The Propagating Beams Frame:
A Novel Framework for UWB Radiation from Volume Source Distribution

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Beam summation (BS) formulations are an important approach in wave theory since they provide a ray-based framework for local construction of spectrally uniform solutions in complex configurations. In these formulations, the field is expanded into a phase-space spectrum of collimated beam propagators that emanate from a set of points and directions in the source domain, and thereafter are tracked locally in the medium, and their contributions at the observation point are summed up. In (A. Shlivinski et al., *IEEE Trans. AP*, 52, 2042-2056, 2004) we have introduced an ultra-wide-band phase-space beam summation method (UWB-PS-BS) for radiation from apertures. In this representation the aperture sources are expanded in terms of a discrete set of beams emerging from a set of points and directions in the aperture. The unique feature of this representation is that the beam lattice and the beam propagation parameters are frequency independent so that only one set of beams needs to be calculated and then used for all frequencies. This feature is due to the use of an overcomplete window Fourier transform frames (WFT-F), which adds a degree of freedom that in not available in the conventional Gabor-based expansions.

Recently (M. Leibovich and E. Heyman, *the XXXI General Assembly of URSI*, Beijing, 2014) we have shown that the set of propagating beams constitutes a frame *everywhere*, i.e., not only in the aperture plane where this set reduces to the conventional WFT-F. The main goal of this work is to present the propagating frame methodology by applying it in the simplest context of radiation from a volume source distribution. Specifically, we formulate a new expansion scheme for volume source distributions wherein the sources are expanded using the beam set, and the expansion coefficients are obtained by projecting the source distribution onto this beam set.

The propagating frame representation provides a new self-consistent framework for wave tracking through weakly scattering media, where the interaction of the propagating beams with the medium heterogeneities is analyzed locally, and then projected onto the same beam set. Applications for wave tracking through random medium and for inverse scattering will be presented.