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Speckle decorrelation in non-linear disordered media

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Light propagating in a disordered medium gives rise to a complex interference pattern called a speckle. This coherent effect has been widely studied in the past, especially for linear materials, since it contains a lot of information on the optical properties and structure of the medium [1]. In this work [2], we consider the case of a non-linear medium with a second harmonic response. We study experimentally, numerically and theoretically the decorrelation processes of the fundamental and second harmonic speckles as a function of the scatterer motion. This motion is due to the radiation pressure induced by the incoming light the power of which is modulated.

Experimentally, we observe that the speckle correlation decreases faster for the second harmonic than for the fundamental beam with increasing power (see Fig. 1). To obtain physical insights of this effect, we have developed a theoretical model based on a diagrammatic approach. This has lead to coupled transport equations for the linear and non-linear speckle correlations that are solved numerically using a Monte Carlo simulation. Two effects have been identified and are responsible of this faster decorrelation with a weight depending essentially on the size of the medium: decorrelation during frequency doubling (SHG process) and decorrelation during propagation of the second harmonic beam.

This work opens up the way for a better understanding of light propagation in non-linear disordered media.

[1] J. W. Goodman, Speckle Phenomena in Optics: Theory and Applications (Roberts & Company, 2007)
[2] R. Samanta, R. Pierrat, R. Carminati and S. Mujumdar, in preparation (2021)

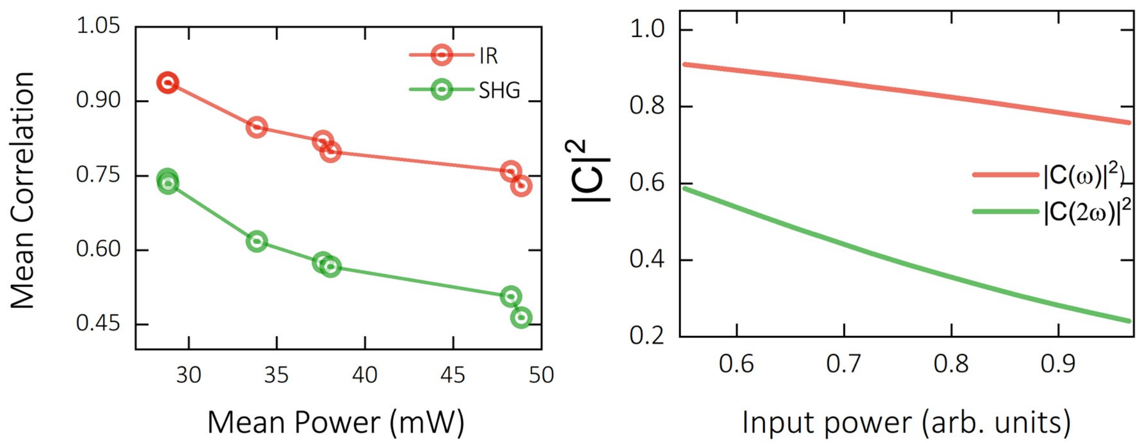

Figure 1: Speckle correlation for the fundamental (red line) and second harmonic (green line) as a function of the input power. Left: experiment (KDP powder, medium size L=680 µm, transport mean-free paths ℓ_t=120 µm at λ=1064 nm and ℓ_t=85 µm at λ=532 nm). Right: theoretical results obtained by a Monte Carlo simulation of the transport model with the same optical parameters. Excellent qualitative agreement is obtained.