NEW INSIGHTS ON COHERENT WAVE TRANSMISSION THROUGH DISORDERED SYSTEMS

A. Girschik,1,∗ A. Peña,2 F. Libisch,1 P. Ambichl,1 A. Brandstötter,1 A. A. Chabanov,2 S. Rotter1

1Vienna University of Technology (TU Wien), A–1040 Vienna, Austria, EU
2University of Texas at San Antonio, TX 78249, San Antonio, Texas, USA

* presenting author: adrian.girschik@tuwien.ac.at

We report on recent results for wave propagation through quasi-one-dimensional scattering setups with strong disorder. In a joint experimental and theoretical microwave study,1 we focus on a scattering regime where the effect of Anderson localization suppresses all but a single transmission channel. To identify the unique crossover to this “single-channel regime” we employ a statistical analysis of both the experimental as well as our numerical data. We find that the single dominant channel is formed by an individual Anderson-localized eigenmode (see Fig. 1) or by several such modes that couple to a so called “necklace state”.2 As a result the speckle patterns measured at the output facet of the system are literally frozen: any spatial or polarization change of the incident wave does not affect the distribution of the speckle intensity at the output but only changes its brightness.3 Pulsed excitations of the disordered samples allow us to also identify the single-channel regime in the time domain as well as to distinguish between long-lived individual localized modes and short-lived necklace states. Additionally, we manage to describe the statistics of transport properties of the multi-dimensional disordered sample in this regime as an effective 1D system with a renormalized localization length. If time permits, I will also report on very recent results on the propagation of waves through systems with a weak and spatially correlated disorder. In such systems that may range from nanoelectronics to ocean acoustics4 the effect of branched flow5 occurs and leads to the formation of surprisingly focused branches in the disordered medium along which the waves propagate over large distances. We will address the question, if and how wave front shaping techniques may allow us to use this effect for improved focusing through the medium.6

FIG. 1. Transport through eigenchannels and eigenmodes in the single-channel regime. a Numerically calculated total transmission $T$ (red curve) as a function of frequency. The empty and solid circles show the real $\text{Re} \nu_m$ and imaginary $\text{Im} \nu_m$ parts of the eigenfrequencies $\nu_m$ of localized eigenmodes. The transmission resonance positions nicely coincide with the real parts of $\nu_m$, the resonance widths correlate with the imaginary parts of $\nu_m$. b Spatial intensity pattern of the scattering state of the transmission eigenchannel (upper panel) and of the individual localized mode (lower panel) at the resonance peak $b$. The similarity reflects the correspondence between the single channel and the localized eigenmode.

6 Girschik A et al (to be submitted)