Compton Form Factors in Scalar QED

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In this talk I discuss some of the issues raised in the review[1] for the case of virtual Compton scattering in scalar QED. My principal concern here is to study the amplitudes in the limit where the virtuality $-Q^2$ of the incoming photon becomes very large compared to the mass scales in the system of study. In the formulation in terms of Generalized Parton Distributions, one usually relies on collinear kinematics to minimize effects of higher twist. Another approximation is to work in the limit $t \to 0$, where t is the Mandelstam variable of the hadronic target: $t = (p' - p)^2$.

It turns out that the latter two limits do not coincide in DVCS, although at sufficiently high Q^2 the t-dependence may have the form t/Q^2, which may be neglected in a suitable kinematics. However, the latter may not be easy to realize in a practical set-up of the experiments.

We write the physical amplitudes in terms of the contractions of the photon polarization vectors with a tensor $T^{\mu\nu}$:

$$A(q', h'; q, h) = \epsilon^*_\mu(q', h') T^{\mu\nu} \epsilon_\nu(q, h). \tag{1}$$

In scalar QED, the tensor $T^{\mu\nu}$ that is contracted with the polarization vectors of the photons to obtain the physical amplitudes, depends on the target and photon momenta only. I choose as a basis the momenta $k_1 = \bar{P} = p' + p$ (sum of the hadron moments), $k_2 = q'$ and $k_3 = q$ (the photon momenta) and utilize the construction proposed by Tarrach[3] to make the tensor $T^{\mu\nu}$ transverse to the photon momenta, which guarantees electro-magnetic gauge invariance. The construction involves a two-sided projector, given by

$$\tilde{g}^{\mu\nu} = g^{\mu\nu} - \frac{q^\mu q'^\nu}{q \cdot q'}. \tag{2}$$

Then the most general form of a transverse tensor is obtained by contracting a basis tensor t from the left and from the right with $\tilde{g}$ as follows

$$T^{\mu\nu} = \tilde{g}^{\mu m}\, t_{mn} \tilde{g}^{n\nu} \quad \text{where } t \text{ is written as} \quad t^{mn} = t_0 g^{mn} + \sum_{i,j=1}^{3} t_{ij}\, k_i^m k_j^n. \tag{3}$$

Because of the properties of $\tilde{g}^{\mu\nu}$ only five terms remain

$$t^{mn} = t_0\, g^{mn} + t_{11}\, \bar{P}^m \bar{P}^n + t_{13}\, \bar{P}^m q^n + t_{21}\, q'^m \bar{P}^n + t_{23}\, q'^m q^n. \tag{4}$$

In the case where the incoming photon is virtual, with virtuality $q^2 = -Q^2$, and the final photon is real, $q'^2 = 0$, only the *Compton form factors* t_0, t_{11}, and t_{13} can be measured.

In the talk the results obtained in a simple solvable model will be discussed and the kinematical issues mentioned above, related to concrete experimental set-ups, e.g. in JLab, will be considered.

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[1] C.-R. Ji and B.L.G. Bakker, Int. J. Mod. Phys. E **22**, 1330002 (2013).
[2] X. Ji, Phys. Rev. Lett. **78**, 610 (1997)
[3] R. Tarrach, Nuovo Cim. A **28**, 409 (1973).