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# Advancing wavefront shaping with resonant metasurface

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In metasurface design, the use of look-up tables based on a local periodicity approximation have been traditionally employed, but can result in sub-optimal designs due to lack of consideration of near-field coupling effects, which are particularly important for resonant systems. This paper explores the benefits of taking into account near-field coupling while optimizing non-local resonant metasurfaces to enhance their performance for wavefront shaping, including the state-of-the-art Huygens's metasurface.

## Summary

Metasurfaces are two-dimensional planar structures constituted of sub-wavelength sized elements that can alter electromagnetic wave properties, including phase, amplitude, and polarization. Metasurfaces are generally locally approximated by periodic structures around each nano-element. This approximation allows the use of the look-up tables to design them, consisting in simulating the optical response of isolated nano-elements and placing them according to a phase profile given by the generalized Snell's law. In highly resonant structures the meta-atoms are not isolated and their response may depend on their neighbors, making the local periodicity approximation irrelevant. In our previous work, we exploited the benefits of global optimization coupled with full-wave solver to significantly improve the performances of metasurfaces [2, 3]. The present work considers resonant configurations including the state-of-the-art Huygens's metasurfaces where the apparition of collective resonances [4] makes the local periodicity assumption obsolete. We use Kriging-based Bayesian optimization as it is well suited for expansive black-box function and can be adapted to handle fabrication uncertainty [5] and multi-objective problems [3]. We illustrate our methodology in the case of a meta-deflector taken from ref. [1]. Figure 1 shows the deflection efficiency of both the optimized and the look-up table design, where simulations are performed using the software suite *DIOGENeS* [6] developed at *Inria Sophia Antipolis*. The drastic improvement of efficiency highlights the need for optimizing the whole period at once in the case of highly resonant structures.

## References

- [1] A. Özdemir et al. Polarization independent high transmission large numerical aperture laser beam focusing and deflection by dielectric huygens' metasurfaces.
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- [3] M. M. Elsaywy et al. Multiobjective statistical learning optimization of rgb metalens.
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- [6] *DIOGENeS : A Discontinuous-Galerkin based software suite for nano-optics*. <https://diogenes.inria.fr/>.

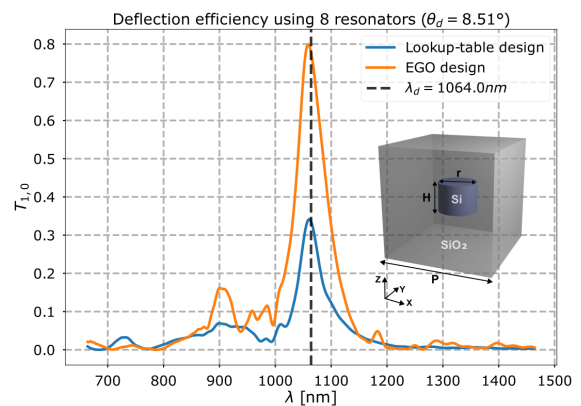


Fig. 1. Deflection efficiency of metagratings obtained with a look-up table and with global optimization. The inset indicates the schematic representation of the structure under consideration [1]