Particle spectrograph

Wave operator and propagator

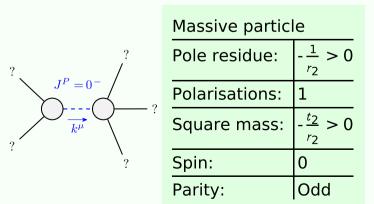
$ \frac{\partial \varphi_{0} a^{t} a^{t} = 0}{\partial \varphi_{0} a^{t} a^{t} = 0} $ $ \frac{\partial \varphi_{0} a^{t} a^{t} = 0}{\partial \varphi_{0} a^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} \partial^{t} a^{t}} $ $ \frac{\partial \varphi_{0} a^{t} a^{t} = 0}{\partial \varphi_{0} a^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} \partial^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} \partial^{t} a^{t}} $ $ \frac{\partial \varphi_{0} a^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} \partial^{t} a^{t}}{\partial \varphi_{0} \partial^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} \partial^{t} a^{t}} $ $ \frac{\partial \varphi_{0} a^{t} a^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} a^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} \partial^{t} a^{t}}{\partial \varphi_{0} \partial^{t} a^{t}} $ $ \frac{\partial \varphi_{0} a^{t} a^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} a^{t} a^{t} a^{t}}{\partial \varphi_{0} \partial^{t} a^{t}} $ $ \frac{\partial \varphi_{0} a^{t} a^{t} a^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} a^{t} a^{t}}{\partial \varphi_{0} \partial^{t} a^{t}} $ $ \frac{\partial \varphi_{0} a^{t} a^{t} a^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} a^{t} a^{t} a^{t}}{\partial \varphi_{0} \partial^{t} a^{t}} $ $ \frac{\partial \varphi_{0} a^{t} a^{t} a^{t} a^{t} + 2 \partial_{\varphi} \partial^{t} a^{t} a^{t} a^{t}}{\partial \varphi_{0} \partial^{t} a^{t}} $ $ \frac{\partial \varphi_{0} a^{t} a^$	$\partial_{\beta}\partial_{\alpha} \tau^{\alpha\beta} == 0$ $\partial_{\beta}\partial_{\alpha} \tau^{\alpha\beta} == \partial_{\beta}\partial^{\beta} \tau^{\alpha} + 2 \partial_{\chi}\partial^{\chi}\partial_{\beta}\sigma^{\alpha\beta}$ $\partial_{\chi}\partial_{\beta}\partial^{\alpha} \tau^{\beta\chi} + \partial_{\delta}\partial^{\delta}\partial_{\chi}\partial_{\beta}\sigma^{\alpha\beta\chi} == \partial_{\chi}\partial^{\chi}\partial_{\beta}\tau^{\alpha\beta} + 3$ $\partial_{\delta}\partial^{\delta}\partial_{\nu}\partial^{\alpha}\sigma^{\beta\chi} + \partial_{\delta}\partial^{\delta}\partial_{\nu}\partial^{\chi}\sigma^{\alpha\beta} = 3$ $\partial_{\delta}\partial^{\delta}\partial_{\nu}\partial^{\alpha}\sigma^{\beta\chi} + \partial_{\delta}\partial^{\delta}\partial_{\nu}\partial^{\chi}\sigma^{\alpha\beta} = 3$
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$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\beta + \partial_{\delta}\partial^{\delta}\partial_{\mathbf{v}}\partial^{\chi}\sigma^{\alpha\beta}$
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	β × × β
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$\partial_{eta} t^{eta lpha}$ 3
$i k \sigma_{1+}^{\#1} \alpha \beta == 0$ $= \sigma_{1+}^{\#2} \alpha \beta$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$	$\alpha^{\beta}_{\beta} == 3 \partial_{\chi} \partial_{\beta} \sigma^{\alpha \beta \chi}$ 3
$= \frac{\sigma_{1}^{\#2} \alpha \beta}{\sigma_{1}^{2}}$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$ $= 0$	$^{\chi} + \partial_{\chi}\partial^{\chi} t^{\alpha\beta} +$ 3
$= \frac{\sigma_{1+}^{\#2} \alpha \beta}{3}$ $= 0$ $= 0$ $= 0$ $4 $ $3 $ $3 $ $3 $ $3 $ $3 $ $3 $ $3 $	$-\partial_{\delta}\partial^{\delta}\partial_{\chi}\sigma^{\beta\chi\alpha}==$
$= \sigma_1^{\#2} \alpha \beta$ $= 0$ $= 0$ $3 \delta_{\epsilon} \delta$ $4 \delta_{\epsilon} \delta$ $3 \delta_{\epsilon} \delta$ $3 \delta_{\epsilon} \delta$ $4 \delta_{\epsilon} \delta$ $3 \delta_{\epsilon} \delta$ $3 \delta_{\epsilon} \delta$ $4 \delta_{\epsilon} \delta$ $5 \delta_{\epsilon} \delta$ $5 \delta_{\epsilon} \delta$ $5 \delta_{\epsilon} \delta$ $5 \delta_{\epsilon} \delta$ $6 \delta_{\epsilon} \delta$ $6 \delta_{\epsilon} \delta$ $6 \delta_{\epsilon} \delta$ $7 \delta_{\epsilon} \delta$ $8 \delta_{\epsilon} \delta$	$t^{\alpha\chi} + \partial_{\chi}\partial^{\chi}\tau^{\beta\alpha} +$
$= \sigma_{1+}^{\#2} \alpha \beta$ $= 0$ $= 0$ $3 \delta_{\epsilon}$	$-\partial_\delta\partial^\delta\partial_\chi\sigma^{\alpha\chi\beta}$
3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	3
$= 0$ $= 0$ $3 \frac{3}{9} \frac{6}{6} \frac{1}{9} \frac{1}{9$	$(+\partial_{\delta}\partial^{\delta}\partial_{\chi}\sigma^{\alpha\chi\beta}==$
$= 0$ $3 \frac{\partial}{\partial \xi}$ $= 0$ $4 \frac{\partial}{\partial \xi}$ $3 \frac{\partial}{\partial \xi}$	$\partial_\delta\partial^\delta\partial_\chi\sigma^{eta\chilpha}$
3.6	$3 \partial_{\epsilon} \partial^{\epsilon} \partial^{\chi} \partial^{\alpha} \sigma^{\beta \delta}{}_{\delta} + 5$
33 4 966	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\beta} \sigma^{\alpha \chi \delta} + 4 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\beta} \sigma^{\alpha \delta \chi} +$
3.6	$2 \partial_{\epsilon} \partial_{\epsilon} \partial_{\delta} \partial_{\delta} \partial^{\chi \delta \alpha} + 4 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\chi} \sigma^{\alpha \beta \delta} +$
3.0 = 3.3	$2 \partial_{\epsilon} \partial_{\delta} \partial_{\lambda} \sigma^{\alpha \delta \beta} + 2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\delta} \sigma^{\beta \chi \alpha} +$
3 de	$\partial^{\alpha}\sigma^{\delta \epsilon}{}_{\delta}+$
3 4 9 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	$\partial_{\delta}\sigma^{eta\deltaarepsilon}+$
36 == 0 4 0 ₀ 6	$\partial^{\epsilon}\sigma^{\alpha\delta}{}_{\delta}==$
== 0 4 4 0 _o s	$+3\partial_{\epsilon}\partial^{\epsilon}\partial^{\chi}\partial^{\beta}\sigma^{\alpha\delta}{}_{\delta}+$
== 0 4 <i>9 8 9 9 9 9 9 9 9 9 9 9</i>	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\alpha} \sigma^{\beta \chi \delta} + 4 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\alpha} \sigma^{\beta \delta \chi} +$
== 0 4 9 _o 6	$2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\alpha} \sigma^{\chi \delta \beta} + 2 \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\chi} \sigma^{\beta \delta \alpha} +$
== 0 4 9 ₆ 6	$4\partial_{\epsilon}\partial_{\delta}\partial_{\delta}\partial^{\sigma}\partial^{\alphaeta\chi} + 2\partial_{\epsilon}\partial^{\epsilon}\partial_{\delta}\partial_{\delta}\partial^{\delta}\sigma^{\alpha\chieta} +$
$==0$ $4 \partial_{\delta} i$ $3 i$	$\partial^{eta}\sigma^{\delta \epsilon}$ +
== 0 4 0 _o c	$\partial_{\delta}\sigma^{\alpha\delta\epsilon}$ +
== 0 4 0 ₆ ¢	$\partial^{\epsilon}\sigma^{eta\delta}$
$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\chi} t^{\alpha \beta} + 3$ $2 \eta^{\alpha \beta} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial_{\chi} t^{\chi'}$ $3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\alpha} t^{\beta \chi} + 3 \partial^{\alpha} \partial^{\beta} \partial^{\alpha} t^{\beta \chi} + 3 \partial^{\alpha} \partial^{\beta} \partial^{\alpha} \partial^{$	$\partial_{\delta}\partial^{\delta}\partial^{\beta}\partial^{\alpha}\tau_{\chi}^{\chi} + 5$
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$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\beta} t^{\alpha \chi} + 3$ $2 \eta^{\alpha \beta} \partial_{\epsilon} \partial^{\epsilon} \partial_{\delta} \partial^{\delta} t^{\chi}$	$+3\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\alpha}\tau^{\chi\beta}+$
$2 \eta^{\alpha\beta} \partial_{\epsilon} \partial_{\delta} \partial_{\delta} \partial_{\tau} \chi$	$3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\beta} \tau^{\alpha \chi} + 3 \partial_{\delta} \partial^{\delta} \partial_{\chi} \partial^{\beta} \tau^{\chi \alpha} +$
	$\partial^{\delta} t^{\chi}_{\chi}$
$\sigma_{2+}^{\#1}{}^{\alpha\beta} == 0 \qquad 3 \partial_{\delta} \partial_{\chi} \partial^{\alpha} \sigma^{\beta \chi \delta} + 3 \partial_{\delta} \partial_{\chi} \partial^{\beta} \sigma^{\alpha \chi \delta} +$	$\partial_{\delta}\partial_{\chi}\partial^{\beta}\sigma^{\alpha\chi\delta}+$ 5
$2 \eta^{\alpha\beta} \partial_{\epsilon} \partial_{\delta} \sigma^{\chi \delta}_{\chi}$	$\sigma^{\chi\delta}_{\chi} = 2 \partial_{\delta}\partial^{\beta}\partial^{\alpha}\sigma^{\chi\delta}_{\chi} +$
$3 \left(\partial_{\delta} \partial^{\delta} \partial_{\chi} \sigma^{\alpha \chi \beta} + \partial_{\delta} \partial^{\delta} \partial_{\chi} \sigma^{\beta \chi \alpha} \right)$	

Quadratic (free) action $S == \begin{cases} S == \\ \int \int \int \int \int \int \int \partial u du du du du du du du $	$t_2 \partial_{\theta} f_{,\alpha} \partial^{\theta} f^{\alpha \prime} - 4t_2 \mathcal{A}_{\alpha\theta \prime} (\mathcal{A}^{\alpha \prime \theta} + \partial^{\theta} f^{\alpha \prime}) + \\ 2t_2 \mathcal{A}_{\alpha \prime \theta} (\mathcal{A}^{\alpha \prime \theta} + 2 \partial^{\theta} f^{\alpha \prime}) + 8r_2 \partial_{\beta} \mathcal{A}_{\alpha \prime \theta} \partial^{\theta} \mathcal{A}^{\alpha \beta \prime} - \\ 4r_2 \partial_{\beta} \mathcal{A}_{\alpha\theta \prime} \partial^{\theta} \mathcal{A}^{\alpha\beta \prime} + 4r_2 \partial_{\beta} \mathcal{A}_{,\theta\alpha} \partial^{\theta} \mathcal{A}^{\alpha\beta \prime} - \\ 2r_2 \partial_{\beta} \mathcal{A}_{\alpha\beta \theta} \partial^{\theta} \mathcal{A}^{\alpha\beta \prime} + 2r_2 \partial_{\theta} \mathcal{A}_{\alpha\beta \prime} \partial^{\theta} \mathcal{A}^{\alpha\beta \prime} - \\ 4r_2 \partial_{\theta} \mathcal{A}_{\alpha \prime \beta} \partial^{\theta} \mathcal{A}^{\alpha\beta \prime})][t, x, y, z] dz dy dx dt$
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$^{l}1^{-}\alpha$	0	0	0	$\frac{6ik}{(3+2k^2)^2}$	$3i\sqrt{2}k$ $(3+2k^2)^2t$	0	$\frac{6k^2}{(3+2k^2)^2t}$	<u>-</u> 2	0	0	0	īkt3	√2 kt	0	$\frac{2k^2t_3}{3}$	$\mathcal{A}_2^\#$)			
				- (3+	3 i (3+2		(3+2)	$f_{1}^{\#2}$		J		. 2 i	$\frac{1}{3}$ \vec{i} $$	J	2 k	$f_{2}^{\#1}$	0	0	0	
l_1	0	0	0	0	0	0	0	$f_{1^-}^{\#1} \alpha$	0	0	0	0	0	0	0	${\mathscr A}_{2^+}^{\#1}{}_{lphaeta}$)	0	0	0	#1.
$O_{1^-} \alpha$	0	0	0	$-\frac{3\sqrt{2}}{(3+2k^2)^2t_3}$	$\frac{3}{(3+2k^2)^2t_3}$	0	$-\frac{3i\sqrt{2}k}{(3+2k^2)^2t_3}$	${\mathcal A}_{1^-}^{\#2}{}_{lpha}$	0	0	0	$\frac{\sqrt{2}t_3}{3}$	[13] 3	0	$\frac{1}{3}$ i $\sqrt{2}$ kt ₃	\mathcal{A}_2^{\sharp}	$\mathcal{A}_{2}^{\#1} + \alpha \beta$		$\mathcal{A}_{2^{-}}^{#1} +^{\alpha \beta \chi}$	$\sigma_{2^{+}}^{\#1} \dagger \\ \tau_{2^{+}}^{\#1} \dagger \\ \sigma_{2^{-}}^{\#1} \dagger^{\alpha}$
$o_{1^-} \alpha$	0	0	0	$\frac{6}{(3+2k^2)^2t_3}$	$\frac{3\sqrt{2}}{(3+2k^2)^2t_3}$	0	$\frac{6ik}{(3+2k^2)^2t_3}$	${\mathscr A}_{1^{\bar{-}}}^{\#1}{}_{\alpha}$	0	0	0	2 <i>t</i> 3	$-\frac{\sqrt{2}t_3}{3}$	0	$\frac{2ikt_3}{3} -$	$\mathcal{A}_0^{\#_2^*}$		$\mathcal{A}_{0}^{\#1}$		$f_{0+}^{\#1}$ $\sqrt{2} kt_3$
$^{\prime}1^{+}\alpha\beta$	$\frac{3\tilde{\imath}\sqrt{2}k}{(3+k^2)^2t_2}$	$\frac{3ik}{(3+k^2)^2t_2}$	$\frac{3k^2}{(3+k^2)^2t_2}$	0	0	0	0	$f_{1}^{\#1}_{\alpha\beta}$	$\frac{1}{3}\bar{l}\sqrt{2}kt_2$	<u>ikt2</u> 3	$\frac{k^2 t_2}{3}$	0	0	0	0	$f_{0}^{\#}$	1 + <i>i</i>			$2k^2t_3$
$\sigma_{1}^{+}\alpha\beta$	$\frac{3\sqrt{2}}{(3+k^2)^2t_2}$	$\frac{3}{(3+k^2)^2 t_2}$	$\frac{3ik}{(3+k^2)^2t_2}$	0	0	0	0	$\mathcal{A}_{1}^{\#2}_{\alpha\beta}$	$\frac{\sqrt{2} t_2}{3}$	2 2 3	$-\frac{1}{3}$ \bar{l} kt_2	0	0	0	0	$\mathcal{A}_0^{\#}$	1 † _	$\sigma_{0^{+}}^{*1}$		0 τ ₀ ^{#1}
$\sigma_{1} + \alpha \beta$	$\frac{6}{(3+k^2)^2 t_2}$	$\frac{3\sqrt{2}}{(3+k^2)^2t_2}$	$-\frac{3 i \sqrt{2} k}{(3+k^2)^2 t_2} - \frac{3 i \sqrt{2} k}{(3+k^2)^2 t_2}$	0	0	0	0	${\mathscr A}_1^{\#1}_{+\alpha\beta}$	$\frac{2t_2}{3}$	$\frac{\sqrt{2}t_2}{3}$	$-\frac{1}{3}\bar{l}\sqrt{2}kt_2$	0	0	0	0	$\sigma_{0^{+}}^{\#1}$ $\tau_{0^{+}}^{\#1}$	† -	$\frac{1}{1+2k^2)^2}$ $i \sqrt{2} k$ $1+2k^2)^2$,	$\frac{i \sqrt{2} k}{(1+2k^2)^2}$ $2k^2$ $(1+2k^2)^2 t$
	$\sigma_1^{\#1} + ^{lphaeta}$	$\sigma_1^{\#2} + \alpha^{\beta}$	$\tau_1^{\#1} + \alpha \beta$	$\sigma_{1}^{\#1} +^{lpha}$	$\sigma_{1}^{\#2} +^{\alpha}$	$\tau_{1}^{\#_{1}} +^{\alpha}$	$\tau_{1}^{\#2} +^{\alpha}$		$\mathcal{A}_1^{\#1} \dagger^{lphaeta}$	$\mathcal{A}_{1}^{\#2} \dagger^{\alpha\beta}$	$f_{1}^{\#1} \dagger^{\alpha\beta}$	$\mathcal{A}_{1}^{\#1}\dagger^{lpha}$	$\mathcal{A}_{1}^{\#2} +^{\alpha}$	$f_{1}^{\#1} \dagger^{\alpha}$	$f_{1}^{\#2} +^{\alpha}$	$\tau_{0}^{\#2}$		0		0
	$\sigma_1^{\#1}$	$\sigma_1^{\#2}$	${\mathfrak l}_1^{\#1}$	$\sigma_1^{\scriptscriptstyle \#}$	$\sigma_1^{\#}$	$t_1^{\#}$	$ au_1^{\#}$		$\mathcal{H}_1^{\#}$	$\mathcal{A}_{1}^{\#}$	$f_{1}^{\#}$	R	R	f	f	$\sigma_0^{\#1}$	†	0		0

 $\sigma_{2+\alpha\beta}^{\#1} \tau_{2+\alpha\beta}^{\#1} \sigma_{2-\alpha\beta\chi}^{\#1}$

Massive and massless spectra



	Massive particle						
?	Pole residue:	$-\frac{1}{r_2} > 0$					
P = 0	Polarisations:	1					
k^{μ}	Square mass:	$-\frac{t_2}{r_2} > 0$					
?	Spin:	0					
	Parity:	Odd					

Unitarity conditions

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