ABSTRACT. This paper constructs two classes of models for the quantum correlation experiments used to test the Bell-type inequalities, synchronization models and prism models. Both classes employ deterministic hidden variables, satisfy the causal requirements of physical locality, and yield precisely the quantum mechanical statistics. In the synchronization models, the joint probabilities, for each emission, do not factor in the manner of stochastic independence, showing that such factorizability is not required for locality. In the prism models the observables are not random variables over a common space; hence these models throw into question the entire random variables idiom of the literature. Both classes of models appear to be testable.

1. INTRODUCTION

I want to call attention to the possibility that the quantum mechanical statistics, found in the various correlation experiments devised to test the Bell-type inequalities, may be accounted for by means of statistical models of the experiments that are local and realistic. (This is the terminology of Clauser and Shimony (1978). The phrase “local hidden variables” is more commonly used.) Despite the various and sometimes elegant derivations of the Bell inequalities, which conflict with the quantum mechanical statistics, the possibility for such local and realistic accounts arises in two ways. First, as I pointed out several years ago (1974), the various derivations of these inequalities invariably rely on background assumptions beyond those of realism and locality. Hence it may be possible to build local and realistic models based on different background assumptions. Second, the application of the Bell results to real experiments always involves special assumptions about the experimental processes. Hence different assumptions may undercut the inequalities while remaining within the framework of locality and realism. The “conspiratorial selection” model proposed for the photon correlation experiments by Clauser and Horne (1974) (and quickly rejected by them as “unnatural”) exploits this second way.

My purpose here is to outline two classes of models, prism models.
and synchronization models, which are local and realistic and which, nevertheless, by taking advantage of the two indicated ways (respectively), yield the quantum mechanical statistics. I offer these models in a Popperian spirit, that is, as conjectures to be further elaborated, criticised, and tested. I hope that some of the workers in this area who find the Bell results compelling, if not conclusive, will find these models an interesting enough challenge to merit response.

2. BACKGROUND AND TERMINOLOGY

The ideal sort of experiment outlined in Clauser and Horne (1974) seems broad enough to encompass the various real experiments performed or contemplated. It consists of a source that emits two-particle systems, where each composite system is in one and the same "singlet" state $\psi$. The "particles" (I shall refer to them as $A$ and $B$) are emitted in opposite directions (these define the $A$-wing and the $B$-wing of the experiment). In each wing there is an analyser that may be set in various positions. It is convenient to take these positions as co-planar angles, relative to some fixed direction, in the plane transverse to the "path" of the particles. The analyser is followed by a detector which, if triggered, will count the presence of a particle of the sort emitted by the source. (I speak here of "particles" and their "paths" and below of "particles passing an analyser and being detected". In the case of photons – or bosons more generally – this language and imagery is out of place. It is a convenient metaphor, however, and I use it for that reason and in the belief that it does not mask any objectionable features of the models.)

The models I shall propose are not designed as general accounts of spin or polarization and their measurements, or the like. They are designed to account for the statistics of experiments, like that outlined above, in the following more restrictive sense. Given the detailed plan for an experiment (already run or contemplated) – that is, the specific geometry of the experimental arrangement, the sequence of analyzer positions and the nature of the source – the models postulate a particular statistical distribution of the particle-pairs that gives rise to the quantum mechanical probabilities for the experimental outcomes. Thus what I call "models" are perhaps better thought of as model schemas that produce specific statistical models for particular experimental designs: feed the design into the schema and out comes a model of the experiment.