The Onset of Grating Lobes in Arrays of Electrically Large Apertures: A Study for Lenslet Arrays

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The onset of grating lobes in arrays of discrete antennas is well understood, but arrays comprised of electrically large apertures are not often considered. In this talk we will compare a linear array of isotropic elements (extent less than λ) and an array of electrically large lenses, called lenslets ($\approx 3.8\lambda$), to understand the onset of gratings lobes.

The array of ideal isotropic antenna elements spaced greater than $\lambda/cos\theta$ apart exhibits grating lobes. On the other hand, an array of contiguous ideal lenslets, defined as lenses which realize linear phase shift above the lens, as shown in the figure below (right), does not exhibit grating lobes (below, left) even though the array elements are spaced 3.8λ apart. While this may seem counter-intuitive from the perspective of array theory, it must be so because the far-field radiation pattern forms a Fourier transform pair with the linear ramp aperture distribution of the lenslet array.

While the above shows that there is promise in combining smaller lenses into larger physical apertures to achieve very high gain, it is important to consider the nonidealities of lens arrays which do result in grating lobes. The figure below (left) shows an ideal lenslet array aperture distribution with a linear phase shift which results in a main-beam and no grating lobes steered to 50 degrees (blue traces). However, if the lenslet array has imperfect linear phase shift across each lenslet, the result is a periodic perturbation in the aperture field which results in significant grating lobes (red traces). In this talk we will draw comparison between the aperture theory perspective and the array theory perspective (array factor and the visible region).

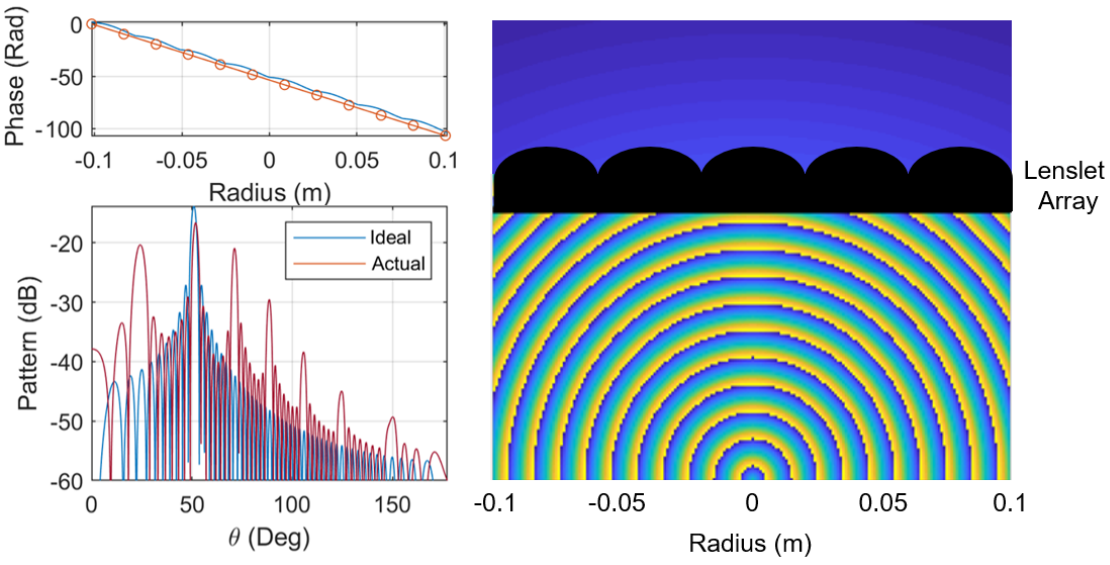

Figure 1: [left] Aperture phase (top) and space factor (bottom) of a lens array with non-linear lenslet phase. [right] Phase from a point-source incident upon a lenslet array.