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Phase-space representation of the wave fields reflected by random rough surfaces

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In order to overcome the bottleneck of wireless bandwidth, it has been proposed that new wireless communication systems and 5G operate at high frequencies, ranging from microwave (6 GHz) to mmWave (above 30 GHz). Wave propagation is a challenging task at these frequencies and will need new modelling tools compared to those used for current wireless systems and also needs inclusion of the complexity of the environment at much finer scale. Therefore, we introduce here a linear operator formulation of ray tracing, the so-called dynamical energy analysis method (DEA) [1], which is a phase-space method for predicting the distribution of waves intensities in complex environments. However, the focus of this work is on integration of scattering from random rough surfaces into DEA type calculations. We present here a method for calculating reflecting wave correlation functions from random rough surfaces driven by statistical sources. This leads to the phase-space representation of wave fields in phase-space. By exploiting the Wigner distribution function (WDF), we provide a model to compute the scattering correlation function from random rough surfaces. We present a scattering operator, which gives an explicit connection between the incident field and the reflected field. Furthermore, we present the integration of scattering operator into numerical phase-space methods, such as DEA. This method has applications in predicting wave distribution in wireless communications, where one has to take into account effects of scattering. Furthermore, based on the recent results presented on [3], one can extract the mean of the correlation function in terms of the underlying ray dynamics. Therefore, we present the approach also for computing the local means of the reflected correlation functions from random rough surfaces.

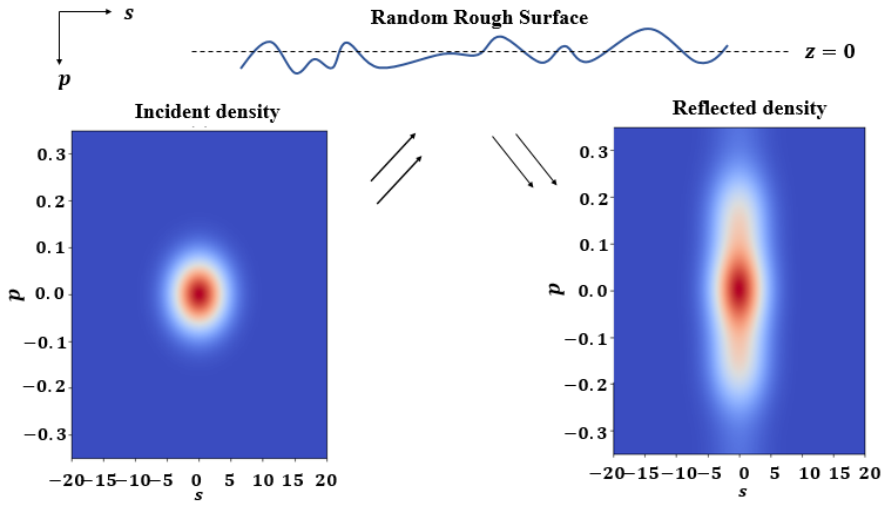

Figure 1: Incident phase space density – Gaussian Schell model and the reflected density by random rough surfaces.

1. Gregor Tanner. Dynamical energy analysis determining wave energy distributions in vibro-acoustical structures in the high-frequency regime. Journal of Sound and Vibration, 320(4):1023–1038, 2009.

2. Gabriele Gradoni, Stephen C Creagh, Gregor Tanner, Christopher Smartt, and David WP Thomas. A phase-space approach for propagating field–field correlation functions. New Journal of Physics, 17(9):093027, 2015.

3. S. C. Creagh, G. Gradoni, T. Hartmann, and G. Tanner, "Propagating wave correlations in complex systems," Journal of Physics A: Mathematical and Theoretical, vol. 50, no. 4, p. 045101