Sudarshan's Optical Researches *

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Z. Naturforsch. **52a**, 2 (1997)

As is evident from the scope of this meeting, Sudarshan's scientific interests and contributions have covered a broad area of physics. Among them optics plays a very prominent role. I say optics rather than quantum optics, as is so fashionable these days, because many of Sudarshan's investigations have been particularly concerned with some striking analogies and some remarkable similarities which were found to exist between these two fields, particularly in the domain of optical coherence. In fact some of Sudarshan's contributions to this area have been largely responsible for the clarifications of several subtle questions, which in the 1960s – soon after the invention of the laser – were rather controversial. I take some pride in having been responsible – together with my colleague Leonard Mandel – for stimulating Sudarshan's interest in this field.

Sudarshan published about 270 papers and 3 books dealing with numerous topics of theoretical physics. Of this very substantial contribution, approximately 30 papers and of the books (co-authored with John Klauder) deal with optics.

One of the early important contributions that Sudarshan has made to optics concerns the relationship between classical and quantum optics. Whereas the conventional view has been that classical optics is a limit of quantum optics for high photon numbers, Sudarshan showed that there is an exact correspondence between the classical and the quantum picture, irrespective of the intensity of the field. This correspondence is provided by means of certain generalized phase-space distributions functions or quasi-probabilities. These objects, unlike true phase-space distribution functions and true probabilities, may take on negative values for some values of their arguments but they extend appreciably the scope of statistical techniques. This description, which was pioneered by Sudarshan, has provided a good deal of insight into many complicated optical problems and has been used extensively since then.

An example where this approach has been particularly successful is in connection with attempts to clarify the foundations of radiometry and the theory of radiative energy transfer. These researches have led rather naturally to the question as to whether one can introduce light rays within the framework of quantum electrodynamics. Here too Sudarshan has made important contributions, particularly in that he introduced the ray concept rigorously for fields of arbitrary states of coherence. Moreover, Sudarshan's generalized rays have led, in a rather natural way, to a new approach for analyzing certain types of optical fields which have become of prominence in recent years, namely partially coherent beams. With this development Sudarshan, in collaboration with N. Mukunda and R. Simon, have also introduced rather powerful group-theoretical methods into classical statistical wave theory. This approach is having a considerable impact on the developing field of beam-field optics.

Remarkable contribution to statistical optics have been made by Sudarshan in a little known paper entitled "Quantum Theory of Optical Coherence", published in *J. Math. Phys.* (Madras, India) **3**, 121–175 (1969). This paper presents a full statistical characterization of optical fields of any state of coherence and includes a wealth of new and interesting ideas whose full significance will undoubtedly be appreciated in the course of time.

* Presented at a Workshop in honor of E. C. G. Sudarshan's contributions to Theoretical Physics, held at the University of Texas in Austin, September 15–17, 1991

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