

Wave operator and propagator

A diagram showing two nucleons (represented by circles) interacting via meson exchange. The left nucleon has two incoming lines and two outgoing lines, with the label $J^P = 0^-$ above it. The right nucleon has two incoming lines and two outgoing lines, with a question mark '?' above it. A dashed line connects the two nucleons, with a blue arrow pointing from left to right and the label k^μ below it.

(No massless particles)

$$r_2 < 0 \ \&\& \ t_2 > 0$$
$$\begin{aligned} & \omega_{,\theta}^{\alpha\beta} \tau_{\alpha\beta} + 6 \omega^{\alpha\beta\gamma} \sigma_{\alpha\beta\gamma} - 4 t_1 \omega_{\alpha}^{\theta} \partial_{\theta} f^{\alpha\omega} + \\ & 4 t_1 \omega_{,\theta}^{\theta} \partial_{\theta} f^{\alpha} - 2 t_1 \partial_{\theta} f^{\alpha} \partial_{\theta} f^{\alpha} - 2 t_1 \partial_{\theta} f^{\alpha\omega} \partial_{\theta} f^{\theta} + \\ & 4 t_1 \partial_{\theta} f^{\alpha} \partial_{\theta} f^{\theta} + 4 t_1 \omega_{,\theta\alpha}^{\theta} \partial_{\theta} f^{\alpha\omega} + 4 t_2 \omega_{,\theta\alpha}^{\theta} \partial_{\theta} f^{\alpha\omega} - \\ & 4 t_1 \partial_{\alpha} f_{,\theta}^{\theta} \partial_{\theta} f^{\alpha\omega} + 2 t_2 \partial_{\alpha} f_{,\theta}^{\theta} \partial_{\theta} f^{\alpha\omega} - 4 t_1 \partial_{\alpha} f_{,\theta}^{\theta} \partial_{\theta} f^{\alpha\omega} - \\ & t_2 \partial_{\alpha} f_{,\theta}^{\theta} \partial_{\theta} f^{\alpha\omega} + 2 t_1 \partial_{\theta} f_{,\alpha}^{\theta} \partial_{\theta} f^{\alpha\omega} + \\ & 4 t_1 \partial_{\theta} f_{,\alpha}^{\theta} \partial_{\theta} f^{\alpha\omega} + t_2 \partial_{\theta} f_{,\alpha}^{\theta} \partial_{\theta} f^{\alpha\omega} + 2 t_1 \partial_{\theta} f_{,\alpha}^{\theta} \partial_{\theta} f^{\alpha\omega} - \\ & t_2 \partial_{\theta} f_{,\alpha}^{\theta} \partial_{\theta} f^{\alpha\omega} + 2 (t_1 + t_2) \omega_{\alpha\theta} (\omega^{\alpha\theta} + 2 \partial_{\theta} f^{\alpha\omega}) + \\ & 2 \omega_{\alpha\theta} ((t_1 - 2 t_2) \omega^{\alpha\theta} + 2 (2 t_1 - t_2) \partial_{\theta} f^{\alpha\omega}) + \\ & 8 r_2 \partial_{\beta} \omega_{\alpha\theta} \partial_{\theta} \omega^{\alpha\beta\omega} - 4 r_2 \partial_{\beta} \omega_{\alpha\theta} \partial_{\theta} \omega^{\alpha\beta\omega} + 4 r_2 \partial_{\beta} \omega_{,\theta\alpha} \\ & \partial_{\theta} \omega^{\alpha\beta\omega} - 2 r_2 \partial_{\omega} \omega_{\alpha\theta} \partial_{\theta} \omega^{\alpha\beta\omega} + 2 r_2 \partial_{\theta} \omega_{\alpha\beta} \partial_{\theta} \omega^{\alpha\beta\omega} - \\ & 4 r_2 \partial_{\theta} \omega_{\alpha\beta} \partial_{\theta} \omega^{\alpha\beta\omega})](t, x, y, z) dz dy dx dt \end{aligned}$$

| | | | | | | | |
|---|-----------------------------------|-------------------------------|------------------------------------|-------------------------|------------------------------|---|-----------------------------|
| $\omega_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\frac{1}{6}(t_1 + 4t_2)$ | $-\frac{t_1-2t_2}{3\sqrt{2}}$ | $-\frac{i k(t_1-2t_2)}{3\sqrt{2}}$ | 0 | 0 | 0 | 0 |
| $\omega_{1+}^{\#2} \dagger^{\alpha\beta}$ | $-\frac{t_1-2t_2}{3\sqrt{2}}$ | $\frac{t_1+t_2}{3}$ | $\frac{1}{3}i k(t_1+t_2)$ | 0 | 0 | 0 | 0 |
| $f_{1+}^{\#1} \dagger^{\alpha\beta}$ | $\frac{i k(t_1-2t_2)}{3\sqrt{2}}$ | $-\frac{1}{3}i k(t_1+t_2)$ | $\frac{1}{3}k^2(t_1+t_2)$ | 0 | 0 | 0 | 0 |
| $\omega_{1-}^{\#1} \dagger^{\alpha}$ | 0 | 0 | 0 | $\frac{t_1}{6}$ | $\frac{t_1}{3\sqrt{2}}$ | 0 | $\frac{i k t_1}{3}$ |
| $\omega_{1-}^{\#2} \dagger^{\alpha}$ | 0 | 0 | 0 | $\frac{t_1}{3\sqrt{2}}$ | $\frac{t_1}{3}$ | 0 | $\frac{1}{3}i\sqrt{2}k t_1$ |
| $f_{1-}^{\#1} \dagger^{\alpha}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $f_{1-}^{\#2} \dagger^{\alpha}$ | 0 | 0 | 0 | $-\frac{1}{3}i k t_1$ | $-\frac{1}{3}i\sqrt{2}k t_1$ | 0 | $\frac{2k^2 t_1}{3}$ |

$$\begin{array}{c}
\begin{array}{c} \omega_0^{\#1} \\ f_0^{\#2} \\ f_0^{\#1} \\ \omega_0^{\#1} \end{array}
\begin{array}{|c|c|c|c|}
\hline
\omega_0^{\#1} & \omega_0^{\#1} & \omega_0^{\#1} & k^2 r_2 + t_2 \\
\hline
f_0^{\#2} & f_0^{\#2} & f_0^{\#2} & 0 \\
\hline
f_0^{\#1} & f_0^{\#1} & f_0^{\#1} & 0 \\
\hline
\omega_0^{\#1} & \omega_0^{\#1} & \omega_0^{\#1} & 0 \\
\hline
\end{array}
\end{array}
\begin{array}{c}
\sigma_0^{\#1} \uparrow \quad \tau_0^{\#1} \uparrow \quad \tau_0^{\#2} \uparrow \quad \sigma_0^{\#1} \\
\sigma_0^{\#1} \uparrow + \quad \tau_0^{\#1} \uparrow + \quad \tau_0^{\#2} \uparrow + \quad \sigma_0^{\#1} \uparrow + \\
\sigma_0^{\#1} \uparrow + \quad \tau_0^{\#1} \uparrow + \quad \tau_0^{\#2} \uparrow + \quad \sigma_0^{\#1} \uparrow +
\end{array}
\begin{array}{|c|c|c|c|}
\hline
\sigma_0^{\#1} \uparrow + & \tau_0^{\#1} \uparrow + & \tau_0^{\#2} \uparrow + & \sigma_0^{\#1} \uparrow + \\
\hline
\sigma_0^{\#1} \uparrow + & \tau_0^{\#1} \uparrow + & \tau_0^{\#2} \uparrow + & \sigma_0^{\#1} \uparrow + \\
\hline
\sigma_0^{\#1} \uparrow + & \tau_0^{\#1} \uparrow + & \tau_0^{\#2} \uparrow + & \sigma_0^{\#1} \uparrow + \\
\hline
\sigma_0^{\#1} \uparrow + & \tau_0^{\#1} \uparrow + & \tau_0^{\#2} \uparrow + & \sigma_0^{\#1} \uparrow +
\end{array}$$

$$\begin{array}{c}
\omega_{2^+}^{\#1} \uparrow \alpha \beta \quad f_{2^+}^{\#1} \uparrow \alpha \beta \quad \omega_{2^+}^{\#1} \uparrow \alpha \beta \\
\omega_{2^+}^{\#1} \uparrow \alpha \beta \quad f_{2^+}^{\#1} \uparrow \alpha \beta \quad \omega_{2^+}^{\#1} \uparrow \alpha \beta \\
\omega_{2^+}^{\#1} \uparrow \alpha \beta \quad f_{2^+}^{\#1} \uparrow \alpha \beta \quad \omega_{2^+}^{\#1} \uparrow \alpha \beta
\end{array}
\begin{array}{|c|c|c|}
\hline
\omega_{2^+}^{\#1} \uparrow \alpha \beta & f_{2^+}^{\#1} \uparrow \alpha \beta & \omega_{2^+}^{\#1} \uparrow \alpha \beta \\
\hline
\omega_{2^+}^{\#1} \uparrow \alpha \beta & f_{2^+}^{\#1} \uparrow \alpha \beta & \omega_{2^+}^{\#1} \uparrow \alpha \beta \\
\hline
\omega_{2^+}^{\#1} \uparrow \alpha \beta & f_{2^+}^{\#1} \uparrow \alpha \beta & \omega_{2^+}^{\#1} \uparrow \alpha \beta
\end{array}$$

$$\begin{array}{c}
\sigma_{2^+}^{\#1} \uparrow \alpha \beta \quad \tau_{2^+}^{\#1} \uparrow \alpha \beta \quad \sigma_{2^+}^{\#1} \uparrow \alpha \beta \\
\sigma_{2^+}^{\#1} \uparrow \alpha \beta \quad \tau_{2^+}^{\#1} \uparrow \alpha \beta \quad \sigma_{2^+}^{\#1} \uparrow \alpha \beta \\
\sigma_{2^+}^{\#1} \uparrow \alpha \beta \quad \tau_{2^+}^{\#1} \uparrow \alpha \beta \quad \sigma_{2^+}^{\#1} \uparrow \alpha \beta
\end{array}
\begin{array}{|c|c|c|}
\hline
\sigma_{2^+}^{\#1} \uparrow \alpha \beta & \tau_{2^+}^{\#1} \uparrow \alpha \beta & \sigma_{2^+}^{\#1} \uparrow \alpha \beta \\
\hline
\sigma_{2^+}^{\#1} \uparrow \alpha \beta & \tau_{2^+}^{\#1} \uparrow \alpha \beta & \sigma_{2^+}^{\#1} \uparrow \alpha \beta \\
\hline
\sigma_{2^+}^{\#1} \uparrow \alpha \beta & \tau_{2^+}^{\#1} \uparrow \alpha \beta & \sigma_{2^+}^{\#1} \uparrow \alpha \beta
\end{array}$$