Frequency Correlations in Reflection from Random Media

Master Thesis
Angelika Knothe
Supervision:
Prof. Dr. Andreas Buchleitner, PD Dr. Thomas Wellens
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Summary

In this master thesis, we study statistical properties of light reflected from a disordered scattering medium; in particular, we focus on the *frequency correlation function* ${}^{R}C_{\vartheta}(\omega, \omega + \Omega)$ quantifying intensity-intensity correlations in frequency space. This function is defined in terms of the intensity $I_{\vartheta}(\omega)$ at frequency ω backscattered from the medium under the backscattering angle ϑ as

$$ {}^{R}C_{\vartheta}(\omega, \omega + \Omega) = \frac{\langle I_{\vartheta}(\omega + \Omega) I_{\vartheta}(\omega) \rangle}{\langle I_{\vartheta}(\omega + \Omega) \rangle \langle I_{\vartheta}(\omega) \rangle} - 1, \tag{1} $$

where the angular brackets denote averaging over different realizations of the disorder.

The work is inspired by experimental observations [1], where, for increasing strength of the disorder, a breakdown of the width $\Delta\Omega_{FWHM}(\vartheta)$ of this correlation function is reported. This effect is unexplained so far. Therefore, we present detailed studies of the properties of the frequency correlation function with special focus on their dependence on the strength of the disorder. For *weakly disordered* scattering media, we explore a theoretical description of the frequency correlation function within the *Gaussian approximation* and second the *approximation of minimal dephasing*, where only the intensity propagators of copropagating pathways (ladder propagation) and counter propagating pathways (crossed propagation) are taken into account. In this frame, we derive a simple relation between the frequency correlation function and the distribution of path lengths of multiple scattering sequences. This approach proves to describe experimental results in this regime but does not describe the breakdown of the peak in the frequency broadening with increasing disorder strength as it was observed experimentally.

Since we are able to show that non-Gaussian terms are negligible for the setup under study, for *stronger disorder*, we explore the ansatz to take into account further scattering processes beyond the ladder and crossed prop-

agation processes of the minimal dephasing approximation. We focus on so-called *Recurrent Scattering Trajectories*, *i.e.* closed scattering loops, as they have been shown to play a crucial role when the strength of the disorder approaches the threshold of the *Anderson Localization Transition* [2]. We investigate the consequences of these scattering processes for the backscattering signal, in particular the impact on the properties of the frequency correlation function, in order to explain the experimentally observed behaviour of ${}^{R}C_{\vartheta}(\omega, \omega + \Omega)$.
The results of this work are published in reference [3].

References

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