Optical Interferometry with Pulsed Fields

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Abstract: An analysis of coherence properties of pulsed fields in interferometric experiments is presented. The results bear on means to recover certain statistical properties of the source in a two-slit experiment.

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Statistical optics, or coherence theory, is the study of the outcome of measurements made with non-deterministic light. Until recently, almost all optical experiments could be well-modeled within the framework of stationary, at least in the wide sense, random processes. This is not the case with pulsed optical fields. Such non-stationary fields must be treated in a must more general setting.

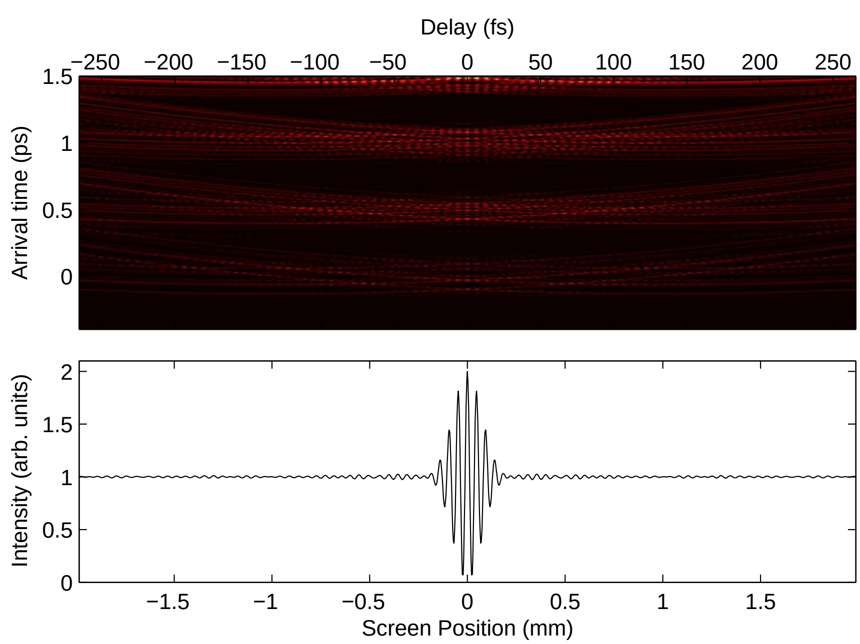

Figure 1: A simulation with a pulse duration of 100fs, interpulse time of 500fs, coherence time of 10fs, Consecutive pulses are not phase stable and no interpulse interference is detected upon long time averaging.

The theoretical study of non-stationary statistical optics has seen a recent resurgence. In references [1, 2] intrinsically stationary sources [3], members of a restricted lass of non-stationary random processes, are studied. A stationary field is modulated in a deterministic fashion. While this model is not the most general one to describe optical phenomena, it is a good bridge between a general theory of two-time, two-point measurements and standard coherence theory.

In this presentation, pulses are treated as resulting from the modulation of a stationary source. A mathematical model is formulated to relate observable quantities to the statistical properties of the source. Specifically, the intensity pattern formed in a two-slit experiment is considered for many different cases of non-stationary pulses. The duration of the pulse, the coherence time of the source, the time between pulses, and the integration time at the detector are all considered. Equivalent intensity profiles are shown for fields with different parameters. In certain cases, it is shown that the coherence properties of the unmodulated process can be recovered.

Simulations (see Fig. 1 and Fig. 2) illustrate the role of detection in the relationship between observables and the underlying coherence properties of the field. Special attention is paid to cases where long-time-average measurements (in a certain sense) are unable to recover the basic statistical properties of the optical field.

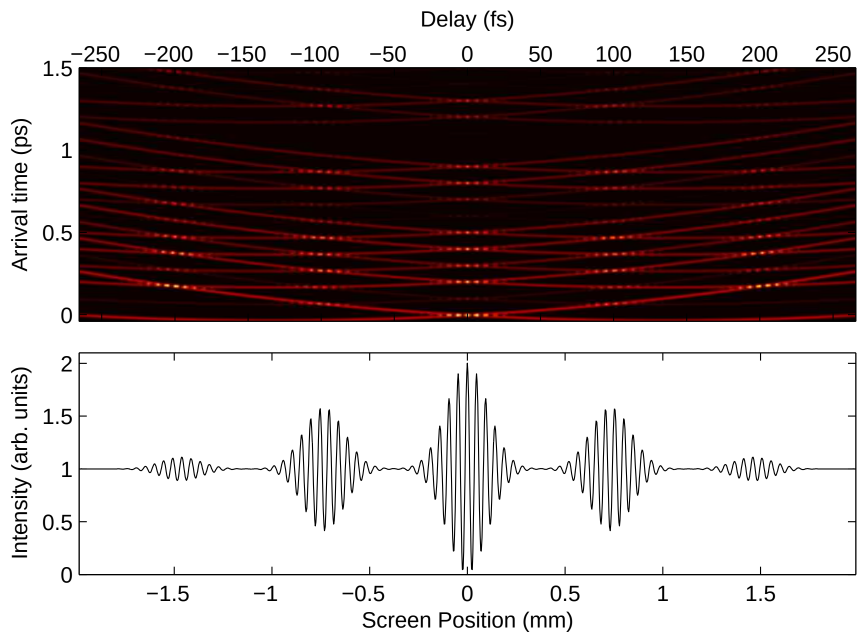

Figure 2: A simulation with pulse duration of 10fs, interpulse time of 100fs, coherence time of 100fs and 500 pulses. In this case, consecutive pulses have some phase stability and these effects show up at the detector as smaller fringe patterns away from the center of the detection screen.

References

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