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A Simple and Efficient Semi-Analytic Method for Designing Disordered Structures to Manipulate Antenna Radiation

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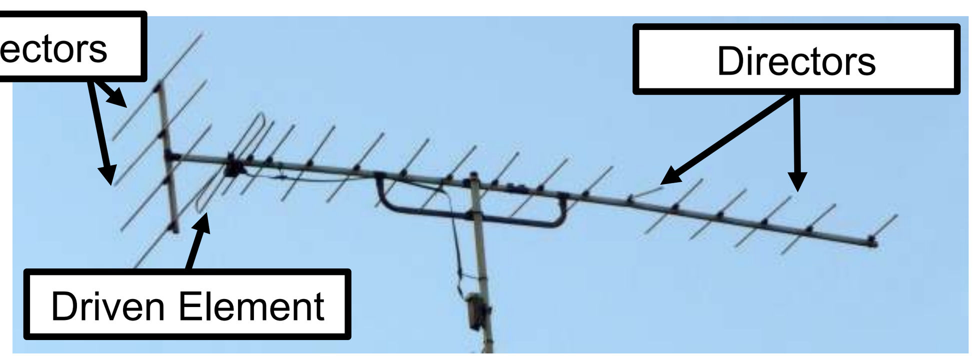
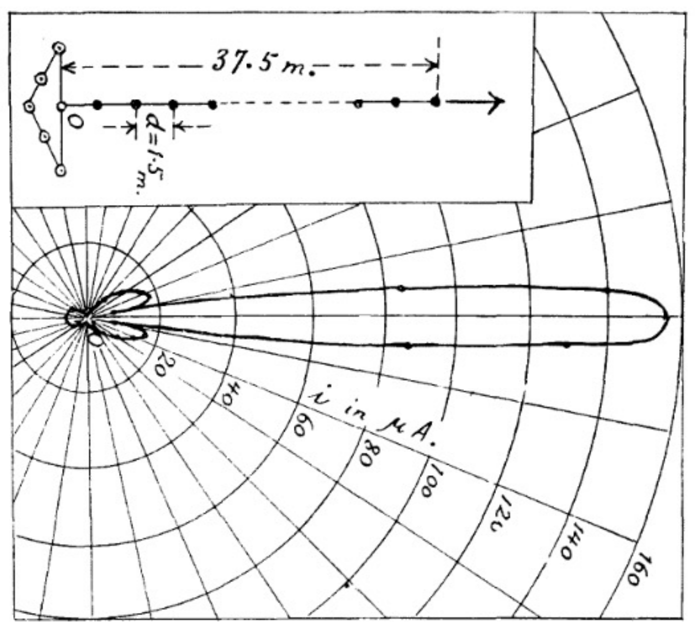
Abstract. We have derived a simple and efficient method for designing wave-shaping materials composed of dipole scatterers. We apply our theory to design aperiodic metasurfaces that re-structure the radiation from a small dipole antenna in several ways including increasing efficiency and manipulating the radiation pattern. Our method is applicable to enhancing the performance of small antenna, reducing mutual coupling and designing custom antenna systems, as well as to other wave scattering effects such as engineering scattering cross-sections.

1. Introduction & Motivation

- Currently, several challenges face antenna systems. For example:
  - Electrically small antenna suffer from degraded performance, which is particularly acute in in body-worn applications.
  - For many applications antennas are tightly packed, causing mutual coupling which leads to reduced performance.
- In this work, we design materials that can increase the efficiency of small emitters and beam steer to mitigate the effects of mutual coupling.





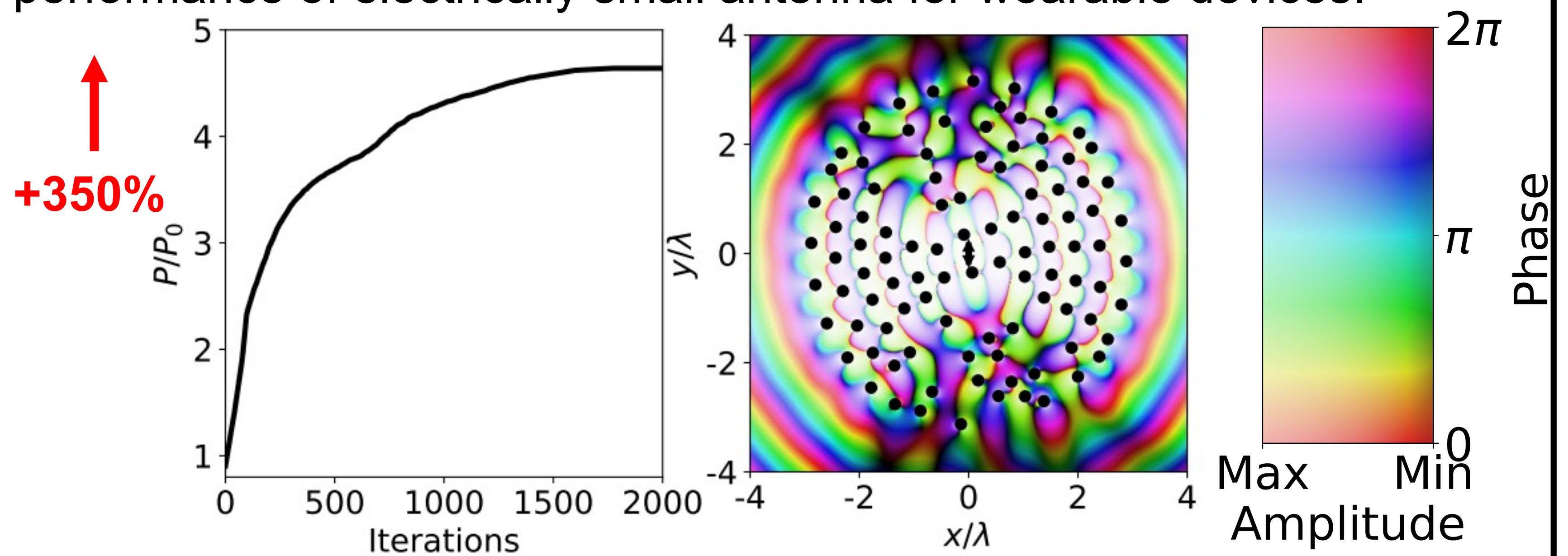
- One way to modify antenna functionality is to surround the antenna with several passive scatterers, manipulating the radiation. This is the idea behind the Yagi-Uda antenna, however this requires a method of deciding where to place the scatterers.
- Currently, the design of this kind of system relies either on numerically expensive full-wave methods, coupled to gradient descent or genetic algorithms [1], or on methods which neglect coupling between the scatterers. This coupling can often be key to optimal performance [2].
- **We have derived a new method for designing aperiodic scattering structures to manipulate antenna radiation [3]. Based on the discrete dipole approximation [4] our method is simple, fast and versatile.**

2. Results

We have used our new method to design aperiodic arrays of dipole scatterers to engineer several features of the emission from a small dipole source.

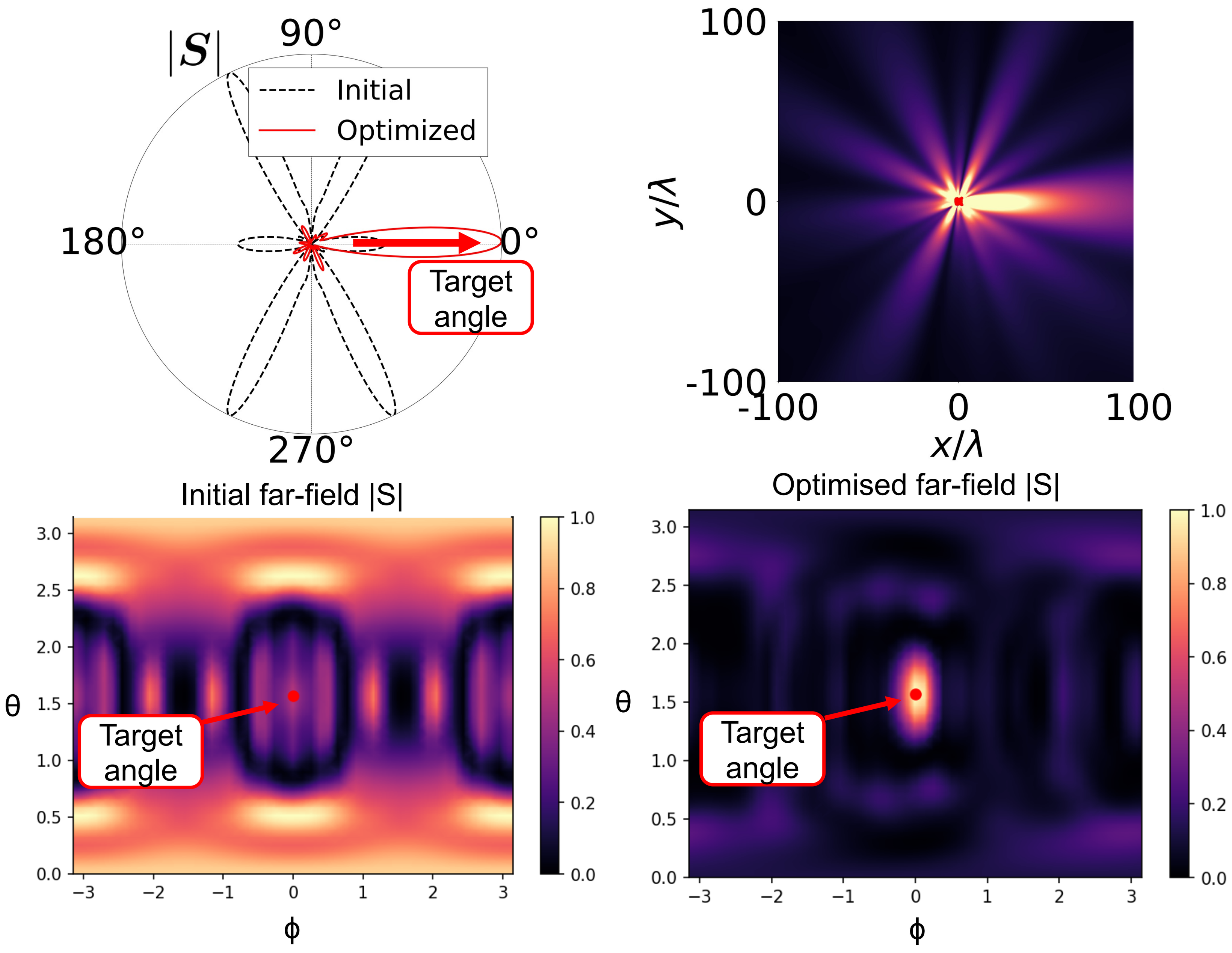
a) Power Emission (Efficiency)

Passively increasing efficiency might be useful for improving the performance of electrically small antenna for wearable devices.



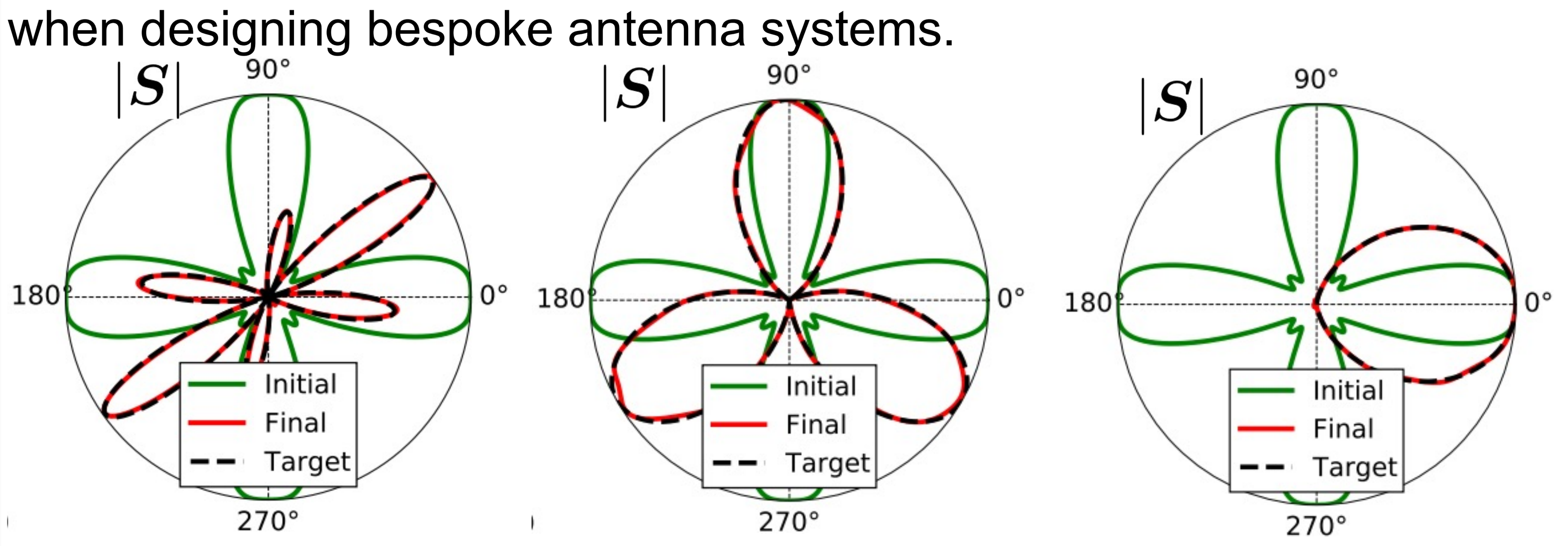
b) Directionality

Directing almost all radiated power into a single direction mitigates mutual coupling to emitters in other directions and offers an approach to lower the electromagnetic signature of a platform.



c) Shape of the Radiation Pattern

Being able to choose the exact shape of the radiation pattern is useful when designing bespoke antenna systems.



3. Outlook

We plan to extend our work to:

- Design **multi-functional devices**, where behaviour is different depending upon the wavelength or the polarisation of the emitter.
- **Engineer the bandwidth** of devices.
- Manipulate other wave scattering effects, such as **scattering cross-sections**.

References

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