RECENT DEVELOPMENT IN PHOTON CORRELATION AND SPECTRUM ANALYSIS TECHNIQUES: II. INFORMATION FROM PHOTODETECTION SPECTROSCOPY

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ABSTRACT

The extraction of information from the measured correlation function or power spectrum is considered. Of particular importance in this context is the selection of an appropriate model for the physical process involved. We shall discuss the information-content limit on the model complexity and the extent to which any model can be justified. In this context a discussion of experimental artifacts which distort the expected data and can thus invalidate the model will be given. Having chosen some model the accuracy with which the parameters of that model can be established from measurements will be discussed with particular reference to Gaussian-Lorentzian light. We conclude with a set of guidelines to govern the choice of experimental parameters in photodetection spectroscopy experiments.
1. INTRODUCTION

In this Part we shall consider the way in which we can extract information from photodetection spectroscopy measurements. We shall assume that ideal instrumentation is available satisfying the requirements outlined in Part I. Having obtained an autocorrelation function or periodogram for the process under study we next discuss the interpretation of this data. There are four main questions than can be identified in such analysis:

A. How is the physics of the process introduced into the interpretation? (Section 2).

B. What fundamental limit is there on the number of physical parameters that can be determined from a given experiment? (Section 3).

C. What effect can experimental artifacts introduce which distort the result and make interpretation in the light of the model adopted under A. inappropriate? (Section 4).

D. For a given model under well-behaved conditions what factors govern the accuracy with which the parameter values can be determined? (Section 5).

The discussion is not intended to provide universal answers so much as to ask questions which should be considered in any series of measurements where reliability and accuracy are required.

2. THE PHYSICAL MODEL

Having measured an autocorrelation function or periodogram there are analysis steps which can be taken immediately which make no a priori assumptions about the physical process giving rise to the data (i.e. the physical model). One can, for example, perform data transformation between time and frequency space if required. Such analysis involving no physical model is of very limited applicability. Further progress requires us to represent the physical process taking place by some model which may be of varying levels of complexity. By fitting the observed function we obtain values of the parameters of the model which characterise the process under study. Let us discuss the relationship between the physical insight into the nature of the process and the model used to interpret it in terms of an example from the field of laser Doppler velocimetry.

In Figure 1 we show measured power spectra and autocorrelation functions obtained in anemometry measurements using the Doppler difference technique (Alldritt et al, 1978). Since the experiment is to measure a Doppler difference frequency the simplest model