DY 15: Quantum chaos I

Time: Wednesday 14:00–16:00 Location: HÜL 386

Invited Talk DY 15.1 Wed 14:00 HÜL 386

Time-reversed waves and super-resolution — •Mathias Fink — Ecole Supérieure de Physique et Chimie Industrielles de la Ville de Paris, University Denis Diderot, UMR CNRS 7587, 10 rue Vauquelin, 75005, Paris, France

Time-reversal invariance is a very powerful concept in classical and quantum mechanics. In the field of classical waves (acoustics and electromagnetism), where time reversal invariance also occurs, time-reversal mirrors (TRMs) may be made simply with arrays of transmit-receive antenna, allowing an incident broadband wave field to be sampled, recorded, time-reversed and re-emitted. TRMs refocus an incident wave field to the position of the original source regardless of the complexity of the propagation medium. TRMs have now been implemented in a variety of physical scenarios from GHz Microwaves to MHz Common to this broad range of scales is a remarkable robustness exemplified by observations at all scales that the more complex the medium (random or chaotic), the sharper the focus. A TRM acts as an antenna that uses complex environments to appear wider than it is, resulting for a broadband pulse, in a refocusing quality that does not depend of the TRM aperture. Time reversal focusing opens also completely new approaches to super-resolution. We will show that in random metamaterials, a time-reversed wave field interacts with the random medium to regenerate not only the propagating but also the evanescent waves required to refocus below the diffraction limit. Focal spots as small as $\lambda/30$ are demonstrated with microwaves. This results in a large increase of the information transfer rate.

DY 15.2 Wed 14:30 HÜL 386

Quantum corrections to the fidelity — •Daniel Waltner[1], Boris Gutkin[2], Martha Gutiérrez[1], Jack Kuipers[1], and Klaus Richter[1] — [1]Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

We study semiclassically quantum corrections to the fidelity for a classically chaotic system. We consider in addition to the diagonal approximation [1], also the effect of very similar trajectory pairs differing in encounters [2] in different regimes of the fidelity decay. We find agreement of our results for the Fermi Golden Rule regime with predictions from Random Matrix Theory (RMT) [3]. Going beyond RMT, we also study the effect of a finite Ehrenfest time on our results for the Fermi Golden Rule regime and make predictions for nondiagonal corrections to the fidelity in the Lyapunov regime inaccessible to RMT.

Using recursion relations to count the considered diagrams, we further show the unitarity of our theory and a relation between the fidelity amplitude and the spectral form factor [4].

[1] F. M. Cucchietti, H. M. Pastawski, R. A. Jalabert, Phys. Rev. B **70**, 035311 (2004),
[2] D. Waltner, M. Gutiérrez, A. Goussev, K. Richter, Phys. Rev. Lett. **101**, 174101 (2008),
[3] H.-J. Stöckmann, R. Schäfer, New J. Phys. **6**, 199 (2004),
[4] H. Kohler, I.E. Smolyarenko, C. Pineda, T. Guhr, F. Leyvraz, T.H. Seligman, Phys. Rev. Lett. **100**, 190404 (2008).

DY 15.3 Wed 14:45 HÜL 386

Coupling fidelity in a microwave billiard — •Bernd Köber[1], Ulrich Kuhl[1], Hans-Jürgen Stöckmann[1], Dmitry Savin[2], Thomas Gorin[3], and Thomas Seligman[4] — [1]Fachbereich Physik, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]Department of Mathematical Sciences, Brunel University, Uxbridge UB8 3PH, UK — [3]Departamento de Fisica, Universidad de Guadalajara, Guadalajara C.P. 44840, Jalisco, Mexico — [4]Instituto de Ciencias Fisicas, Universidad Nacional Autonoma de Mexico, Cuernavaca, Mexico

We investigate the scattering fidelity in a microwave billiard. In former studies we found for global perturbation an agreement with prediction from random matrix theory[1], whereas in case of a local perturbation an algebraic decay was found[2]. In this presentation we use the coupling to an external channel as a perturbation parameter, which is inherent to systems to be used for quantum computing. We derive an exact formula using an supersymmetrical ansatz and compare it with experiments in an chaotic billiard, where the coupling of a channel was changed by means of an slit. Again an algebraic decay for large times is found and the experiment confirms this findings.

[1] R. Schäfer, H.-J. Stöckmann, T. Gorin, and T. H. Seligman, Phys. Rev. Lett. 95, 184102 (2005).
[2] R. Höhmann, U. Kuhl, and H.-J. Stöckmann. Phys. Rev. Lett. 100, 124101 (2008).

DY 15.4 Wed 15:00 HÜL 386

Study of diffraction patterns and temporal properties in open microwave billiards — •Pedro Oria Iriarte, Stefan Bittner, Barbara Dietz, Maksim Misky-Oglu, Achim Richter, and Florian Schaefer — Institut fuer Kernphysik, TU Darmstadt, Schlossgartenstr. 9, Darmstadt, Germany

The outcoming electromagnetic flush from open microwave billiards with regular and chaotic dynamics is investigated. Time decay properties and field diffraction patterns are related to periodic orbits in the billiards. Results of the famous double slit experiment are also shown and discussed.

DY 15.5 Wed 15:15 HÜL 386

Diffraction effects on transport properties of a circular cavity — •Tobias Dollinger[1], Michael Wimmer[1], Iva Brezinova[2], Joachim Burgdörfer[2], and Klaus Richter[1] — [1]Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany — [2]Institut für Theoretische Physik, Technische Universität Wien, 1040 Vienna, Austria

It is by now well established that quantum transport properties can be predicted analytically by starting from semiclassical expressions for the Greens-function. This approach proves particularly useful for systems with classical analoga revealing chaotic dynamics. Here we will use a semiclassical approach to re-examine a circular billiard, which is integrable in the classical case. We mainly focus on diffraction at the openings and analyse how it influences quantum effects, such as weak localization, for different curvatures at the points that connect leads and billiard boundary. This is motivated by an analysis of scattering matrix elements obtained from quantum simulations, in which features of the corresponding classical scattering system are observed.

DY 15.6 Wed 15:30 HÜL 386

Microwave experiments with dielectric circular billiards — •Stefan Bittner, Barbara Dietz, Maksim Miski-Oglu, Pedro Oria-Iriarte, Achim Richter, and Florian Schäfer — Institut für Kernphysik Darmstadt, Germany

Microlasers typically consist of a flat dielectric micro-cavity surrounded by media with smaller index of refraction. For the theoretical description of the three-dimensional electromagnetic fields of highly excited modes one usually uses a two-dimensional approximation based on the so-called effective index of refraction. The validity and precision of this approximation is tested experimentally with two flat circular microwave resonators of different height made of Teflon. The resonance frequencies as well as intensity distributions of several hundreds of TE- and TM-modes were measured, and the related quantum numbers were identified. These data are compared to computations based on the effective index of refraction approximation. Significant deviations between the measured and computed resonance frequencies as well as the resonance widths were found for both polarizations and especially in the long wavelength limit.

DY 15.7 Wed 15:45 HÜL 386

Extended ray dynamics for optical microcavities — •Julia Unterhinninghofen[1], Jan Wiersig[1], and Martina Hentschel[2] — [1]Institut für Theoretische Physik, Otto-von-Guericke-Universität Magdeburg, 39106 Magdeburg — [2]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

Optical microcavities have important applications in various fields of physics; deformed optical microdisks in particular attract interest in the quantum chaos community because they can be used to study ray-wave correspondence in open systems both theoretically and experimentally. As smaller and smaller cavities can be fabricated, corrections to the ray picture become important. Unfortunately, analytical formulas for the lowest-order corrections (so-called Goos-Hänchen shift and

Fresnel filtering) only exist for certain limiting cases. Here, we present a method that allows the numerical calculation of there corrections; the corrections can be applied to the full phase space, which is not possible using the analytical results. We present results for the extended ray dynamics of elliptical and Limacon-shaped microdisks and compare them to wave calculations.