URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Phenomenology of Complex Source Beam Diffraction by Circular Cones

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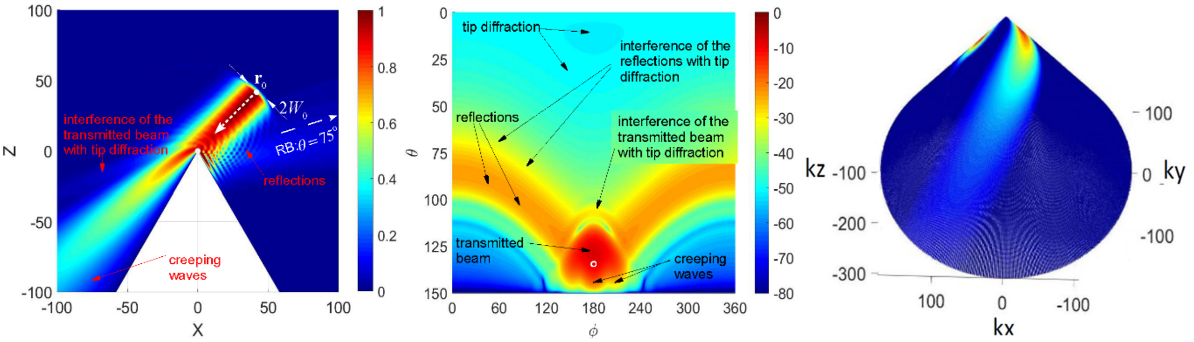
In previous publications, the problem of beam diffraction by wedges [1,2] and circular cones [3] have been studied via the complex source (CS) approach. One of the main results has been the generalization of the straightforward CS formulation, which by definition models only situations where the incident beam is *diverging* as it hits the scatterer, to model situations where the incident beam is *converging* there.

In the present paper, we present the modified CS formulation and apply it to explore the local scattering phenomena induced by a converging or diverging beam that hits near a tip of circular cones, involving grazing reflections, tip diffraction, and creeping beam-waves, where all of them coalesce when the beam hits near the tip. By controlling the beam direction and collimation, we selectively excite and explore these phenomena and their footprints in and near the penumbra zone. We also explore these phenomena in the limits of narrow- and wide-angle cones. The presentation focuses on the modified CS method and the local phenomena as demonstrated in the examples below. The field is calculated exactly via a spherical harmonics expansion of the CS field.



(a) **(b)** **(c)**

Figure. Local phenomena for beam scattering by circular cone with half apex angle of 30°. In all cases, the beam collimation distance b is taken to be $kb = 100$ where k is the wavenumber, such that the beamwidth is $kW_0 = (kb)^{1/2} = 10$ and the beam-diffraction angle is $\Theta_D = 0.1[rad]$. In (a) and (b), the cone is soft and the beam hits the tip at 45°. (a) shows a cross-sectional cut of the field-magnitude in the symmetry plane while (b) shows the diffraction pattern in the (θ,ϕ) plane (in a dB). Note in (b): the footprint of the transmitted part of the beam (the incident beam axis is tagged as a white circle); the penumbral reflections by the cone-surface near the tip, and in particular the grazing reflections in the forward direction; and the footprint of the creeping waves that propagate around the surface of the cone in the $\pm\phi$ directions, whose interference causes the broad three-lobe scattering pattern in the shadow side (around $\theta = 145°$). (c) A *creeping beam wave* (CBW) on a hard cone due to a beam with the same parameters as above hitting tangentially at a distance of 3 beamwidths away from the tip. As shown, the propagation axis of the CBW follows a geodesic, while its transversal properties depend are fully described by beam-equations

References

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[2] M. Katsav, and E. Heyman, “Converging and diverging beam diffraction by a wedge: A complex source formulation and alternative solutions,” *IEEE Trans. Antennas Propagat.*, **64**, 7, July 2016, pp. 3080-3093.

[3] R. H. Bruens, L. Klinkenbusch, M. Katsav, and E. Heyman, “Spherical-multipole analysis of an arbitrarily directed complex-source beam diffracted by an acoustically soft or hard circular cone,” *Adv. Radio Sci.,* **13**, 2015, pp. 57-61, doi:10.5194/ars-13-57-2015.