The Design of Random Surfaces with Specified Scattering Properties

Tamara A. Leskova,[1] Alexei A. Maradudin[1*], and Eugenio R. Méndez[2]
[1]Department of Physics and Astronomy
and Institute for Surface and Interface Science
University of California, Irvine, CA 92697-4575
Email: leskova@duey.ps.uci.edu, aamaradu@uci.edu

[2] Divísión de Física Aplicada
Centro de Investigación Científica y de Educación Superior de Ensenada
Apdo. Postal 2732,
Ensenada, B.C. 22800, México
Email: emendez@cicese.mx

abstract

In this paper a novel type of inverse scattering problem is discussed. A description is presented of methods that have been developed recently for designing one- and two-dimensional randomly rough surfaces that scatter waves with a specified angular or spatial distribution of the scattered intensity. These methods are based on the geometrical optics limit of the Kirchhoff approximation. In the case of a one-dimensional random surface the surface profile function is assumed to have the form $\zeta(x_1) = a_n x_1 + b_n$ for $nb \leq x_1 \leq (n+1)b$ with $n = 0, \pm 1, \pm 2, \ldots$; in the case of a two-dimensional circularly symmetric random surface the surface profile function is assumed to be given by $\zeta(x_1, x_2) = H(r) = a_n r + b_n$ for $nb \leq r \leq (n+1)b$ with $n = 0, 1, 2, \ldots$, where $r = (x_1^2 + x_2^2)^{\frac{1}{2}}$. In both cases b is a characteristic length, the $\{a_n\}$ are independent, identically distributed, random deviates, and the $\{b_n\}$ are determined by the requirement that the surface profile function be a continuous function of its argument. It is the probability density function of the $\{a_n\}$ that is sought, from which an ensemble of realizations of the surface is generated. The scattering problem for each realization is then solved numerically. It is shown by computer simulation calculations that the resulting surfaces possess the postulated scattering properties when multiple scattering processes of all orders are taken into account. To illustrate these approaches they are applied to the design of one- and two-dimensional random surfaces that produce a constant scattered intensity within a specified range of scattering angles and produce no scattering outside this range – band-limited uniform diffusers; random surfaces that produce a scattered intensity that is proportional to the cosine of the polar scattering angle – Lambertian diffusers; and random surfaces that produce a specified distribution of scattered intensity along the axis normal to the scattering surface in the absence of the roughness. It is then shown that the results in the last case can be used to generate random surfaces that produce a scattered field that has the nature of a pseudo-nondiffracting beam.