6th International Workshop on Pseudo-Hermitian Hamiltonians in Quantum Physics

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PREFACE

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Attempts to understand the quantum mechanics of non-Hermitian Hamiltonian systems can be traced back to the early days, one example being Heisenberg's endeavour to formulate a consistent model involving an indefinite metric. Over the years non-Hermitian Hamiltonians whose spectra were believed to be real have appeared from time to time in the literature, for instance in the study of strong interactions at high energies via Regge models, in condensed matter physics in the context of the XXZ-spin chain, in interacting boson models in nuclear physics, in integrable quantum field theories as Toda field theories with complex coupling constants, and also very recently in a field theoretical scenario in the quantization procedure of strings on an AdS_5 x S^5 background. Concrete experimental realizations of these types of systems in the form of optical lattices have been proposed in 2007.

In the area of mathematical physics similar non-systematic results appeared sporadically over the years. However, intensive and more systematic investigation of these types of non-Hermitian Hamiltonians with real eigenvalue spectra only began about ten years ago, when the surprising discovery was made that a large class of one-particle systems perturbed by a simple non-Hermitian potential term possesses a real energy spectrum. Since then regular international workshops devoted to this theme have taken place. This special issue is centred around the 6th International Workshop on Pseudo-Hermitian Hamiltonians in Quantum Physics held in July 2007 at City University London. All the contributions contain significant new results or alternatively provide a survey of the state of the art of the subject or a critical assessment of the present understanding of the topic and a discussion of open problems. Original contributions from non-participants were also invited.

Meanwhile many interesting results have been obtained and consensus has been reached on various central conceptual issues in the growing community of this subject. It is, for instance, well understood that the reality of the spectrum can be attributed either to the unbroken PT-symmetry of the entire system, that is, invariance of the Hamiltonian and the corresponding wavefunctions under a simultaneous parity transformation and time reversal, or more generally to its pseudo-Hermiticity . When the spectrum is real and discrete the Hamiltonian is actually quasi-Hermitian, with a positive-definite metric operator, and can in principle be related by a similarity transformation to an isospectral Hermitian counterpart. For all approaches well-defined procedures have been developed, which allow one to construct metric operators and therefore a consistent description of the underlying quantum mechanical observables. Even though the general principles have been laid out, it remains a challenge in most concrete cases to implement the entire procedure. Solvable models in this sense, some of which may be found in this issue, remain a rare exception. Nonetheless, despite this progress some important questions are still unanswered. For instance, according to the current understanding the non-Hermitian Hamiltonian does not uniquely define the physics of the system since a meaningful metric can no longer be associated with the system in a non-trivial and unambiguous manner. A fully consistent scattering theory has also not yet been formulated. Other issues remain controversial, such as the quantum brachistochrone problem, the problem of forming a mixture

between a Hermitian and non-Hermitian system, the new phenomenological possibilities of forming a kind of worm-hole effect, etc.

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We hope this special issue will be useful to the newcomer as well as to the expert in the subject.

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Figure 1. Participants of the 6th International Workshop on Pseudo-Hermitian Hamiltonians in Quantum Physics