Particle spectrograph

Wave operator and propagator

$\Gamma_1'' + \alpha \beta$	$\begin{array}{c cccc} \sigma_{1}^{*+}\alpha_{\beta} & \tau_{1}^{*+}\alpha_{\beta} \\ & & & & & & & & \\ & & & & & & & \\ & & & & $
$(\alpha_0-4\beta_1)(1+k^2)$	$\frac{1}{1+k^2}$ (α_0
$\frac{2ik}{(\alpha_0-4\beta_1)(1+k^2)^2}$	$\frac{2}{(\alpha_0 - 4\beta_1)(1 + k^2)^2} - \frac{2ik}{(\alpha_0 - 4\beta_1)(1 + k^2)^2}$
$\frac{2k^2}{(\alpha_0-4\beta_1)(1+k^2)^2}$	$\frac{2ik}{(\alpha_0\!-\!4\beta_1)(1\!+\!k^2)^2} - \frac{2k^2}{(\alpha_0\!-\!4\beta_1)(1\!+\!k^2)^2}$
0	0 0
$0 \qquad \frac{2\sqrt{2}}{(\alpha_0 - 4\beta_1)(1 + 2k^2)}$	0 0
0	0 0
$0 \frac{4ik}{(\alpha_0-4\beta_1)(1+2k^2)}$	0 0

_	$\sigma_{0}^{\#1}$	$ au_{0}^{\#1}$	$ au_{0}^{\#2}$	$\sigma_0^{\sharp 1}$
$\sigma_{0}^{\!\#1}\dagger$	$\frac{8 \beta_1}{\alpha_0^2 - 4 \alpha_0 \beta_1 + 8 \alpha_6 \beta_1 k^2}$	$-\frac{i\sqrt{2}(\alpha_{0}-4\beta_{1})}{\alpha_{0}(\alpha_{0}-4\beta_{1})k+8\alpha_{6}\beta_{1}k^{3}}$	0	0
$\tau_{0}^{\#1}$ †	$\frac{i \sqrt{2} (\alpha_0 - 4 \beta_1)}{\alpha_0 (\alpha_0 - 4 \beta_1) k + 8 \alpha_6 \beta_1 k^3}$	$-\frac{\alpha_0 - 4 \beta_1 + 2 \alpha_6 k^2}{k^2 (\alpha_0^2 - 4 \alpha_0 \beta_1 + 8 \alpha_6 \beta_1 k^2)}$	0	0
$\tau_{0}^{\#2}$ †	0	0	0	0
$\sigma_0^{\sharp 1}$ †	0	0	0	$\frac{2}{\alpha_0$ -4 β_1

	$\sigma_{2^{+}lphaeta}^{\#1}$	$\tau_{2}^{\#1}{}_{\alpha\beta}$	$\sigma_{2}^{\#1}{}_{\alpha\beta\chi}$
$\sigma_{2}^{\#1} \dagger^{lphaeta}$	$-\frac{16\beta_1}{\alpha_0^2-4\alpha_0\beta_1}$	$\frac{2 i \sqrt{2}}{\alpha_0 k}$	0
$ au_2^{\#1} \dagger^{lphaeta}$	$-\frac{2i\sqrt{2}}{\alpha_0 k}$	$\frac{2}{\alpha_0 k^2}$	0
$\sigma_{2}^{\#1}\dagger^{lphaeta\chi}$	0	0	$\frac{1}{-\frac{\alpha_0}{4} + \beta_1}$

9	3								Quadra	itic (free) ac	tion					
Multiplicities									S == [[]	$\int \int (-\frac{1}{2} (\alpha_0 - 4 \beta)$	$oldsymbol{eta_1})~oldsymbol{\mathcal{A}}^{lphaeta}_{lpha}$	$_{\alpha} \mathcal{A}_{\beta \chi}^{\chi} + f$	$ \tau^{\alpha\beta} \tau_{\alpha\beta} + \mathcal{A}^{\alpha\beta\chi} $	$\sigma_{\alpha\beta\chi}$ -4	eta_1 A	${}^{\chi}_{\alpha} \partial_{\beta} f^{\alpha\beta}$ -
M.Iti	1	ا س	0	2				10		C	$\alpha_0 f^{\alpha\beta} \partial$	$\beta \mathcal{A}_{\alpha X}^{X} + \alpha$	$\sigma_0 \partial_{\beta} \mathcal{A}^{\alpha\beta}_{\alpha} + 4 \beta_1$	$\mathcal{A}_{\beta \ \chi}^{\ \chi} \partial^{\beta}$	$^3f^{\alpha}_{\alpha}$ -	
Ė	- ' ' '	.,	(,	,			'	<u> </u>		2	$2 \beta_1 \partial_{\beta} f^{\prime}$	$(\chi \partial^{\beta} f^{\alpha}_{\alpha} - 2)$	$\beta_1 \partial_{\beta} f^{\alpha\beta} \partial_{\chi} f_{\alpha}^{\chi}$	$+$ 4 β_1 ∂^{eta}	$f^{\alpha}_{\alpha}\partial_{\gamma}$	$_{\alpha}f_{\beta}^{X}+$
		$\sigma^{\alpha\beta\chi}$,-	$f^{\alpha}_{\alpha} \partial_{\chi} \mathcal{A}^{\beta \chi}_{\beta}$ -2	, ,,		
		$\partial_\delta\partial^\delta\partial_\chi\partial_\beta\sigma^{\alpha\beta\chi}$			βχ ==						7.1		$\partial_{\beta}f_{\alpha\chi}\partial^{\chi}f^{\alpha\beta} + \beta$			
		$\partial_\delta\partial^\delta$		+ _β ,	$\partial_\chi \sigma^\alpha$	ų	0					_	$\mathcal{A}_{\alpha\chi\beta}$ (($lpha_0$ - 4 eta_1)			$(f^{\alpha\beta}) +$
		$t^{\beta}+2$	За	$-\partial_{\chi}\partial^{\chi}\tau^{\alpha\beta}+$. 0 ₀ 0	; 	$\partial^{\beta}\sigma^{\alpha \lambda}$			<u>:</u> :	$rac{2}{3} \ lpha_6 \partial_eta \mathcal{F}$	$\mathcal{A}^{lphaeta}_{lpha}\partial_{\delta}\mathcal{A}^{\lambda\dot{lpha}}$	(x, y, z] dz	zdydx d	¶t	
fields	5	$\partial_{\chi}\partial^{\chi}\partial_{\beta}\tau^{\alpha\beta}$	$: \partial_{\chi} \partial^{\chi} \partial_{\beta} \tau^{\beta \alpha}$	+	$\beta \chi \delta + 2$	$-\chi_{\alpha}^{1}g^{Q}$	$2 \partial_{\delta} \partial_{\chi} \partial^{\beta} \sigma^{\alpha \chi o}$	ió		${\mathscr R}^{\sharp 1}_{1^+ lpha eta}$	${\mathscr R}_{1}^{\#2}{}_{lphaeta}$	$f_{1}^{\#1}{}_{lphaeta}$	${\mathscr R}_{1^{-}lpha}^{\#1}$	$\mathcal{A}_{1-lpha}^{\#2}$	$f_{1-\alpha}^{\#1}$	$f_{1-\alpha}^{\#2}$
Eundamental fields	0 ==	1	1 !!	$\partial_{\chi}\partial^{\alpha}\tau^{\beta\chi} + \partial_{\chi}\partial^{\beta}\tau^{\chi\alpha}$	$2 \partial_{\delta} \partial_{\chi} \partial^{\alpha} \sigma^{\beta \chi \delta} + 2 \partial_{\delta} \partial^{\delta} \partial_{\chi} \sigma^{\alpha \beta \chi}$	$\partial_{\chi}\partial^{\alpha}\tau^{\chi\beta} + \partial_{\chi}\partial^{\beta}\tau^{\alpha\chi} +$	$+ \frac{1}{2} \frac{\partial^{\chi} \tau^{\beta \alpha}}{\partial x^{\alpha}} + \frac{1}{2} \frac{\partial^{\chi} \tau^{\beta \alpha}}{\partial$	generators:	${\cal A}_1^{\sharp 1}\dagger^{lphaeta}$	$\frac{1}{4}$ (α_0 - 4 β_1)	$\frac{\alpha_0 - 4 \beta_1}{2 \sqrt{2}}$	$\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	0	0	0	0
מפטמו	$\partial_{\beta}\partial_{\alpha}\tau^{\alpha\beta}$:	$\partial_{\chi}\partial_{\beta}\partial^{\alpha}\tau^{\beta\chi}$	$\partial_{\chi}\partial_{\beta}\partial^{\alpha}\tau^{\beta\chi}$:	$g_{\alpha} \iota_{\beta X}$	2 0 ₆	$\partial_\chi\partial^\alpha t^\lambda$			$\mathcal{A}_{1}^{\sharp 2}\dagger^{lphaeta}$	$\frac{\alpha_0 - 4 \beta_1}{2 \sqrt{2}}$	0	0	0	0	0	0
ــــــــــــــــــــــــــــــــــــــ	9 _β	0	o _x	== 0 0 x				gange	$f_{1+}^{\#1}\dagger^{\alpha\beta}$	$-\frac{\bar{i}(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	0	0	0	0	0	0
רושונור		$\sigma_{1}^{\#2\alpha}$ ==		$\sigma_1^{\#2}\alpha\beta$ =:	•		100	l otal constraints/gauge	$\mathcal{A}_1^{\sharp 1} \dagger^{lpha}$	0	0	0	$\frac{1}{4}\left(\alpha_0-4\beta_1\right)$	$-\frac{\alpha_0-4\beta_1}{2\sqrt{2}}$	0	$-\frac{1}{2}\bar{i}(\alpha_0-4\beta_1)$
Source consi	2	2 ik o	0 ==	īk			3	onstra	$\mathcal{A}_{1}^{\#2}\dagger^{lpha}$	0	0	0	$-\frac{\alpha_0-4\beta_1}{2\sqrt{2}}$	0	0	0
urce (3) ji	0 == 1	+ π		$t_1^{\#1}\alpha\beta$ +			-	ral c	$f_{1}^{#1} \dagger^{\alpha}$	0	0	0	0	0	0	0
	r#2	$t_{1}^{#2}\alpha$	$\tau_{1}^{\#_{1}\alpha}$	$t_1^{\#}$			l F	0	$f_{1}^{#2} \dagger^{\alpha}$	0	0	0	$\frac{1}{2}$ \bar{i} (α_0 - 4 β_1) k	0	0	0

_	${\mathscr H}^{\sharp 1}_{1^+lphaeta}$	$\mathcal{A}_{1}^{\#2}{}_{lphaeta}$	$f_{1}^{\#1}{}_{lphaeta}$	${\mathscr R}_1^{\sharp 1}{}_{lpha}$	$\mathcal{F}_{1}^{\#2}{}_{\alpha}$	$f_{1-\alpha}^{\#1}$	$f_{1}^{#2}{}_{\alpha}$
$\mathcal{A}_{1}^{\sharp 1}\dagger^{lphaeta}$	$\frac{1}{4}\left(\alpha_0-4\beta_1\right)$	$\frac{\alpha_0 - 4 \beta_1}{2 \sqrt{2}}$	$\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	0	0	0	0
$\mathcal{A}_{1}^{\#2}\dagger^{lphaeta}$	$\frac{\alpha_0 - 4 \beta_1}{2 \sqrt{2}}$	0	0	0	0	0	0
$f_{1}^{\#1}\dagger^{\alpha\beta}$	$-\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	0	0	0	0	0	0
${\cal R}_1^{\#_1}\dagger^lpha$	0	0	0	$\frac{1}{4}\left(\alpha_0-4\beta_1\right)$	$-\frac{\alpha_0-4\beta_1}{2\sqrt{2}}$	0	$-\frac{1}{2}\bar{i}(\alpha_0-4\beta_1)k$
$\mathcal{A}_{1}^{\#2}\dagger^{lpha}$	0	0	0	$-\frac{\alpha_0-4\beta_1}{2\sqrt{2}}$	0	0	0
$f_{1}^{#1} \dagger^{\alpha}$	0	0	0	0	0	0	0
$f_{1}^{#2} \dagger^{\alpha}$	0	0	0	$\frac{1}{2}\bar{i}(\alpha_0-4\beta_1)k$	0	0	0

\mathcal{A}_{0}^{*1}	συ υ	$\frac{3}{2}$ - 2 β_1 + α_6	$i(\alpha_0-4\beta_1)k$	√2 √2	C	D	Û	>
	. [#]	¥, ± + 0 + 1 + 0 + 1 + 0	. [#٧	f"+ T	£#5 +	1 +0 /	4 #1+	-0.5
$\mathcal{A}_{i}^{\#1}$	$\mathcal{A}_{2^{-}}^{\#1} \alpha \beta \chi$			0		$\frac{\partial}{\partial \omega}$	$^{-4}$ $^{+}$ p_1	
$f_{\perp}^{#1}$	' $2^{T}\alpha\beta$	$\frac{i(\alpha_0-4\beta_1)k}{\alpha_0}$	2 1/2	2 B. k ²	٠ ام ١		0	
$\mathcal{A}^{\#1}$	$\sim .2^{+} \alpha \beta$	$-\frac{\alpha_0}{2}+\beta_1$	4	$-\frac{i(\alpha_0-4\beta_1)k}{\alpha_0}$	2 1/2	c	0	
		В		В		×		•

 $\frac{1}{2} (\alpha_0 - 4 \beta_1)$

0

0

0

0

 $-\frac{i(\alpha_0-4\,\beta_1)\,k}{\sqrt{2}}$

 $-4 \beta_1 k^2$

Massive and massless spectra

Massive particle
Pole residue:
$$\frac{1}{\alpha_0} + \frac{1}{\alpha_6} - \frac{1}{4\beta_1} > 0$$
Polarisations:
$$1$$
Square mass:
$$-\frac{\alpha_0 (\alpha_0 - 4\beta_1)}{8 \alpha_6 \beta_1} > 0$$
Spin:
$$0$$
Parity: Even

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

Source constraints SO(3) irreps

Unitarity conditions

 $\alpha_0 > 0 \&\& \alpha_6 > 0 \&\& \beta_1 < 0 \mid |\beta_1 > \frac{\alpha_0}{4}$