



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

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

Unitarity conditions

(No massless particles)

| | $\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$ | $\tau_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\sigma_{1-}^{\#1} \alpha$ | $\sigma_{1-}^{\#2} \alpha$ | $\tau_{1-}^{\#1} \alpha$ | $\tau_{1-}^{\#2} \alpha$ |
|---|---|--|---|----------------------------|----------------------------|--------------------------|--------------------------|
| $\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\frac{2}{3k^2r_3}$ | $-\frac{2\sqrt{2}}{3k^2r_3+3k^4r_3}$ | $-\frac{2i\sqrt{2}}{3kr_3+3k^3r_3}$ | 0 | 0 | 0 | 0 |
| $\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$ | $-\frac{2\sqrt{2}}{3k^2r_3+3k^4r_3}$ | $\frac{9k^2r_3+4t_2}{3(k+k^3)^2r_3t_2}$ | $\frac{i(9k^2r_3+4t_2)}{3k(1+k^2)^2r_3t_2}$ | 0 | 0 | 0 | 0 |
| $\tau_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\frac{2i\sqrt{2}}{3kr_3+3k^3r_3}$ | $-\frac{i(9k^2r_3+4t_2)}{3k(1+k^2)^2r_3t_2}$ | $\frac{9k^2r_3+4t_2}{3(1+k^2)^2r_3t_2}$ | 0 | 0 | 0 | 0 |
| $\sigma_{1-}^{\#1} \dagger^{\alpha}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\sigma_{1-}^{\#2} \dagger^{\alpha}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\tau_{1-}^{\#1} \dagger^{\alpha}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\tau_{1-}^{\#2} \dagger^{\alpha}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Lagrangian density

$$\begin{aligned} &\frac{2}{3}t_2\omega_{\lambda'}^{\kappa\lambda}\omega_{\kappa\lambda}^{'\prime}+\frac{1}{3}t_2\omega_{\kappa\lambda}^{'\prime}\omega_{\kappa\lambda}^{\kappa\lambda\prime}+f^{\alpha\beta}\tau_{\alpha\beta}+\omega^{\alpha\beta\chi}\sigma_{\alpha\beta\chi}+\\ &\frac{2}{3}r_2\partial^\beta\omega_{\kappa}^{\theta\alpha}\partial_\theta\omega_{\alpha\beta}^{\kappa}-\frac{1}{3}r_2\partial_\theta\omega_{\alpha\beta}^{\kappa}\partial_{\kappa}\omega^{\alpha\beta\theta}-\frac{2}{3}r_2\partial_\theta\omega_{\alpha\beta}^{\kappa}\partial_{\kappa}\omega^{\theta\alpha\beta}+\\ &r_3\partial_\alpha\omega_{\lambda}^{\alpha}{}_{\theta}\partial_{\kappa}\omega^{\theta\kappa\lambda}-r_3\partial_\theta\omega_{\lambda}^{\alpha}{}_{\alpha}\partial_{\kappa}\omega^{\theta\kappa\lambda}+\frac{1}{6}t_2\partial^\alpha f_{\theta\kappa}^{\kappa}\partial_{\alpha}^{\kappa}f_{\theta}^{\theta}-\frac{1}{6}t_2\partial^\alpha f_{\theta}^{\theta}\partial_{\alpha}^{\kappa}f_{\kappa}^{\kappa}+\\ &\frac{1}{6}t_2\partial^\alpha f_{\kappa}^{\lambda}\partial_{\alpha}^{\kappa}f_{\lambda}^{\lambda}+\frac{1}{3}t_2\omega_{\theta\kappa}^{'\prime}\partial_{\kappa}^{\kappa}f^{\lambda\theta}-\frac{2}{3}t_2\omega_{\theta\kappa}^{'\prime}\partial_{\kappa}^{\kappa}f^{\lambda\theta}-\frac{1}{3}t_2\omega_{\theta\kappa}^{'\prime}\partial_{\kappa}^{\kappa}f^{\lambda\theta}+\\ &\frac{2}{3}t_2\omega_{\theta\kappa\lambda}^{'\prime}\partial_{\kappa}^{\kappa}f^{\lambda\theta}-\frac{1}{6}t_2\partial^\alpha f_{\lambda}^{\lambda}\partial_{\alpha}^{\kappa}f_{\theta}^{\theta}-\frac{1}{6}t_2\partial_{\kappa}^{\kappa}f_{\theta}^{\theta}+\frac{1}{6}t_2\partial_{\kappa}^{\kappa}f_{\theta}^{\lambda}\partial_{\lambda}^{\kappa}f_{\theta}^{\theta}+\\ &\frac{1}{3}r_2\partial_{\kappa}\omega^{\alpha\beta\theta}\partial^{\kappa}\omega_{\alpha\beta\theta}+\frac{2}{3}r_2\partial_{\kappa}\omega^{\theta\alpha\beta}\partial^{\kappa}\omega_{\alpha\beta\theta}-\frac{2}{3}r_2\partial^\beta\omega_{\lambda}^{'\prime}\partial_{\lambda}\omega_{\alpha\beta}^{'\prime}+\\ &\frac{2}{3}r_2\partial^\beta\omega_{\lambda}^{'\prime}\partial_{\lambda}\omega_{\alpha\beta}^{'\prime}-4r_3\partial^\beta\omega_{\lambda}^{'\prime}\partial_{\lambda}\omega_{\alpha\beta}^{'\prime}\partial_{\lambda}\omega_{\theta}^{\alpha}\partial^{\lambda}\omega_{\kappa}^{\theta\kappa}+r_3\partial_\theta\omega_{\lambda}^{\alpha}\partial^{\lambda}\omega_{\kappa}^{\theta\kappa} \end{aligned}$$

| | $\omega_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\omega_{1+}^{\#2} \dagger^{\alpha\beta}$ | $f_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\omega_{1-}^{\#1} \alpha$ | $\omega_{1-}^{\#2} \alpha$ | $f_{1-}^{\#1} \alpha$ | $f_{1-}^{\#2} \alpha$ |
|---|---|---|--------------------------------------|----------------------------|----------------------------|-----------------------|-----------------------|
| $\omega_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\frac{1}{6}(9k^2r_3+4t_2)$ | $\frac{\sqrt{2}t_2}{3}$ | $\frac{1}{3}i\sqrt{2}kt_2$ | 0 | 0 | 0 | 0 |
| $\omega_{1+}^{\#2} \dagger^{\alpha\beta}$ | $\frac{\sqrt{2}t_2}{3}$ | $\frac{t_2}{3}$ | $\frac{ikt_2}{3}$ | 0 | 0 | 0 | 0 |
| $f_{1+}^{\#1} \dagger^{\alpha\beta}$ | $-\frac{1}{3}i\sqrt{2}kt_2$ | $-\frac{1}{3}ikt_2$ | $\frac{k^2t_2}{3}$ | 0 | 0 | 0 | 0 |
| $\omega_{1-}^{\#1} \dagger^{\alpha}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\omega_{1-}^{\#2} \dagger^{\alpha}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $f_{1-}^{\#1} \dagger^{\alpha}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $f_{1-}^{\#2} \dagger^{\alpha}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

$\omega_{2+}^{\#1} \dagger^{\alpha\beta}$
 $f_{2+}^{\#1} \dagger^{\alpha\beta}$
 $\omega_{2-}^{\#1} \dagger^{\alpha\beta\chi}$

| | | | |
|---|----------------------|---|---|
| $\omega_{2+}^{\#1} \dagger^{\alpha\beta}$ | $-\frac{3k^2r_3}{2}$ | 0 | 0 |
| $f_{2+}^{\#1} \dagger^{\alpha\beta}$ | 0 | 0 | 0 |
| $\omega_{2-}^{\#1} \dagger^{\alpha\beta\chi}$ | 0 | 0 | 0 |

Source constraints

| SO(3) irreps | # |
|--|----|
| $\tau_{0+}^{\#2} == 0$ | 1 |
| $\tau_{0+}^{\#1} == 0$ | 1 |
| $\sigma_{0+}^{\#1} == 0$ | 1 |
| $\tau_{1-}^{\#2\alpha} == 0$ | 3 |
| $\tau_{1-}^{\#1\alpha} == 0$ | 3 |
| $\sigma_{1-}^{\#2\alpha} == 0$ | 3 |
| $\sigma_{1-}^{\#1\alpha} == 0$ | 3 |
| $\tau_{1+}^{\#1\alpha\beta} + ik\sigma_{1+}^{\#2\alpha\beta} == 0$ | 3 |
| $\sigma_{2-}^{\#1\alpha\beta\chi} == 0$ | 5 |
| $\tau_{2+}^{\#1\alpha\beta} == 0$ | 5 |
| Total #: | 28 |

$\sigma_{0+}^{\#1} \dagger$
 $\tau_{0+}^{\#1} \dagger$
 $\tau_{0+}^{\#2} \dagger$
 $\sigma_{0-}^{\#1}$

| | | | | |
|-----------------------------|---|---|---|------------------------|
| $\sigma_{0+}^{\#1} \dagger$ | 0 | 0 | 0 | 0 |
| $\tau_{0+}^{\#1} \dagger$ | 0 | 0 | 0 | 0 |
| $\tau_{0+}^{\#2} \dagger$ | 0 | 0 | 0 | 0 |
| $\sigma_{0-}^{\#1} \dagger$ | 0 | 0 | 0 | $\frac{1}{k^2r_2+t_2}$ |

$\omega_{0+}^{\#1} \dagger$
 $f_{0+}^{\#1} \dagger$
 $f_{0+}^{\#2} \dagger$
 $\omega_{0-}^{\#1}$

| | | | | |
|-----------------------------|---|---|---|--------------|
| $\omega_{0+}^{\#1} \dagger$ | 0 | 0 | 0 | $k^2r_2+t_2$ |
| $f_{0+}^{\#1} \dagger$ | 0 | 0 | 0 | 0 |
| $f_{0+}^{\#2} \dagger$ | 0 | 0 | 0 | 0 |
| $\omega_{0-}^{\#1}$ | 0 | 0 | 0 | 0 |

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

| | | | |
|---|----------------------|---|---|
| $\sigma_{2+}^{\#1} \dagger^{\alpha\beta}$ | $-\frac{2}{3k^2r_3}$ | 0 | 0 |
| $\tau_{2+}^{\#1} \dagger^{\alpha\beta}$ | 0 | 0 | 0 |
| $\sigma_{2-}^{\#1} \dagger^{\alpha\beta\chi}$ | 0 | 0 | 0 |