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Propagation of Stochastic Field Emissions: A Wigner Function Approach

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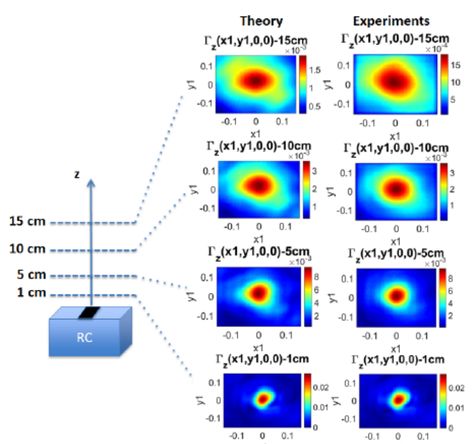
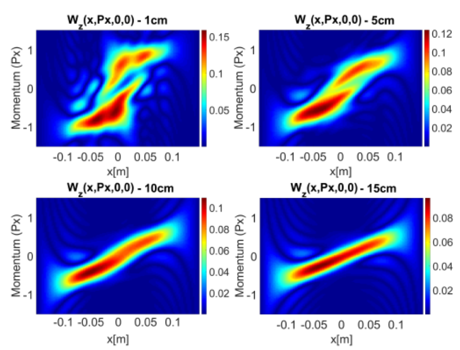
Modeling of complex wave sources is an important topic in several scientific and engineering communities. In the context of electromagnetic compatibility, the complexity of field emissions from extended and broadband planar sources allows for the use of statistical methods to characterize the development of far field interferences from the near field, obtained from scanning at planes parallel to the source. We review and describe recent progresses of an analogue near-to-far field operator for statistical sources, whose exact version is directly related to Green's function formalism. This operator exploits directional and positional information encoded in the two-point correlation function through a *phase-space* representation (Wigner function) [1]. We start from an experimental two-probe scanning procedure to collect field data in space and time, from which the field-field correlation function is calculated by time averaging. An approximated propagation operator can be obtained conveniently in phase-space. For propagating waves, i.e., for planes at distances greater than a wavelength beyond the source, the Wigner function is advanced by a transport equation that configures as a Frobenius-Perron operator and has a direct connection to ray tracing algorithms for densities of waves. For evanescent waves, i.e., for planes at distances less than a wavelength beyond the source, the Wigner function is advanced by a diffusion operator in its position variable. An example of the overall procedure is reported in Fig. 1a, where stochastic emissions from a mode-stirred cavity backed aperture are characterized at different planes through experiments to validate the Wigner function based theory [2]. Figure 1b shows the corresponding Wigner functions. Results are relevant in emission source microscopy and in source reconstruction of statistical sources.



a)



b)

Figure 1. a) Comparison between theoretical and experimental correlation function measured at selected scanning planes (1 cm, 5 cm, 10 cm, and 15 cm) beyond the source (a mode-stirred cavity backed aperture). **b)** Wigner function obtained from correlation measurements at different heights.

1. G. Gradoni, S. C. Creagh, G. Tanner, C. Smartt, D. W. P. Thomas, "A phase-space approach for propagating field–field correlation functions," *New Journal of Physics*, **17**, 093027, September 2015, pp. 138-139, doi: 10.1088/1367-2630/17/9/093027.

2. G. Gradoni, L. R. Arnaut, S. C. Creagh, G. Tanner, Mohd Hafiz Baharuddin, C. Smartt, D. W. P. Thomas, "Wigner-Function-Based Propagation of Stochastic Field Emissions From Planar Electromagnetic Sources," *IEEE Transactions on Electromagnetic Compatibility*, **60**-3, June 2018, pp. 580-588, doi: 10.1109/TEMC.2017.2738329