Abstract

The main topic discussed in this dissertation is the electromagnetic cloaking of conductive cylinders and the analysis of the field scattered by metasurface cloaked cylinders. Among the different cloaking techniques, here the mantle cloaking is investigated. This method is based on the scattering cancellation approach and it aims to reduce (ideally to annul) the field scattered by an object such that the total field surrounding the object resembles the incident field pattern. To do so, the object is covered by a metasurface coating layer which consists of a periodically repeated metallic pattern, printed on a dielectric layer. The latter is necessary in the cloaking of conductive structures to avoid short circuits between the cylinder and the metasurface metallic pattern.

Electromagnetic cloaking can find application in the reduction of interference between nearby antennas, or of disturbances introduced by obstacles presents in the proximity of an antenna, such to avoid interference and distortions of the antenna radiation pattern.

The dissertation presents a comprehensive and deep investigation of the mantle cloaking method. In the first part, the main focus is the theoretical analysis of the scattering by a metasurface coated cylinder. For this purpose, the metasurface is modelled as a surface impedance boundary condition at the object-background interface. The scattered field is examined in terms of harmonic composition, and a great attention is given to the computation of the scattering coefficients, which are a measure of the presence of a specific harmonic in the total scattering. In a first time, a homogeneous value of surface impedance is considered, and a closed formulation to express the scattering coefficients is derived. From this formulation, the surface impedance condition which annuls one harmonic of the scattered field is computed in a closed form, valid also beyond the quasi-static limit.

Moreover, the surface impedance condition that leads to a minimum of the scattered field is investigated, with particular focusing of non-electrically small

structure. Indeed, since the initial development of cloaking devices, numerous studies addressing different aspects of the cloaking problem have been proposed in literature, however, the cloaking beyond the quasi-static limit is still challenging, especially with the use of passive metasurface coatings.

In this framework, a possible solution to address this problem is proposed by using a single layer passive metasurface. It is found that, with an appropriate choosing of the dielectric layer properties, and with the use of an inductive surface impedance, a partial reduction of the scattering can be obtained with a homogeneous metasurface.

The analytical results are then applied to the design of a practical metasurface cloaking. An example of cloaking for electrically small structure is given, and then it is adapted to the cloaking of cylinders with radius comparable with the wavelength of the incident field. Moreover, the effect of the metasurface conformal shape on the scattering reduction is investigated.

In the second part of the thesis, the use of an inhomogeneous surface is investigated with the aim of improving the cloaking effect. Two inhomogeneous metasurfaces are presented based on the the combination of unit cells with same shape but different dimension. Both metallic square patch and strips are considered as unit cell and it is shown that with a specific arrangement of the unit cells, a further increase of the cloaking bandwidth and of the scattering reduction can be obtained.