\beta} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\delta} \tau^{\chi}_{\chi}$	
Total constraints/gauge		24

	l _											<i>C</i> #
	αι-	$a^{\alpha\beta}$				$\theta^{\theta}f^{\alpha\prime}$) +						-
	$\omega_{\alpha}^{\kappa}\partial_{f}$	$^{\prime }^{\prime }$ $^{\prime }$	+ _θ	$f_{\theta'} g^{\theta} f^{\alpha'}$	$\partial_{\theta} f_{\alpha \prime}$ -	$\omega^{\alpha\prime\theta} + 2$	+	_'	ر		ľt	# C#
	$^{i\beta\chi}$ $\sigma_{\alpha\beta\chi} + 8t_3$	$8t_3\;\omega_{'\kappa}^{\kappa}\;\partial'f^{\alpha}_{\;\alpha}+4t_3\partial_!f^{\kappa}_{\;\kappa}\partial'f^{\alpha}_{\;\alpha}-6r_3\partial_\beta\omega_{'\theta}^{\;\theta}\partial'\omega^{\alpha\beta}_{\;\alpha}-$	$6 r_3 \partial_{\alpha} \omega^{\alpha \beta'} \partial_{\theta} \omega_{, \beta}^{\theta} + 12 r_3 \partial' \omega^{\alpha \beta}_{\alpha} \partial_{\theta} \omega_{, \beta}^{\theta} +$	$4t_2\ \omega_{i\theta\alpha}\ \partial^\theta f^{\alpha\prime} + 2t_2\ \partial_\alpha f_{i\theta}\ \partial^\theta f^{\alpha\prime} - t_2\ \partial_\alpha f_{\theta\prime}\ \partial^\theta f^{\alpha\prime} -$	$t_2 \partial_i f_{\alpha \theta} \partial^{\theta} f^{\alpha i} + t_2 \partial_{\theta} f_{\alpha i} \partial^{\theta} f^{\alpha i} - t_2 \partial_{\theta} f_{i\alpha} \partial^{\theta} f^{\alpha i} -$	$4t_2\omega_{\alpha\theta_I}(\omega^{\alpha\prime\theta}+\partial^\theta f^{\alpha\prime}) + 2t_2\omega_{\alpha\prime\theta}(\omega^{\alpha\prime\theta}+2\partial^\theta f^{\alpha\prime}) +$	$8r_2\partial_\beta\omega_{\alpha\prime\theta}\partial^\theta\omega^{\alpha\beta\prime} - 4r_2\partial_\beta\omega_{\alpha\theta\prime}\partial^\theta\omega^{\alpha\beta\prime} +$	$4r_2\partial_\beta\omega_{1\theta\alpha}\partial^\theta\omega^{\alpha\beta\prime} - 24r_3\partial_\beta\omega_{1\theta\alpha}\partial^\theta\omega^{\alpha\beta\prime} -$	$2r_2\partial_i\omega_{\alpha\beta\theta}\partial^\theta\omega^{\alpha\beta^i} + 2r_2\partial_\theta\omega_{\alpha\beta^i}\partial^\theta\omega^{\alpha\beta^i}$	$\partial_{i}f^{\alpha i}\partial_{\kappa}f_{\alpha}^{\ \ \kappa}$	$8t_3 \partial' f^{\alpha}_{\alpha} \partial_{\kappa} f'^{\kappa}))[t, \kappa, y, z] dz dy d\kappa dt$	#
	$^{\alpha\beta} \tau_{\alpha\beta} + 6 \omega^{\alpha}$	$\partial' f^{\alpha}_{\ \alpha} + 4 t_3 \partial_{,} f$	$^{\beta'}\partial_{\theta}\omega_{'}^{\;\;\theta}+12$	$\partial^{\theta} f^{\alpha\prime} + 2 t_2 \partial_{\alpha}$	$f^{\alpha\prime} + t_2 \partial_{\theta} f_{\alpha\prime}$	$(\omega^{\alpha\prime\theta}+\partial^{\theta}f^{\alpha\prime})$	$_{\theta}\partial^{\theta}\omega^{\alpha\beta\prime}$ - 4 $_{r_{2}}$	$_{\alpha}\partial^{\theta}\omega^{\alpha\beta\prime}$ - 24 $_{r}$	$_{19}\partial^{\theta}\omega^{\alpha\beta\prime}+2r_{z}$	$4 r_2 \partial_\theta \omega_{\alpha \iota \beta} \partial^\theta \omega^{\alpha \beta \iota} + 4 t_3 \partial_\iota f^{\alpha \iota} \partial_\kappa f_\alpha^{\ \ \kappa} -$	$\partial_{\kappa}f_{\ \ \ \ \ \ }^{\ \ \ \ \ })][t,\ ext{χ,$$$$$$$$ y,}$	_#1
tion	$\alpha'_{\alpha} \omega'_{\kappa} + 6 f$	$8t_3 \omega_{'\kappa}^{\kappa}$	$6 r_3 \partial_{\alpha} \omega^{\alpha t}$	$4t_2\omega_{_I heta lpha}$	$t_2 \partial_i f_{\alpha \theta} \partial^{\epsilon}$	$4t_2 \omega_{lpha heta_1}$	$8 r_2 \partial_{\beta} \omega_{\alpha_{l}}$	$4 r_2 \partial_eta \omega_{I heta}$	$2 r_2 \partial_i \omega_{\alpha\beta}$	$4 r_2 \partial_{\theta} \omega_{lpha_{\prime}}$	$8t_3\partial'f^{lpha}$	*
Quadratic (free) action	$S == \iiint \left(\frac{1}{6} \left(-4 t_3 \ \omega^{\alpha}_{\alpha} \ \omega^{\kappa}_{l \ \kappa} + 6 \ f^{\alpha\beta} \ \tau_{\alpha\beta} + 6 \ \omega^{\alpha\beta\chi} \ \sigma_{\alpha\beta\chi} + 8 t_3 \ \omega^{\kappa}_{\alpha \ \kappa} \ \partial_{l} f^{\alpha l} - \right) \right)$											
Qua	S											

1								1		
$\tau_1^{\#^2}{}_{\alpha}$	0	0	0	$\frac{6ik}{(3+2k^2)^2t_3}$	$\frac{3 i \sqrt{2} k}{(3+2 k^2)^2 t_3}$	0	$\frac{6k^2}{(3+2k^2)^2t_3}$	ı		
$\tau_{1}^{\#1}{}_{\alpha}$	0	0	0	0	0	0	0	$f_{1}^{\#2}$	0	0
$\sigma_{1}^{\#2}$	0	0	0	$\frac{3\sqrt{2}}{(3+2k^2)^2t_3}$	$\frac{3}{(3+2k^2)^2t_3}$	0	$\frac{3i\sqrt{2}k}{(3+2k^2)^2t_3}$	$f_{1^-}^{\#1} lpha$	0	0
$\sigma_{1^{ ext{-}}lpha}^{\#1}$	0	0	0	$\frac{6}{(3+2k^2)^2t_3} \left -\frac{6}{(3+2k^2)^2t_3} \right $	$\frac{3\sqrt{2}}{(3+2k^2)^2t_3}$	0	$\frac{6ik}{(3+2k^2)^2t_3}$ - ${}$	$\omega_{1^{-}}^{\#2}{}_{\alpha}$	0	0
	3 <u>-3</u>	-t2) r3 t2	^{t2} 3 ^t 2	(3+	- (3-		(3+	$\omega_{1^{-}}^{\#1}{}_{\alpha}$	0	0
$\tau_1^{\#1}_{+}\alpha\beta$	$-\frac{2i\sqrt{2}}{3kr_3+3k^3r_3}$	$\frac{i(9k^2r_3+4t_2)}{3k(1+k^2)^2r_3t_2}$	$\frac{9k^2r_3+4t_2}{3(1+k^2)^2r_3t_2}$	0	0	0	0	$f_{1}^{\#1}$	$\frac{1}{3}\bar{I}\sqrt{2}kt_2$	<u>ikt2</u> 3
$\sigma_{1}^{\#2}$	$\frac{2\sqrt{2}}{3k^2r_3+3k^4r_3}$	$\frac{9k^2r_3+4t_2}{3(k+k^3)^2r_3t_2}$	$\frac{i(9k^2r_3+4t_2)}{3k(1+k^2)^2r_3t_2}$	0	0	0	0	$\omega_{1}^{\#2}{}_{+}$	$\frac{\sqrt{2}t_2}{3} \qquad \frac{1}{3}\vec{l}$	3 3
$\sigma_{1}^{\#1}$	$\frac{2}{3k^2r_3}$ - $\frac{2}{3}$	$\frac{2\sqrt{2}}{3k^2r_3+3k^4r_3} = \frac{9}{3k^3r_3}$	$\frac{2i\sqrt{2}}{3kr_3+3k^3r_3} - \frac{i}{3k}$	0	0	0	0	$\omega_{1}^{\#1}_{\alpha\beta}$	$\frac{1}{6} (9 k^2 r_3 + 4 t_2)$	$\frac{\sqrt{2} t_2}{3}$
	$r_1^{#1} + \alpha \beta$	$r_1^{#2} + \alpha \beta = \frac{1}{3 k^2}$	$a_{1+}^{*1} + \alpha \beta$	$\sigma_{1}^{\#_{1}} +^{\alpha}$	$\sigma_1^{\#2} + \alpha$	$ au_1^{\#_1} +^{lpha}$	$\tau_{1}^{#2} + \alpha$		$a_1^{\#1} + \alpha \beta = \frac{1}{6}$ (9)	$a_1^{\#2} + \alpha \beta$

	0	0	$-\frac{2}{3}$ ikt ₃	$\frac{1}{3}\bar{l}\sqrt{2}kt_3$	0	$\frac{2k^2t_3}{3}$										
	0	0	0	0	0	0										
	0	0	$-\frac{\sqrt{2}t_3}{3}$	13 3	0	$\frac{1}{3}$ \bar{l} $\sqrt{2}$ kt_3							$\sigma_{2^+}^{\sharp 1} \dagger^{lphaeta}$	$\sigma_{2}^{\#1}$		7
1	0	0	2 <i>t</i> 3	$\frac{\sqrt{2}t_3}{3}$	0	2 i k t 3 3							$ au_2^{\#1} \dagger^{\alpha\beta}$			
+			(4)			2			$\omega_{2}^{\#1}{}_{\alpha\beta}$	$f_{2+\alpha\beta}^{\#1}$	$\omega_2^{\#1}$	αβχ	$\sigma_2^{\#1} \dagger^{\alpha\beta\chi}$	0		
n	<u>i kt2</u> 3	$\frac{k^2 t_2}{3}$	0	0	0	0	$\omega_{2}^{\#1}$ †	αβ αβ	$-\frac{3k^2r_3}{2}$	0	0			$\omega_{0}^{\#1}$	0	
Υ	3 3	$-\frac{1}{3}$ \vec{i} k t_2	0	0	0	0	$\omega_2^{\#1} \dagger^{\alpha}$		0	0	0			$f_{0}^{\#2}$ c	0	
o o	$\frac{\sqrt{2} t_2}{3}$	- <u>1</u> 3	0	0	0	0	$\sigma_{0^{+}}^{\#1}\dagger$	(1+	$\sigma_{0}^{\#1}$ $\frac{1}{(2k^{2})^{2}t_{3}}$ $i\sqrt{2}k$ $2k^{2})^{2}t_{3}$	$\tau_{0}^{\#}$ $-\frac{i\sqrt{1+2k}}{(1+2k^{2})}$ $\frac{2k}{(1+2k^{2})}$	$\frac{2}{2} \frac{k}{(2)^2 t_3}$	τ ₀ ^{#2} 0	σ ₀ -1 0 0	$\omega_{0}^{\#1}$ $f_{0}^{\#1}$	t_3 $-i \sqrt{2} k t_3$	
4	$\omega_1^{\#2} + \alpha^{eta}$	$f_{1}^{#1} + \alpha \beta$	$\omega_{1}^{\#1} +^{\alpha}$	$\omega_1^{\#2} +^{lpha}$	$f_1^{\#1} + ^\alpha$	$f_1^{\#2} +^{\alpha}$	$ au_{0^{+}}^{#2} \dagger ag{0^{-1}} \dagger$		0	0		0	$\frac{1}{k^2 r_2 + t_2}$)	$\omega_{0}^{\#1}$ †	

Massive and massless spectra



Massive particle						
Pole residue:	$-\frac{1}{r_2} > 0$					
Polarisations:	1					
Square mass:	$-\frac{t_2}{r_2} > 0$					
Spin:	0					
Parity:	Odd					

Unitarity conditions