

## Slide 19

$$\begin{aligned}
\frac{1}{2} &= \langle P \frac{1}{2} | \hat{J}_z | P \frac{1}{2} \rangle \\
&= \lim_{\Delta \rightarrow 0} \int d\mathbf{x} e^{i\mathbf{x} \cdot \Delta} \left[ x_1 \langle P + \Delta/2, \frac{1}{2} | T^{02}(0) | P - \Delta/2, \frac{1}{2} \rangle \right. \\
&\quad \left. - x_2 \langle P + \Delta/2, \frac{1}{2} | T^{01}(0) | P - \Delta/2, \frac{1}{2} \rangle \right] \\
&= \lim_{\Delta \rightarrow 0} \int d\mathbf{x} e^{i\mathbf{x} \cdot \Delta} \left[ x_1 \bar{u}(P + \Delta/2) \gamma^0 u(P - \Delta/2) A_{20}(\Delta) P_2 \right. \\
&\quad \left. - x_2 \bar{u}(P + \Delta/2) \gamma^0 u(P - \Delta/2) A_{20}(\Delta) P_1 \right] + \dots \\
&= \int d\mathbf{x} u^\dagger(P) u(P) (\mathbf{x} \times \mathbf{P})_3 A_{20}(0) + \int d\mathbf{x} \chi^\dagger \frac{(\boldsymbol{\sigma} \times \mathbf{P})_3}{2M} \chi B_{20}(0) \\
&= \frac{1}{2} [A_{20}(0) + B_{20}(0)] ,
\end{aligned}$$

dove

$$u(P) = \begin{pmatrix} \chi \\ \frac{\boldsymbol{\sigma} \cdot \mathbf{P}}{E+M} \chi \end{pmatrix}, \quad E = \sqrt{P^2 + M^2}, \quad \chi = \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \quad (1)$$

e il primo termine in Eq. (1) rappresenta la densità di momento angolare orbitale, mentre il secondo rappresenta la densità di momento magnetico.