Exploiting field intensity and signal filtering in imaging through random cloud-like media with short pulses

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We describe further results in the development of an approach to imaging through dilute obscuring particulate media, in which energy absorption in the scatterers is small and the attenuation is caused primarily by scattering.

The approach is based on two elements: (i) imaging with the help of field intensity of the transmitted pulse or its two-frequency mutual coherence function (MCF), rather than the coherent mean-field amplitude; and (ii) processing the received intensity (or the MCF) by means of "interference gating" – essentially, by applying to it a specific high pass filter.

In order for this techniques to offer advantages compared to the conventional methods based on heterodyne detection of the coherent field, several conditions must be met: (a) The intensity or the MCF must be attenuated at a reduced rate. This fact is well established for scatterers large or at least comparable to the wavelength, in which case the intensity attenuation rate is proportional not to the total cross-section on a scatterer, but rather to an appropriately defined large-angle-scattering cross-section. However, the physical mechanism which reduces attenuation – i.e., the recovery of the *incoherent* contribution to the intensity – is also a source of diffusive processes which may cause a significant pulse elongation and thus a serious degradation of the range resolution (which is controlled by the pulse length). The filtering procedure (ii) in our approach is designed to suppress the long diffusive tails of the evolved pulses, while preserving their initial rapidly varying segments. For this technique to be effective, it is necessary that (b) The intensity space-time distribution must contain a sizable component propagating in "wave-like" manner near the light cone, also attenuated at a reduced rate, and characterized by a small rise time.

We examine to what extent the conditions (a) and (b) hold in several scenarios relevant to remote sensing and imaging problems in millimeter wave and optical regions, involving scatterers small or large compared to the wavelength, and, similarly, small or large pulse-emitting apertures. Our conclusions are based on the rigorous solution of the full Bethe-Salpeter equation (in the ladder-approximation, valid for dilute media). We also compare those solution with approximate ones (the radiative-transfer equation and the paraxial approximation) and with the solutions for the special case of small scatterers.

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