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COMMENTARY

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Commentary to "Delay time in the transfer of modulation between microwave beams"

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Abstract

New results, as reported in a forthcoming paper (Cacciari & Ranfagni, 2022), induced us to modify our point of view on the origin of the transfer of modulation between microwave beams. We believe that a commentary and addition of information to the paper published as Reference 1 appear appropriate.

KEYWORDS

stochastic process, microwave

JEL CLASSIFICATION

Electrical and electronic engineering

In a recent paper, we reported on the delay-time measurements in the modulation transfer between a modulated microwave beam to an unmodulated one.[1] The observed behavior was explained there on the basis of two possible interpretations, both of them referable to a stochastic model. This model consists of a zig-zag random path experienced by the "particle", a kind of motion that is known to be described with the telegrapher's equation.[2] Subsequently, we realized that interference could be merely responsible of part of the transferred signal.[3] This fact induced us to modify the experimental apparatus in order to minimize such residual*.

In consideration of these facts, we repute necessary adding new information to Reference 1 in a commentary. Initially, we repeated the delay-time measurements in order to compare them with those already reported in figures 2 and 3 of Reference 1. For this aim, the experimental setup according to Reference 3, has been modified. The results obtained are shown here in Figure 1. They, indeed, are similar to the ones in Reference 1. However, the zig-zag nature of the hypothesized random paths, although still present, is less evident.

Again, the motion of the "particle" is believed to occur in a two-dimensional temporal space described by a density distribution $g(r,t)$, where t is the normal time and r is a randomized time.[4] The asymptotical form of $g(r,t)$ is assumed to be nearly a Gaussian, with standard deviation given by $\sigma = \sqrt{t/a}$, where a is the dissipative parameter entering the telegrapher's equation. Specifically, $g(r,t)$ results to be formed by the sum of two Gaussians, one centered at $r = 0$, and the other at $r = 1/a$. As a consequence the average value of r is given by[5]

$$\langle r \rangle = \frac{1}{2a}\left(1 - e^{-2a\rho/v}\right), \tag{1}$$

ρ being the traveled distance and v the velocity. By adopting the same parameters values as in Reference 1 that are $a = 10^9$ s^{-1} and $v = 3$ cm/ns (alternatively $a = 0.5 \times 10^9 s^{-1}$ and $v = 1.5$ cm/ns) we depict the curve $2\sigma(t)$, as shown in Figure 1. This curve represents the border line of the half area that contains the paths with a probability of $\sim 95\%$. The same curve represents $\sigma(t)$ in the alternative selection of a and v, and the probability will be of $\sim 68\%$.

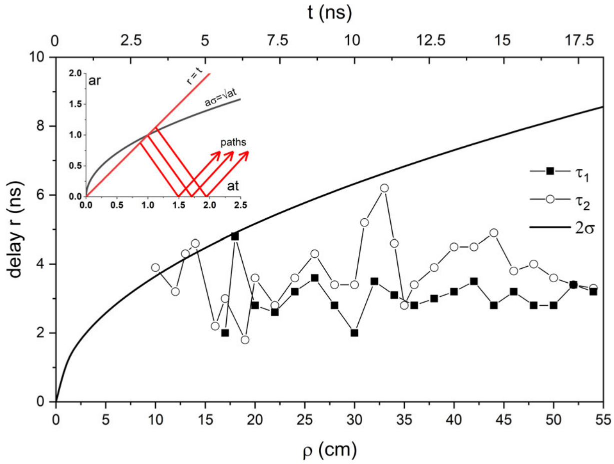

FIGURE 1 Two determinations of delay time, in the transfer of modulation between microwave beams, measured as a function of the distance ρ between the launcher of the unmodulated beam and the receiver antenna, in presence of the perpendicular modulated beam. Each determination was obtained as an average between the rise—and fall—time measurements. The series of data limited to $\rho \geq 17$ cm was obtained with a reference signal measured with a small horn antenna (6×8 cm ^{2}) situated in front of the modulated beam at a distance of 28 cm from the relative launcher. Hypothetical paths with reversals are represented in the (ar, at) plane of the inset as in Reference 1.

Moreover, the asymptotic value of $\langle r \rangle$, for ρ sufficiently large, is given by $(2a)^{-1}$, and turns out to be of the order of nanoseconds, in agreement with the experimental observation.

As anticipated in Reference 1, it is noteworthy that in the present case of near-field propagation, we have an inversion of roles between r and t, in the sense that r becomes the observable quantity. Typically this occurs in classically forbidden processes, as f.i. in the tunneling. Therefore, in addition to the confirmed stochastic character of the observed behavior, the transfer of modulation seems reasonable to be considered as a case of classically forbidden process.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ENDNOTE

*The experimental apparatus adopted in Reference 3 is essentially the same of Reference 1 with the addition of an absorbing material, between the launchers of the beams, in order to reduce their cross-talking.

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