Garnier, Josselin; **Sølna, Knut**

Scaling limits for wave pulse transmission and reflection operators. (English) Zbl 1231.78026

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Summary: The random paraxial wave equation is revisited to take into account not only random forward scattering, but also random backscattering. In this paper we are interested in the transmitted wave fronts and also wave fronts reflected by a strong interface buried in a random medium. In the weakly heterogeneous regime the reflected and transmitted wave fields are characterized by reflection and transmission operators that are the solutions of Itô-Schrödinger diffusion models. These models allow for the computations of the Wigner distributions and the autocorrelation functions of the reflected and transmitted waves. They also fully take into account the fact that the waves travel through the same medium during the propagation to and from the interface, which induces an increase of the beam radius and of the correlation radius, and also predict the enhanced backscattering effect in the backscattered direction.

MSC:

78A45 Diffraction, scattering
35P25 Scattering theory for PDEs
35R60 PDEs with randomness, stochastic partial differential equations
60H15 Stochastic partial differential equations (aspects of stochastic analysis)
76Q05 Hydro- and aero-acoustics

Keywords:

waves; random media; Schrödinger equations; partially coherent beams; enhanced backscattering

Full Text: DOI

References:

[1] Bal, G.; Papanicolaou, G.; Ryzhik, L., Self-averaging in time reversal for the parabolic wave equation, Stoch. dyn., 2, 507-531, (2002) · Zbl 1020.35126

[2] Barabanenkov, Y.N., Wave corrections for the transfer equation for backward scattering, Izv. vyssh. uchebn. zaved. radiofiz., 16, 88-96, (1973)

[3] Blomgren, P.; Papanicolaou, G.; Zhao, H., Super-resolution in time-reversal acoustics, J. acoust. soc. am., 111, 230-248, (2002)

[4] Dawson, D.; Papanicolaou, G., A random wave process, Appl. math. optim., 12, 97-114, (1984) · Zbl 0564.60061

[5] Fannjiang, A.C., White-noise and geometrical optics limits of wigner – moyal equation for beam waves in turbulent media II: two-frequency formulation, J. stat. phys., 120, 543-586, (2005) · Zbl 1081.78004

[6] Fannjiang, A.; Sølna, K., Propagation and time-reversal of wave beams in atmospheric turbulence, SIAM multiscale model. simul., 3, 522-558, (2005) · Zbl 1075.35084

[7] Fante, R.L., Wave propagation in random media: a systematic approach, (), 341-398

[8] Feizulin, Z.I.; Kravtsov, Yu.A., Broadening of a laser beam in a turbulent medium, Radio quantum electron., 10, 33-35, (1967)

[9] Fouque, J.-P.; Garnier, J.; Papanicolaou, G.; Solna, K., Wave propagation and time reversal in randomly layered media, (2007), Springer New York · Zbl 1386.74001

[10] J. Garnier, K. Sølna, Coupled paraxial wave equations in random media in the white-noise regime, Ann. Appl. Probab. (in press), available at http://www.math.uci.edu/~ksolna or http://www.proba.jussieu.fr/~garnier. · Zbl 1175.60066

[11] Ishimaru, A., Wave propagation and scattering in random media, (1978), Academic Press San Diego

[12] Mazar, R.; Bronshtein, A., Coherence properties of retro-reflected radiation in a power-law random medium, Opt. lett., 15, 66-768, (1990)

[13] Mazar, R.; Bronshtein, A., Double passage analysis in random media using two-scale random propagators, Wave random media, 1, 341-362, (1991) · Zbl 0760.73015

[14] van Rossum, M.C.W.; Nieuwenhuizen, Th. M., Multiple scattering of classical waves: microscopy, mesoscopy, and diffusion, Rev. mod. phys., 71, 313-371, (1999)

[15] ()

[16] Thrane, L.; Frosz, M.H.; Jørgensen, T.M.; Tycho, A.; Yura, H.T.; Andersen, P.E., Extraction of optical scattering parameters and attenuation compensation in optical coherence tomography images of multilayered tissue structures, Opt. lett., 29, 1641-1643, (2004)

[17] Thrane, L.; Yura, H.T.; Andersen, P.E., Analysis of optical coherence tomography systems based on the extended huygens – fresnel principle, J. opt. soc. am. A, 17, 484-490, (2000)

[18] Yura, H.T.; Thrane, L.; Andersen, P.E., Closed-form solution for the Wigner phase-space distribution function for diffuse reflection and small-angle scattering in a random medium, J. opt. soc. am. A, 17, 2464-2474, (2000)