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Pseudo Feynman Amplitudes in Classical Electrodynamics

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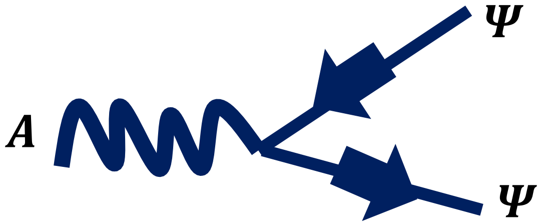
Commonly the Feynman amplitudes are derived from a pure quantum scenario. In this work, based on the Hartemann-Kerman equation, one can extend the meaning of quantum amplitude in a pseudo-amplitude built entirely in classical electrodynamics.

Normally one can associate a Feynman diagram with an amplitude probability:

$$\mathcal{S} = \int d^4p\psi(p)\mathcal{A}(k)\,\boldsymbol{G}(p,p')\mathcal{A}(k')\,\psi(p)$$

Basic Light-Matter Interaction:



The Hartemann-Kerman equation was done in a scenario of Nonlinear Compton backscattering.

Features:

1.- All ingredients are classical.

2.- Amplitude analogue to covariant integration

3.- Cross section: the second derivative of radiation intensity

4.- Proportional to e^2/137

F. V. Hartemann, A. K. Kerman, Phys Rev. Lett, 76, No 4, 624-627 (1996).

$$\frac{d^2I}{d\omega^2 d\Omega^2} = \rho\left|\int_{-\infty}^{\infty} d\phi\,\boldsymbol{A}_x(\phi)Exp\left[i\chi\left(\phi + \int_{-\infty}^{\phi}\boldsymbol{A}^2(u)du\right)\right]\right|^2$$

This work suggests that this classical equation yields amplitudes because the integration at the exponential.

Relation to Relativistic Solutions : The exponential is similar to spineless Volkov states.

$$\frac{d^2 I}{d\omega^2 d\Omega^2} = \rho \left| \int_{-\infty}^{\infty} d\phi\, \boldsymbol{A}_x(\phi) Exp\left[i\chi \left(\phi + \int_{-\infty}^{\phi} \boldsymbol{A}^2(u) du \right) \right] \right|^2$$

Approximations that allows us to arrive a closed-form. The complex exponential plays a crucial role.

$$Exp\left[i\chi \left(\phi + \int_{-\infty}^{\phi} \boldsymbol{A}^2(u) du \right) \right] = Exp[i\chi(\phi + Sin(\phi))]$$

$$\boldsymbol{A} = \left| \int_{-\infty}^{\infty} \boldsymbol{d\phi A_x(\phi)} \sum_{m}^{M} \boldsymbol{C_m(\phi)} \sum_{n}^{N} \boldsymbol{D_n(\phi)\delta([m+1]k + p - [n-1]k' - p')} \right|^2$$

4-dimensional Delta function

It gives rise to the Hartemann-Kerman Rules

Final State

Initial State

Propagator

4-momentum conservation

$$\boldsymbol{A} \approx \left| \int_{-\infty}^{\infty} \boldsymbol{d\phi} \sum_{m,n}^{M,N} \boldsymbol{C_m(\phi)} \frac{\boldsymbol{1}}{\boldsymbol{1+\omega^2}} \boldsymbol{D_n(\phi)\delta([m+1]k + p - [n-1]k' - p')} \right|^2$$

It Should be Noted !!

The “x” component of 4-vector potential would acquire a form that simulates the shape 1/w^2.

Pseudo quantization: that encloses the simple and nonlinear Compton scattering.

The initial and final states are seen at the orthonormal functions. It is in agreement with precursor procedures such as the one given by Reiss, Eberly; Ritus and Nikishov at the 60s.

CONCLUSION

From a pure classical intensity radiation formulation it was derived the pseudo amplitudes with similar structure to the ones derived in a full Quantum Electrodynamics scenario.