The dependence of the intensity PDF of a random beam propagating in the maritime atmosphere on source coherence

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Introduction

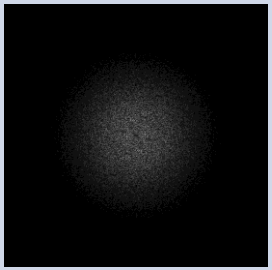
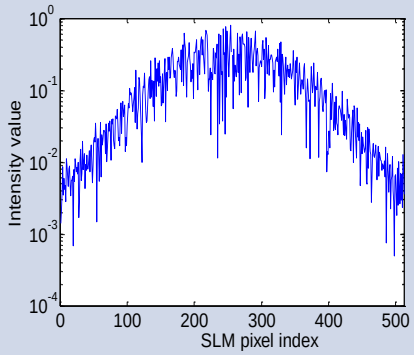
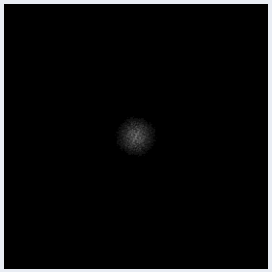
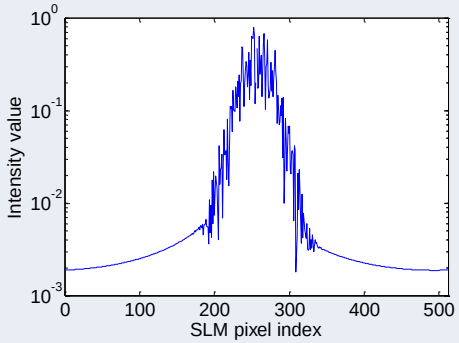
- Measurements of intensity statistics of a spatially pre-randomized laser beam propagating in a turbulent atmosphere at the Naval Academy
- The pre-randomization of the laser beam was made by using a spatial light modulator placed at the laser source exit.
- The beam's phase is randomized with Gaussian statistics with zero mean and fully controllable degree of coherence.
- The results for the intensity PDF, the CDF and for the scintillation index are presented for a variety of
- The analytical PDFs are reconstructed from the statistical moments of intensity with the help of the Gamma-Laguerre model.

The USNA field tests
Partially coherent beam propagation

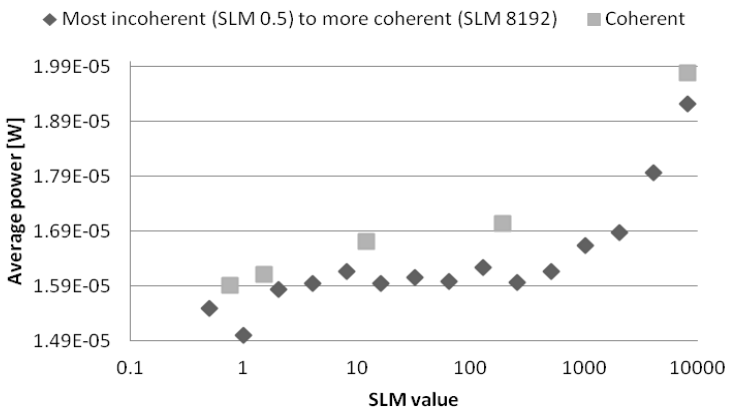
375 m land-link above grassy ground in close proximity to the Severn River

314 m link over College Creek.

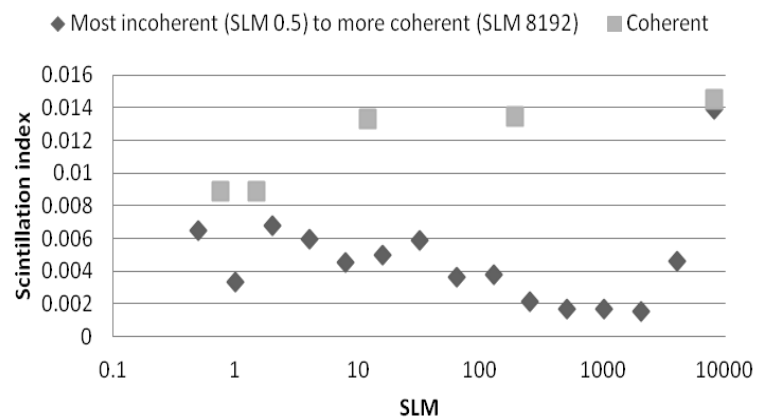
2D far-field intensity distribution as calculated using FFT of the SLM screen and 1D far-field intensity through the beam center for coherence level=2 (nearly incoherent light) and coherence level = 32 (more coherent light).

Far field beam pattern	**Intensity distribution across the beam center**	**Coherence level**
		**2**
		**32**

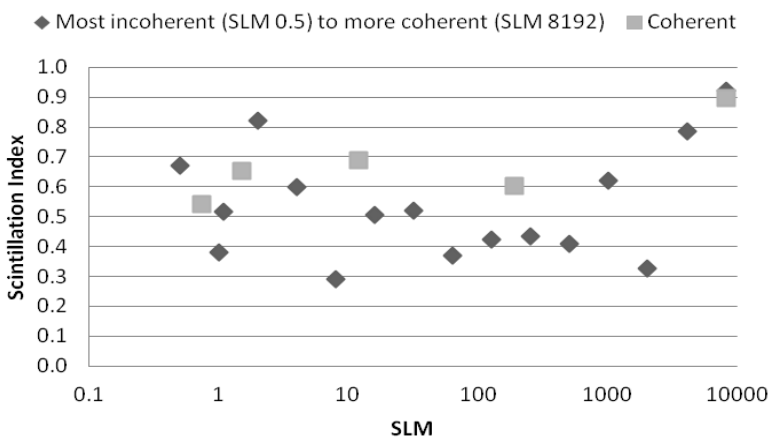
Beam propagation for 375 m link in proximity to maritime environment.



Measured average power

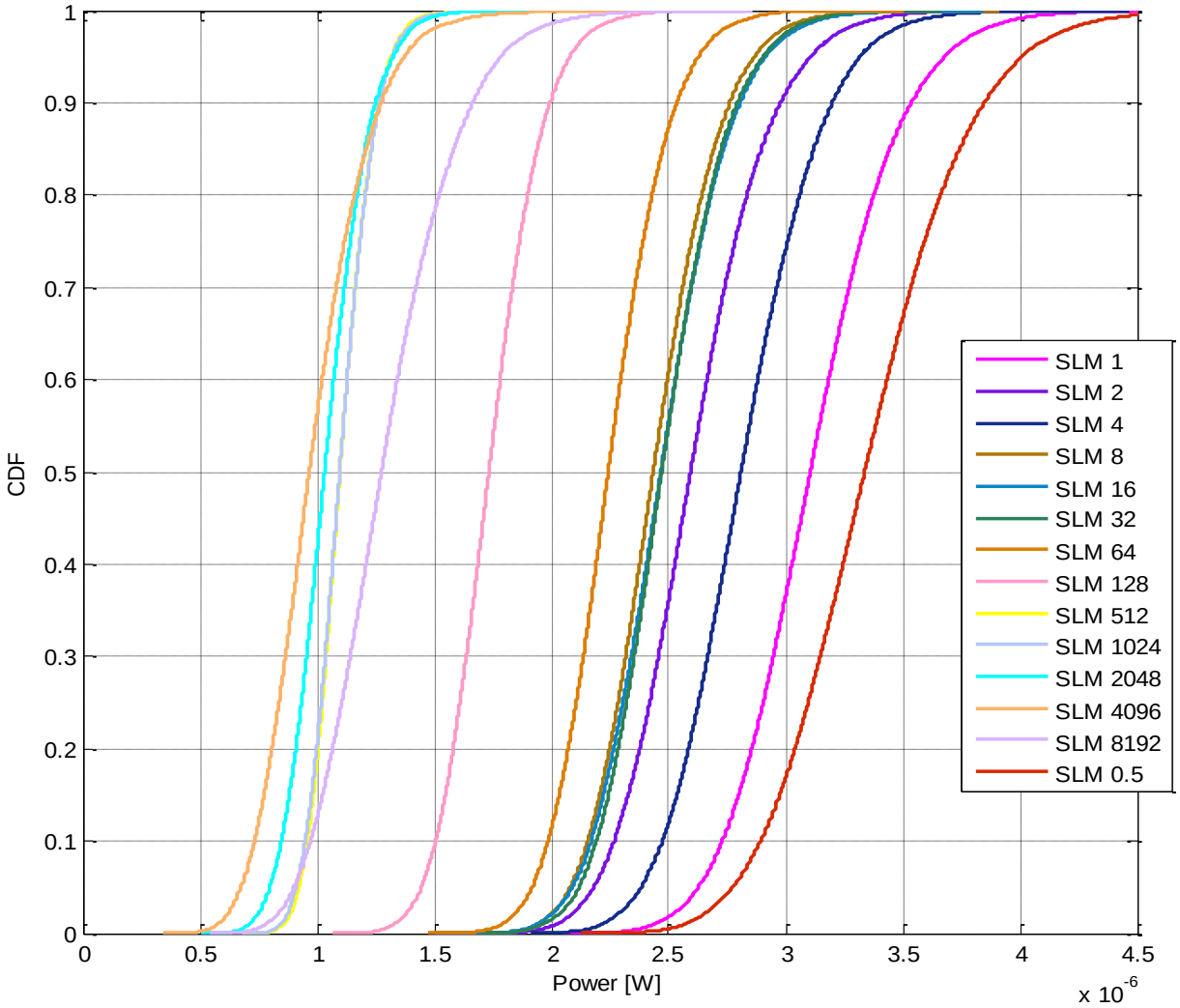


Scintillation index calculated normalizing the variance with measured average power.



Scintillation index calculated normalizing the variance with power for which offset has been eliminated. Note the SLM is labeled by the values of coherence level.

Measured parameters are displayed chronologically and as a function of level of coherence. Coherent beam performance is superimposed for the reference

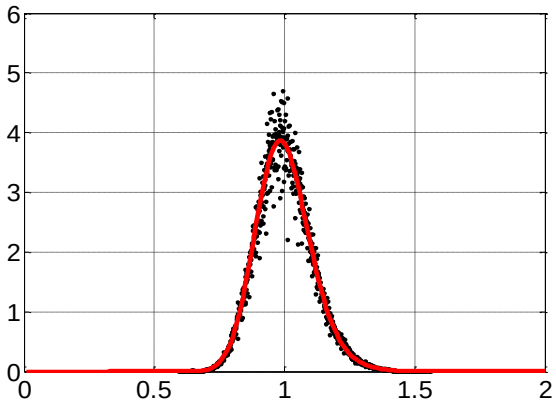


Beam propagation for 314 m over-the-water link.
CDF for various levels of coherence.

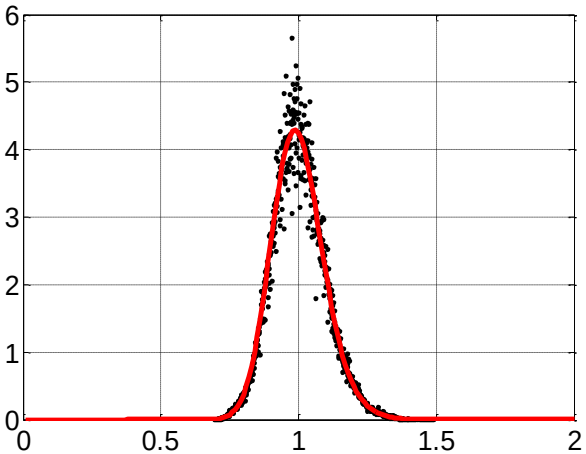
Beam propagation for 314 m

PDF and data histogram as functions of normalized intensities.

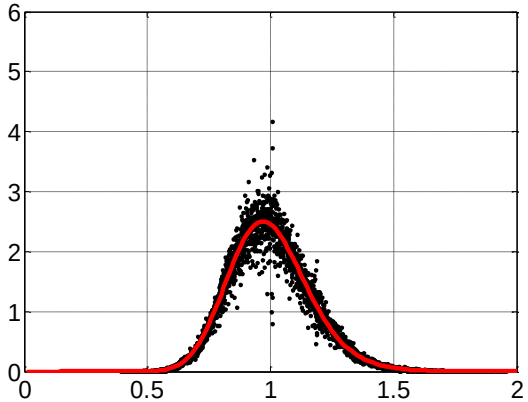
Stationary screens



Coherence level 2, strong diffuser, nearly incoherent beam.



Coherence level 32, more coherent beam.



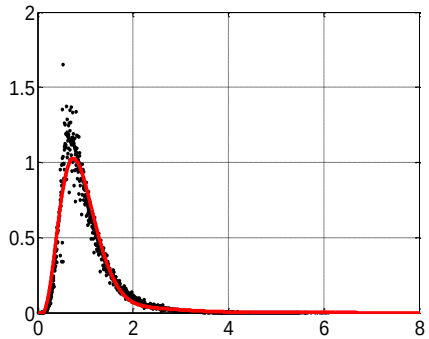
Coherent beam.

There is less normalized variance for the partially coherent beams vs. coherent light

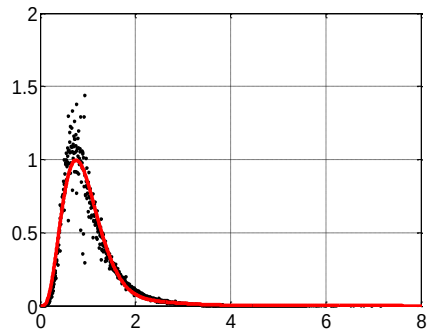
Beam propagation for 375 m near maritime link

PDFs and data histograms as functions of normalized intensities

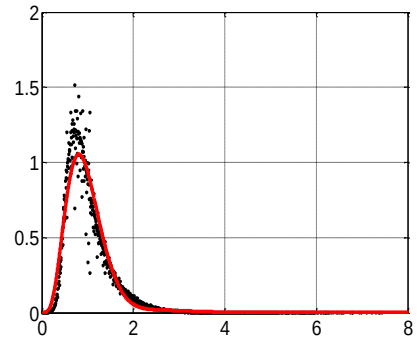
Cycling screens with period of 19 ms



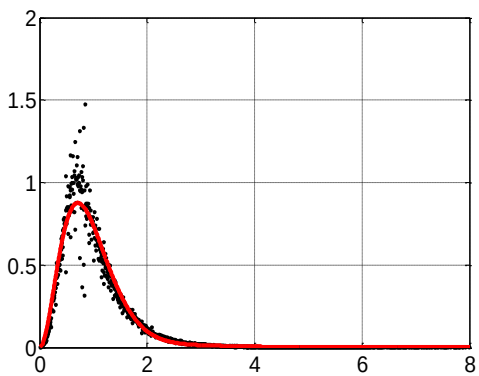
Coherence level 0.5



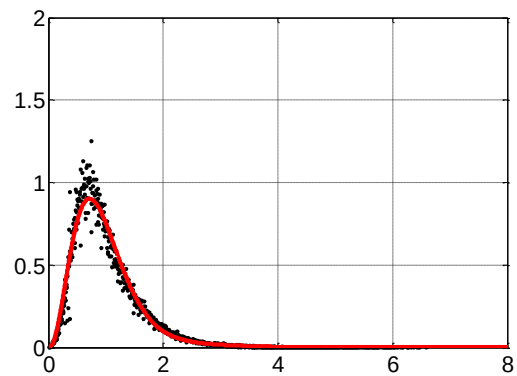
Coherence level 2



Coherence level 4



Coherence level 8



Coherence level 16

Conclusions

- For the first time we have experimentally demonstrated in the field that the random beams produced with the help of the SLM carry better characteristics on propagation in atmospheric turbulence in maritime environment

- Two different sets of data taken in different environments imply that the power PDFs of randomized beams generally have narrower shapes with higher maximum values compared to the coherent beams

- The scintillation power flux is lower for randomized beams and takes on minimum value for certain SLM choices, depending on other source parameters and the atmospheric link properties, in agreement with previous theoretical predictions

Conclusions cont

- The optimal intensity PDFs can be determined in all the cases, by adjusting the of source coherence width to a certain value.
- Source partial coherence is capable of mitigation of atmosphere-induced degradation even in the presence of scatterers.
- Even with single stationary screen the influence of source partial coherence on the propagating beam's intensity PDF is clearly seen.