Beampattern and polarisation synthesis of 3D RF-seeker antenna arrays

Background

Existing RF seeker antennas are flat and steer the beam with a rotational mechanism. The drawbacks:

- Slow, bulky, fragile
- Limited coverage

To counteract these drawbacks, a 3D conformal electronically steerable antenna is proposed. The possible advantages are:

- Wider elevation coverage due to the 3D shape
- Faster moving beam that can potentially allow multi-target tracking as a result of the electronic control

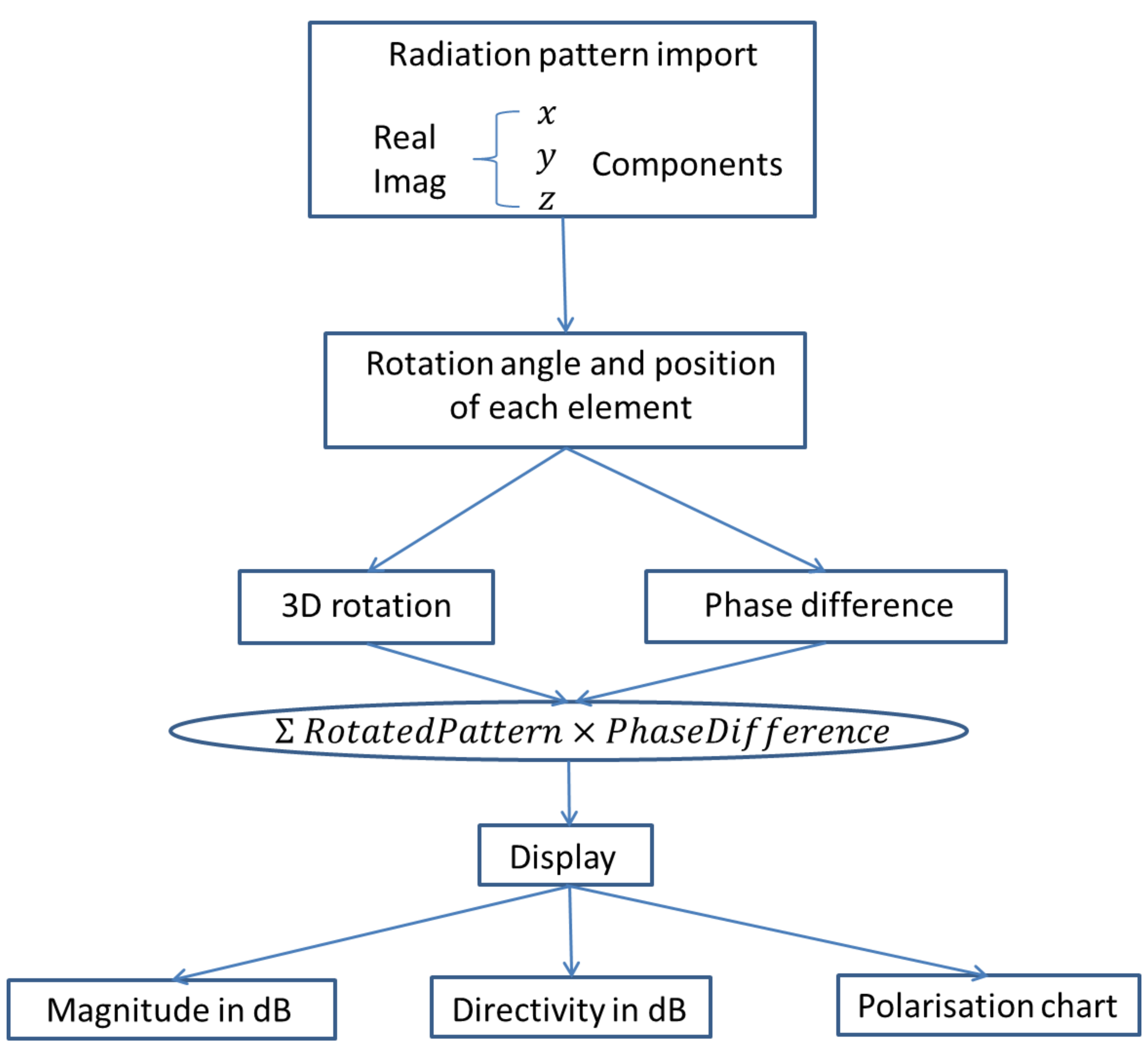
Challenges:

- For a flat array, the global polarisation follows that of a single element
- For a complex 3D array, beams of each element interfere with one another resulting in complex co-pol and cross-pol patterns

The overall objective of our research is to design, prototype and assess the electromagnetic performance of novel 3D conformal antenna arrays for RF seekers. To achieve this, we developed a Matlab program that computes the radiation pattern of any 3D arrays by importing the pattern of a single element. The characterisation of the global resulting field is carried out by calculating and displaying

- Directivity
- Polarisation chart
- Polarisation ellipse

Scheme of the Matlab tool



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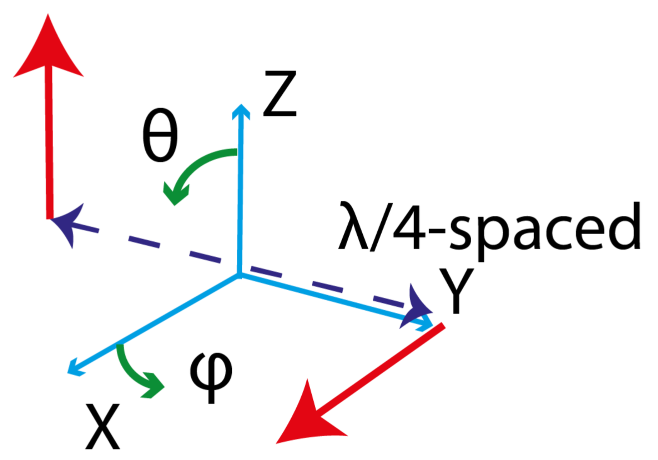
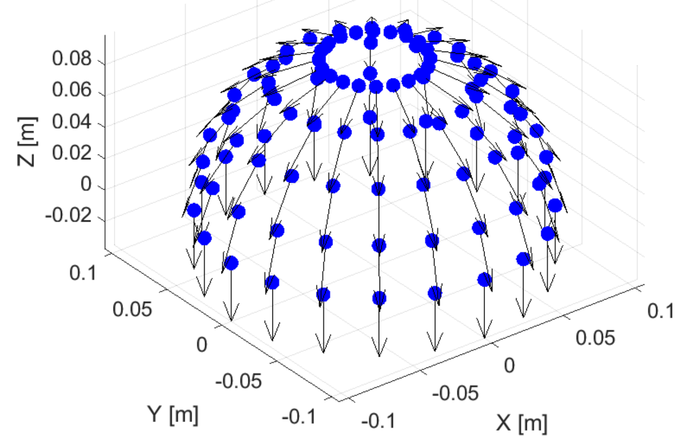
Results

The radiation pattern of any array is computed using the following equation:

$$\mathbf{E}_{\text{total}}(\theta,\varphi)=\sum_n \mathbf{E}_{\text{n}}(\theta_{\text{nj}},\varphi_{\text{nj}})\cdot e^{-\text{j}k\boldsymbol{r}\cdot\mathbf{u}_{\text{n}}}$$

The polarisation is studied for two different arrays consisting of Hertzian dipoles: 1) two orthogonal elements lying on orthogonal planes and 2) a Half-sphere with 100 elements.

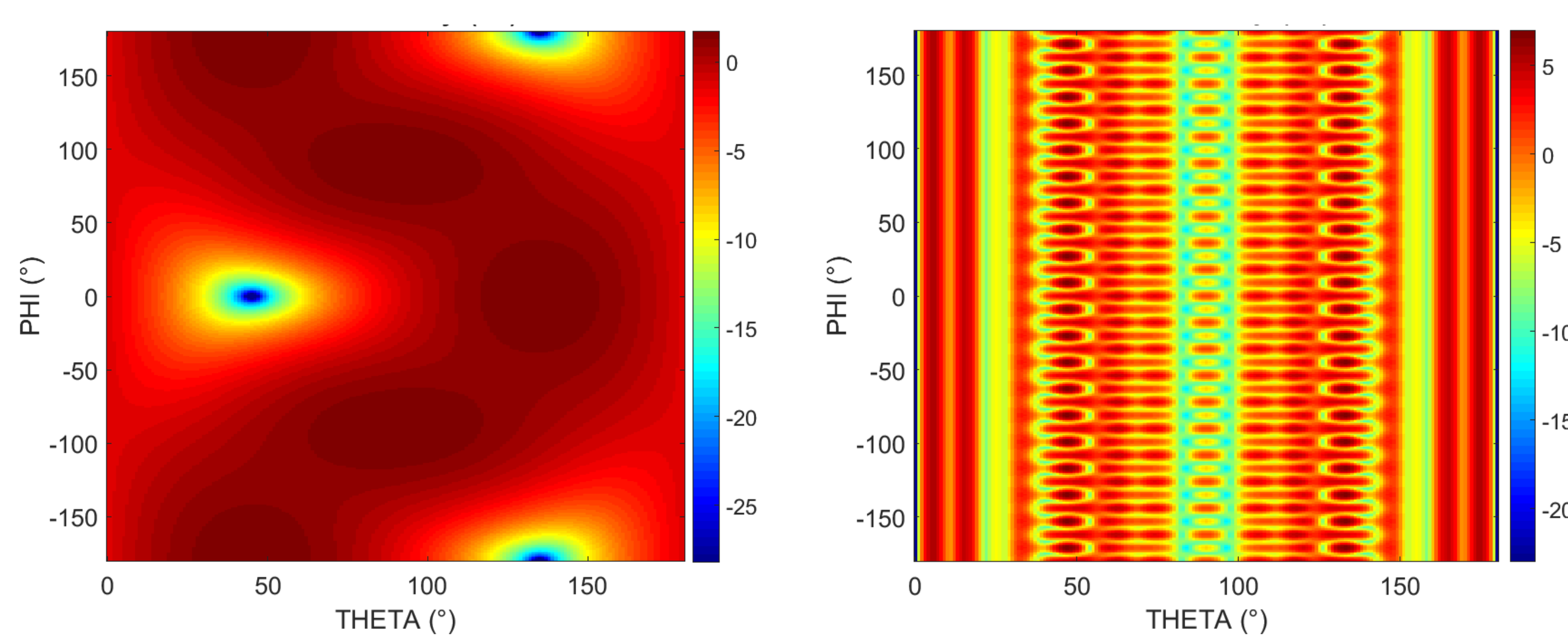




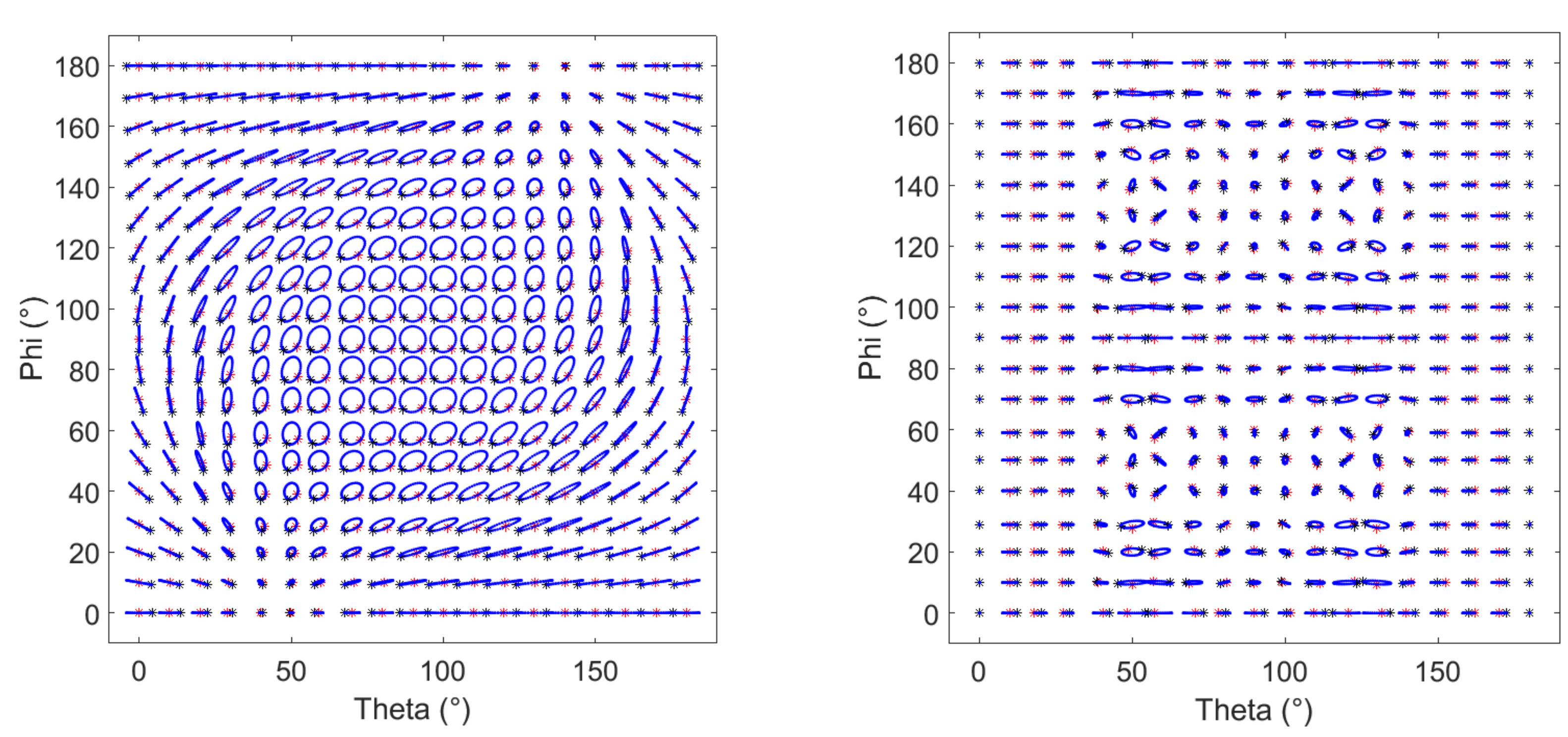
The second array consists of 5 rings of 20 elements each, and these are arranged so that the spacing between elements increases as the angle increases. There is no element at θ= 0°. The characterisation of the fields is carried out thanks to the polarisation chart which displays the trajectory of the field vectors and the polarisation ellipticity.

The polarisation ellipticity is calculated using the E fields as: $\chi=\frac{1}{2}\arcsin\left(\frac{Imag(\rho)}{1+|\rho^2|}\right)$ where $\rho=\frac{E_\theta}{E_\varphi}$.

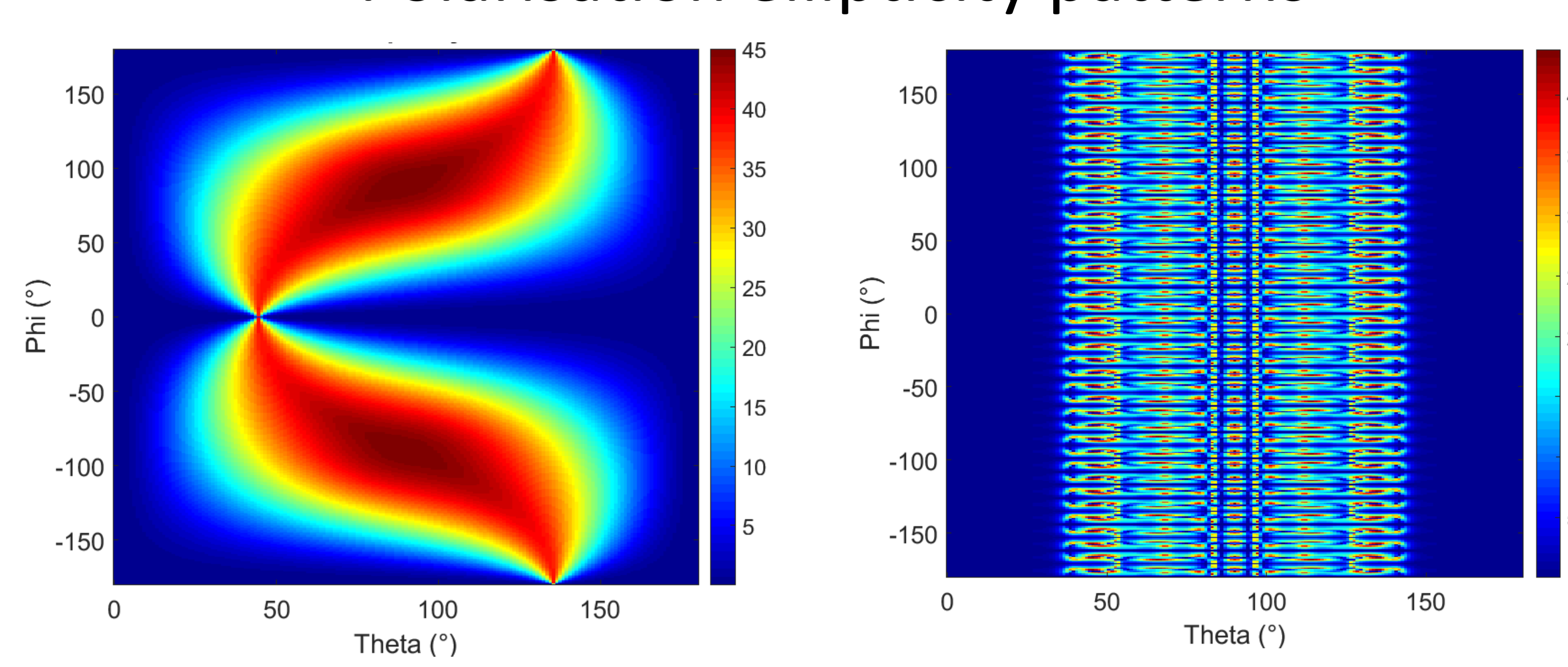
Directivity Patterns



Polarisation charts



Polarisation ellipticity patterns



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