We experimentally measure and study the monochromatic transmission matrix in optics. It allows light focusing and detection through a complex medium. Having access to the transmission matrix opens the road to a better understanding of light transport.

**Transmission Matrix H**

- **Input k**
- **Output k**
- **Input**
- **Output**
- **Random Matrix**
- **Identity Matrix**
- **Free space**
- **Scattering sample**

Information can be easily reconstructed using the experimentally measured data.

\[
E_{\text{out}}^{\text{ref}} = \sum_n h_n E_{\text{in}}^{\text{ref}}
\]

Measuring the TM

\[
E_{\text{out}}^{\text{ref}} = E_{\text{in}}^{\text{ref}}
\]

**Statistical Properties of the TM**

**Tool:** Singular Value Decomposition

\[
H = U \Lambda V^T
\]

**Output basis**

\[
\Lambda = \begin{bmatrix}
\lambda_1 & 0 & 0 & 0 \\
0 & \lambda_2 & 0 & 0 \\
0 & 0 & \lambda_3 & 0 \\
0 & 0 & 0 & \lambda_4
\end{bmatrix}
\]

\(\lambda_i > 0\) represents the energy transmission through the ith channel. \(\Sigma \lambda_i \) corresponds to the total transmission for a plane wave.

We filter the reference speckle to remove those correlations and study the distribution of (normalized) singular values \(\rho(\lambda)\).

Amplitude of Reference Speckle induces correlation that modify the distribution.

**Objective:** Measuring the Transmission Matrix

**Hypothesis:** Coherence of the illumination, Stability of the Medium, Linearity

**Setup**

- **Input Control**
  - Spatial Light Modulator (SLM)
- **Output Detection**
  - CCD Camera

**Image Detection**

\[
E_{\text{out}}^{\text{obj}} = O \cdot E_{\text{in}}^{\text{ref}}
\]

Perfect reconstruction when the image is complex.

**Conclusion and Perspectives**

- Developed a faster setup (micromirror arrays, ferromagnetic SLMs) for biological purposes
- Study more complex media (Anderson localization, photonic crystals, Levy glasses...)

**References**