

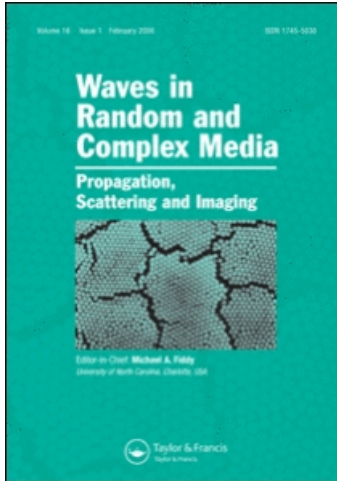
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Waves in Random and Complex Media

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Introduction to Wave Scattering, Localization and Mesoscopic Phenomena. Second edition

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BOOK REVIEW

Introduction to Wave Scattering, Localization and Mesoscopic Phenomena. Second edition

PING SHENG

(Springer-Verlag Heidelberg 2006, 333 pp, \$179.00 hardback, (ISBN 3 54029 155 5))

For any researcher working with waves in disordered media, it is crucial to have a solid reference to elementary principles with the details worked out in a complete and transparent way. This is very helpful for new students that join the group, and quite useful when preparing courses or presentations. The study of wave propagation in random media is characterized by a great deal of unavoidable technical, mathematical approaches, which in spite of their complexity do not even provide the rigorous answers. Mean field theories, diagrammatic expansions and diffusion approximations have been designed to capture the basic physics as accurately as possible, yet despite the many glorious experimental confirmations, they often leave enough room for lively debates at conferences and Summer Schools: everybody working on radiative transfer, Anderson localization or effective medium approaches knows that. Nevertheless, great principles have emerged from these calculations that have become solid guide lines to new studies.

The first edition of the book by Ping Sheng was released in 1995 by Academic Press. What I always liked about this book is that it provided *both* the global picture – the basic issues and concepts – *and* the technical calculation that is supposed to provide the approximate answer. What I did not like about the book was that it was so rapidly sold out. One of my students once came back excited from his holiday since he had finally been able to purchase his own copy in some foreign second-hand store! And between the lines of the book, the expert senses the struggle that was needed to find the right approach in a mess of unsolvable physics. How to do better than the independent-scatterer approximation in a successful effective medium theory? Is the familiar diffuse pole in wave transport robust when going beyond classical radiative transfer by incorporating superposition and interference? Does such anomalous diffusion have any relation to Anderson localization, and can we handle this by using just one parameter? Do resonances affect the transport velocity of classical waves much more than they do in electronic transport? What is the origin of non-Gaussian speckle, that seems to be long-range and that seems to govern conductance fluctuations entirely? These are typical issues discussed in Ping Sheng's book. All have been

major struggles that have led to major breakthroughs. Most of them are still under active research.

The position of Ping Sheng as a widely recognized scientist in the field of wave propagation justifies his role as the author of a leading monograph. But there is more. Ping has been working on many different subjects, from liquid crystals, electronics and superconductivity, to optics, acoustics and seismology. These activities have made him one of the first researchers to put mesoscopic wave propagation in a much larger perspective. This development still continues and this increases the urge for a new edition even more. A second point is that Ping Sheng has always been a theoretician inspired by experimental reality, and has co-authored many pioneering experimental papers. The second edition of the book contains a new Chapter 4 that compares – with colour pictures – the observation of acoustic and electromagnetic quasi-modes to a new elegant effective-medium approach, based on the spectral function. My own experience also confirms that the most fundamental breakthroughs in our understanding of mesoscopic wave transport have been accompanied or even created by clever experimentalists who had understood the theoretical struggle.

The second edition, released this time by Springer, must thus be a welcome surprise. It is true that since the first edition in 1995 many things have happened. Of course computers have become faster and much more complex models – for effective medium, radiative transfer, Anderson localization or bandgap materials – can now be solved. During the last 10 years the random matrix theory has proved to be a successful new approach to model and to understand many aspects of mesoscopic wave transport. As for experiments, Anderson localization and universal conductance fluctuations of light and microwaves have been reported. Diffusion, diffuse wave spectroscopy and coherent backscattering of acoustic and even seismic waves have been observed, and random lasers now exist. Anisotropic diffusion and photon Hall effect have been reported. The stability of time-reversal and the utility of imaging without a source have both been demonstrated in random media. Photonic and phononic ‘meta-’ and ‘nano-’ materials – with periodicity and/or negative index of refraction – can now be manufactured, with numerous applications. Mesoscopic wave transport has been observed in cold atomic gases and one is already speculating about the possibility of Anderson localization of cold matter in disordered light speckle.

Should a second edition cover all these new exciting developments? The author decided not to, insisting in his Preface to the second edition on the fact that some of these issues have not yet converged towards their final picture. That is certainly true, although one can still regret his choice a little, saying that some upgrade on recent developments would have been welcomed by many of us. Personally, I think random matrix theory ought to have appeared as a separate chapter, since it has revealed itself so many times as the sole non-perturbative approach that we have at our disposal. Nevertheless, many developments mentioned above rely on concepts discussed in the book by Ping Sheng. The items discussed in the first edition still comprise the basic foundations. This can be taken as a compliment for the initial choices that were made, and this justifies the issue of a second edition.

I am convinced that many students and professors are delighted to see this book available again. It is true that in the meantime another important work has been published by Eric Akkermans and Gilles Montambaux (*Physique mésoscopique des électrons et des photons*, EDP Sciences, 2004) whose English version is due to be published in April 2007 (Cambridge). The latter is clearly more up to date, yet only a partial overlap exists. The work by Ping Sheng provides a lot more information about Anderson localization and effective medium approaches, and discusses much better the Ward identities and the associated transport velocity, which have been shown to be so dramatically different for classical waves. The work by Akkermans and

Montambaux establishes more links to electronic mesoscopic and interaction, with random matrix theory omnipresent as a powerful tool.

I welcome all good books on mesoscopic physics of waves, because so few exist. The *oeuvre* of Ping Sheng, in either the first or upgraded second edition, should not be missing on the shelf of any researcher working on mesoscopic wave transport.

Bart van Tiggelen, 2007

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