BOOK REVIEW

Collected Works of S. Pancharatnam. Oxford University Press. 1975. Price: £15/25$

It is indeed a great honour to review the volume of collected papers of one of our great scientists. The importance of some of his work has been realized only recently and it is hoped that some of his other work would become important in the coming years. I have been well aware of his work on the interference of light beams which as originally pointed out by Ramaseshan and Nityananda (*Curr. Sci.*, 1986, 55, 1225), and by Berry is the first work on the geometrical phase that a light beam acquires after going through a succession of optical elements such that the polarization state of the beam returns to the original state. In this context it is important to note that this work of Pancharatnam was brought into limelight by Ramaseshan and Nityananda, otherwise this remarkable piece of work would have been lost in the enormous body of literature that is published. Clearly Pancharatnam was far ahead of his time. In the course of my review it will become clear that there are other remarkable contributions of Pancharatnam that should become important in many other problems in optics.

I would like to classify his works in the following categories: a) Achromatic birefringent plate; b) Propagation of light in an absorbing bi-axial medium; c) Pancharatnam phase; d) Theory of mirages; e) Partial coherence and interference; f) Quantum interferences in scattering; g) Spin alignment and magnetic resonance. The work on geometrical phases has now been well recognized and hence I will not dwell on it further.

In paper number 2 Pancharatnam posed the problem whether it is possible to realize say, an optical element like quarter wave plate that would work as a quarter wave plate over a large region of wavelengths. He showed that this is indeed possible and presented mathematical formulae so that one can derive the achromatic range. The interest in this has been revived by a recent work of Hariharan and co-workers (*J. Modern Optics*, 1994, **41**, 15). The achromatic combinations and related devices are becoming very important in the context of the Wolf shifts (E. Wolf, *Opt. Commun.*, 1987, **62**, 12). For example, G. M. Morris and D. Falkis (*Opt. Commun.*, 1987, **62**, 5) used an achromatic lens to demonstrate the changes in the spectral content of the light beam as it propagates. These changes arise from the presence of spatial correlations in the source. The achromatic combination changes the nature of such correlations. I am hoping that one should find good applications of Pancharatnam's work in the study of Wolf shifts and the scaling laws which were introduced by Wolf (*Phys. Rev. Lett.*, 1986, **56**, 1370).

In paper number 13 Pancharatnam with Raman formulated a first principle theory of mirages and also presented experimental results on this subject. I found the model quite intriguing. They considered a medium whose dielectric constant was taken to vary linearly with the distance z. The beauty of the model is that they can get exact field distributions everywhere and thus they were able to answer a number of questions on mirages in a quantitative fashion. It was interesting to see how the Airy functions strike again and again in optics!

In two papers (numbers 15 and 16) he developed the theory of interference of partially polarized beams in frequency domain. Unfortunately these papers have gone completely unnoticed, though these days there is enormous interest in using coherence theory in frequency domain as it has been realized now that the interference law is much more general in the frequency domain (cf. D. F. V. James and E. Wolf, *Opt. Commun.*, 1991, **81**, 150; X. Y. Zou, T. P. Grayson and L. Mandel, *Phys. Rev. Lett.*, 1992, **69**, 3041; G. S. Agarwal, *Found. Phys.* (in press)). Pancharatnam even gave an example where one would need the interference law in frequency space. He had thus anticipated an important result very early. His formulation of the interference in a dispersive medium is even more remarkable. He introduced the group velocity in a very elegant way in such interference problems and he was able to explain many of the observations of Wood. I believe that interference of wavepackets in a dispersive medium should attract a lot more attention in the future; even new experiments can be devised here (J. D. Franson, *Phys. Rev.*, 1992, **A45**, 3126).

In a number of papers (3, 4, 10, 12) Pancharatnam developed in great detail the theory of light propagation in a biaxial medium which in turn could be absorbing as well. He gives a complete electromagnetic treatment. He derives the structure of the modes and the fields associated with them. My colleagues like D. Home are seriously thinking of generalizing the formulation of the paper number 12 so as to be applicable to single photon fields and then study the correlation properties of the quantum fields in such a medium.

In paper number 17 Kibble and Pancharatnam developed the theory of quantum mechanical interferences between different pathways contributing to a given scattering process. In atomic systems such interferences are especially important because of the magnetic degeneracy of the levels and the fact that the linearly polarized light can couple several levels at the same time. They confirmed their predictions by carrying out experiments on Hg atom. This paper has a lot of educational value. In my opinion this is the kind of material that should find a place in modern textbooks of quantum mechanics.

In a series of papers (numbers 21 to 24) Pancharatnam developed the theory of spin alignment with arbitrary spin value and carried out a series of experiments to observe birefringence in gaseous samples. I find the work on higher spins specially interesting. The ellipsoidal representation should be quite useful in many current investigations on squeezing in atomic systems. For almost a century physicists have been using Poincaré and Bloch spheres in many problems in different disciplines of physics and I do not see why the ellipsoidal representation should not find its appropriate place in physics. We could all express our gratitude to Prof. George Series for bringing out this set of papers for the benefit of the scientific community.

The last paper dealing with the light shifts is quite intriguing as this, in my opinion, establishes a link between the modern polariton work that is mostly semiclassical and a fully quantum mechanical approach. The relation between the interaction energy and atomic polarizability is obtained. Such relations are extensively used in modern physics.

In the end I must add that I have learnt a great deal by reviewing this book and I do hope that I can even use some of Pancharatnam's ideas in my personal research. I must also add that Pancharatnam really followed Raman's tradition where experiment and theory went together. The scientific experience will be much richer if many of us were to follow the tradition of the Raman school.

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List of papers as appeared in the *Collected Works*