Scientific report of the conference "Tunneling and scattering in complex systems – from single to many particle physics"

This conference was devoted to bringing together experts working on various aspects of tunneling in connection with open system dynamics such as scattering and decay. Being traditionally rooted in atomic and molecular physics, the topic of tunneling has proven its relevance in many other fields of physics, such as mesoscopic science and superconductivity, wave optics in microcavities, as well as ultracold quantum gases. Open issues arise here from the mathematical and conceptual point of view, especially concerning the semiclassical description of tunneling in terms of complex trajectories. They are, moreover, introduced by novel many-body experiments using Bose-Einstein condensates that consist of ultracold atoms.

In view of the diversity of communities that are involved in this topic, the organizers considered it useful to begin this conference with a one-week summer school devoted to the most relevant aspects of this topic. We were happy that we could gain Stephen Creagh (Nottingham) and Akira Shudo (Tokyo) as lecturers for that school, who gave excellent introductions into the mysteries and pitfalls of the complexified classical phase space, and who showed how those ones can help us to obtain a semiclassical understanding of tunneling. Martin Holthaus (Oldenburg) and Oliver Morsch (Pisa), on the other hand, taught us the basics of tunneling with ultracold bosonic quantum gases both from the theoretical and from the experimental point of view. Uzy Smilansky (Rehovot), finally, gave an easily accessible introduction into classical and quantum scattering in chaotic systems.

The didactical part of this meeting culminated on the first day of the main conference in the second week, when Eric Heller (Harvard) delivered an inspiring and motivating colloquium talk devoted to dynamical tunneling and the beauty of semiclassical physics. It was impressive to see how Eric Heller could relate various kinds of nonclassical phenomena, including those that one would most naturally associate with ordinary diffraction, with the notion of dynamical tunneling. On the same day, moreover, Steven Tomsovic (Pullman/WA) gave a very good introductory talk on chaos-assisted tunneling.

Apart from the colloquium talk, we had, in total, 30 oral contributions during this main conference, among them, 4 from atomic and molecular physics, 4 from mesoscopic science, 7 from ultracold quantum gases, 5 from electromagnetic and optical systems, and 9 from quantum chaos and semiclassics. It was an intriguing experience that quite a few speakers did not only focus on the understanding of tunneling and scattering in their respective context, but also pointed out the possible relevance and impact of these phenomena from the application-oriented point of view. This includes the influence of tunneling on the

(uni-)directionality of light emitted from chaotic microcavities (e.g. talk by Jan Wiersig/Magdeburg), the usefulness of the semiclassical perspective in order to coherently control tunneling-induced reactions in molecules (talk by Srihari Keshavamurthy/Kanpur), the possibility to read individual quantum bits through tunneling across Josephson junctions (talk by Joachim Ankerhold/Ulm), as well as the impact of tunneling (or rather its inhibition) of K-shell vacancies on the creation of Bell states with diatomic molecules (talk by Reinhard Dörner/Frankfurt). During the lunch breaks and poster sessions, we could observe and participate at quite a few cross-disciplinary discussions, some of which might lead to novel theoretical approaches and experiments in the years to come.

The meeting ended with an informal workshop week where the participants of the conference had the occasion to continue their discussions. This week began with a three-days focus meeting devoted to nonlinear dynamics in complex scattering. Following the tradition of the annual "billiard workshops" that bring together the German quantum chaos community in (mostly) Marburg or Göttingen once per year since 2001, we reserved an entire afternoon session for contributed 30-minutes talks given by younger researchers, such as PhD students and young postdocs. We have to admit that this focus meeting turned out to be a bit less focused than originally anticipated, as some of the invited experts on scattering systems with intrinsic nonlinear dynamics (such as in nonlinear optics or Bose-Einstein condensates) decided to talk about different, more recent subjects of their research. The diversity of aspects discussed in this focus meeting, on the other hand, impressively revealed to us how seemingly different topics, such as localization, graphene, and microwave systems, are now about to become strongly connected to each other.

Altogether, we received very positive feedback from the participants, not only concerning the scientific aspects of the conference but also the perfect organization managed by our conference secretary Mandy Lochar. We should like to thank Mandy as well as the team of the MPIPKS visitors program for their continuous support without which this conference would not have been possible.