

NUSTEC 2024: Problem set 2

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1 Normalization of form factor

Consider the matrix element of the electromagnetic current

$$\langle A(p+q) | \mathcal{J}_\mu | A(p) \rangle \quad (1)$$

- 1) Argue that as $q \rightarrow 0$ it must be proportional to p_μ . Up to a normalization constant
- 2) Evaluate the following in two different ways

$$\lim_{q \rightarrow 0} \int d^3x \langle A(p+q) | \mathcal{J}_0(0, \mathbf{x}) | A(p) \rangle \quad (2)$$

a) By shifting the current to the origin using the generator of translations (momentum operator). Then do the space integral explicitly.

b) By bringing the integral inside the matrix element and using the charge operator $\int d^3x \mathcal{J}_0 = Q$.

Use (a) and (b) to fix the constant of proportionality
(Hint: Use $\langle A(p') | A(p) \rangle = 2E_p (2\pi)^3 \delta(\mathbf{p} - \mathbf{p}')$).

2 Pion form factor

Using conservation of the electromagnetic current, construct the most general elastic form factor of the pion

$$\langle \pi(p') | \mathcal{J}_\mu | \pi(p) \rangle \quad (3)$$