Optical properties of surface plasmon polaritons launched via metallic grooves

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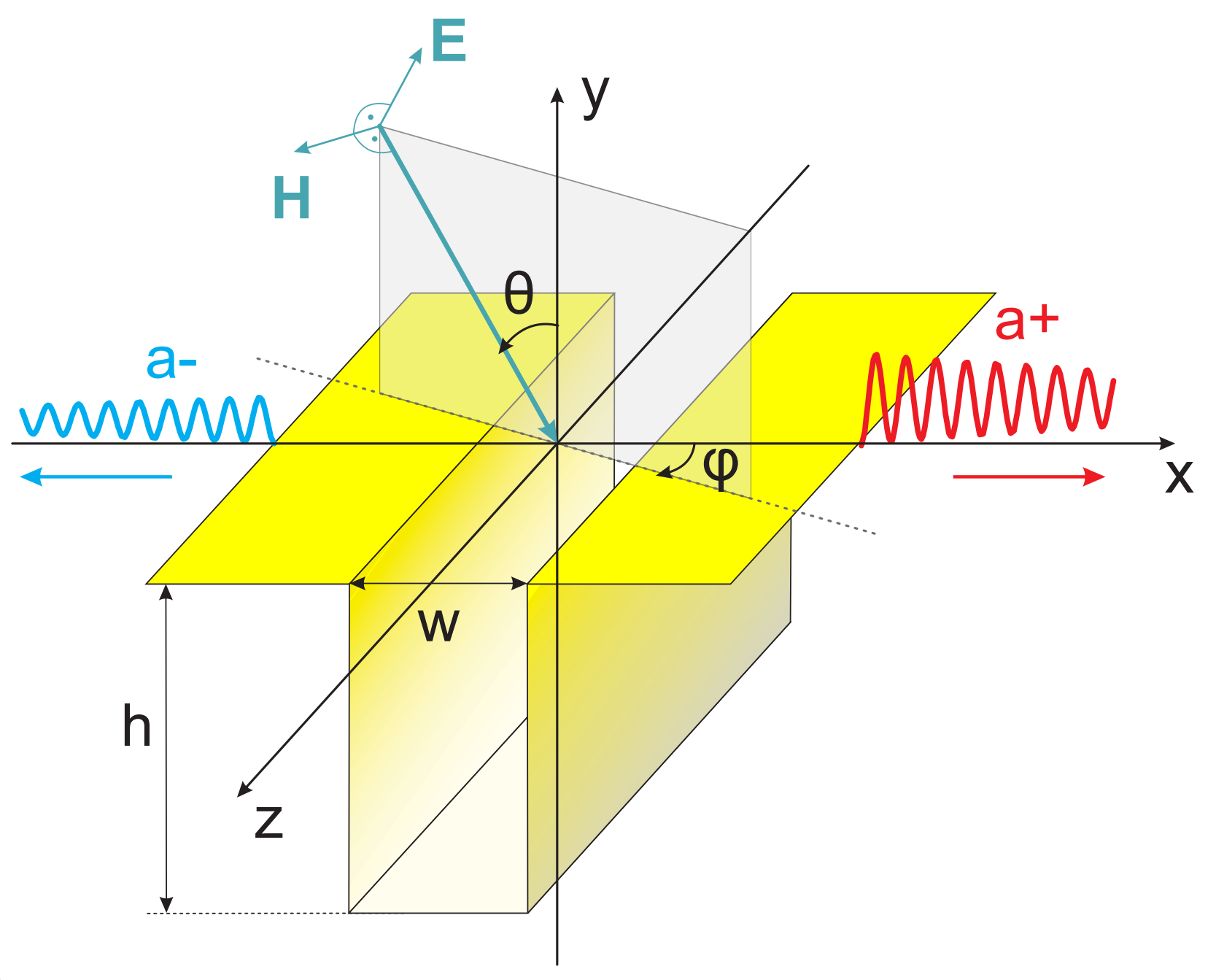
Introduction

The optical properties of surface plasmon polaritons (SPPs) including field enhancement, subwavelength field confinement, and high sensitivity to the structure of the dielectric/metal interfaces have been exploited for numerous applications ranging from sensors to optical integrated circuits [1]. One of the key requirements for building a SPP based device is a controllable and efficient conversion of the free-space light to the SPPs. In the last two decades, isolated nano-sized slits and grooves perforated in metal films have been utilized as efficient SPP launchers in novel, compact SPP based devices, where high density of integration, amongst other properties, plays an important role [2].

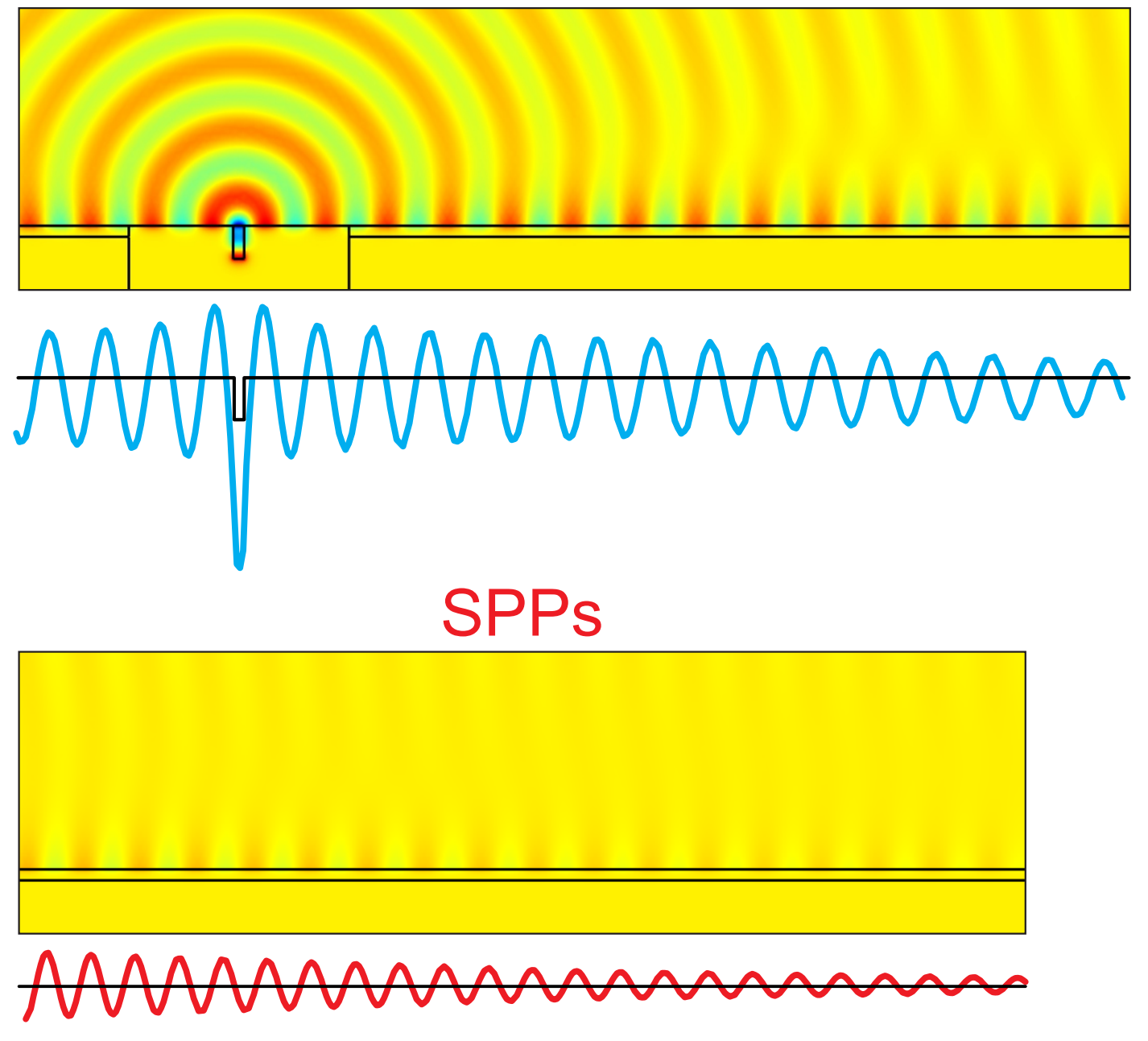
In this work we investigate the SPPs launched on a metal grove using finite element method numerical simulations. In particular, we study the effects of various parameters such as grove shape and the incident angle on the properties of launched SPPs and the launching efficiency. The launching efficiency of the SPPs exhibits maxima (minima) whenever the scattering into SPPs is in constructive (destructive) interference with the scattering arising via the groove mode excitation. The extremal points position is found to be dependent on the groove shape and virtually independent on the incident angle. We show that the rotation of the plane of incidence modifies the SPP wavevector by introducing an offset between the amplitude and phase fronts of the launched SPP. The former becomes slanted with respect to the Poynting vector, while the latter remains perpendicular to it.

Geometry

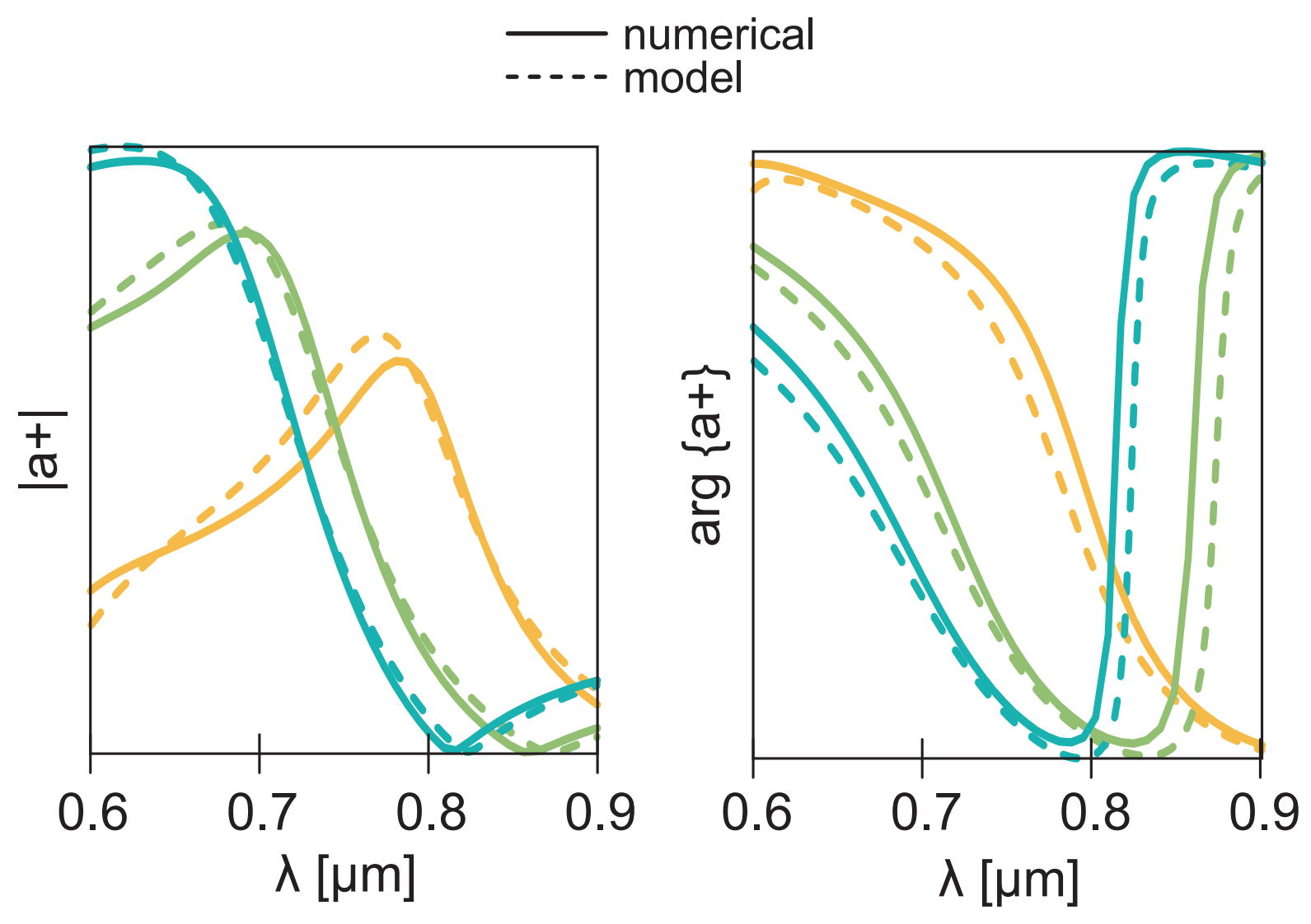


Scattered fields

Cylindrical waves, groove modes, SPPs

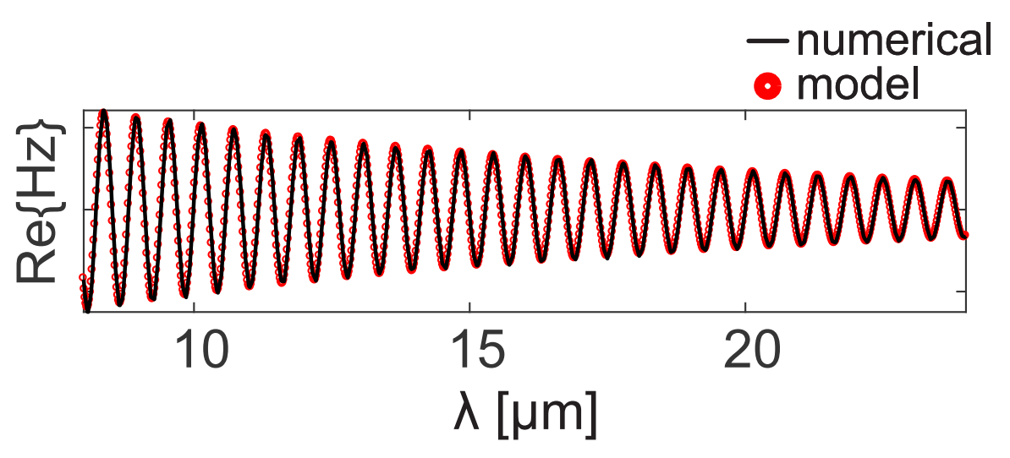


Scattering/Launching efficiency



a+ and a- are calculated using CMM and FEM

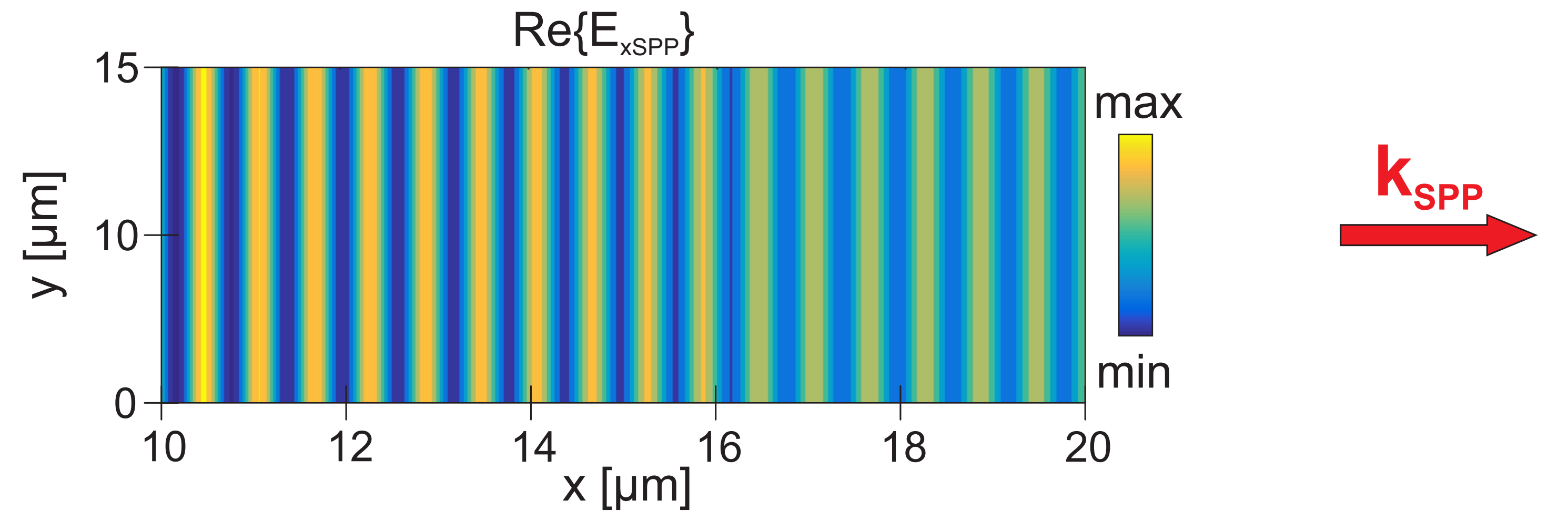
Scattering coefficient extraction



a+ and a- are evaluated by dividing the SPP H field in the presence of the groove (FEM) and the SPP H field of a flat interface (analytical)

SPPs

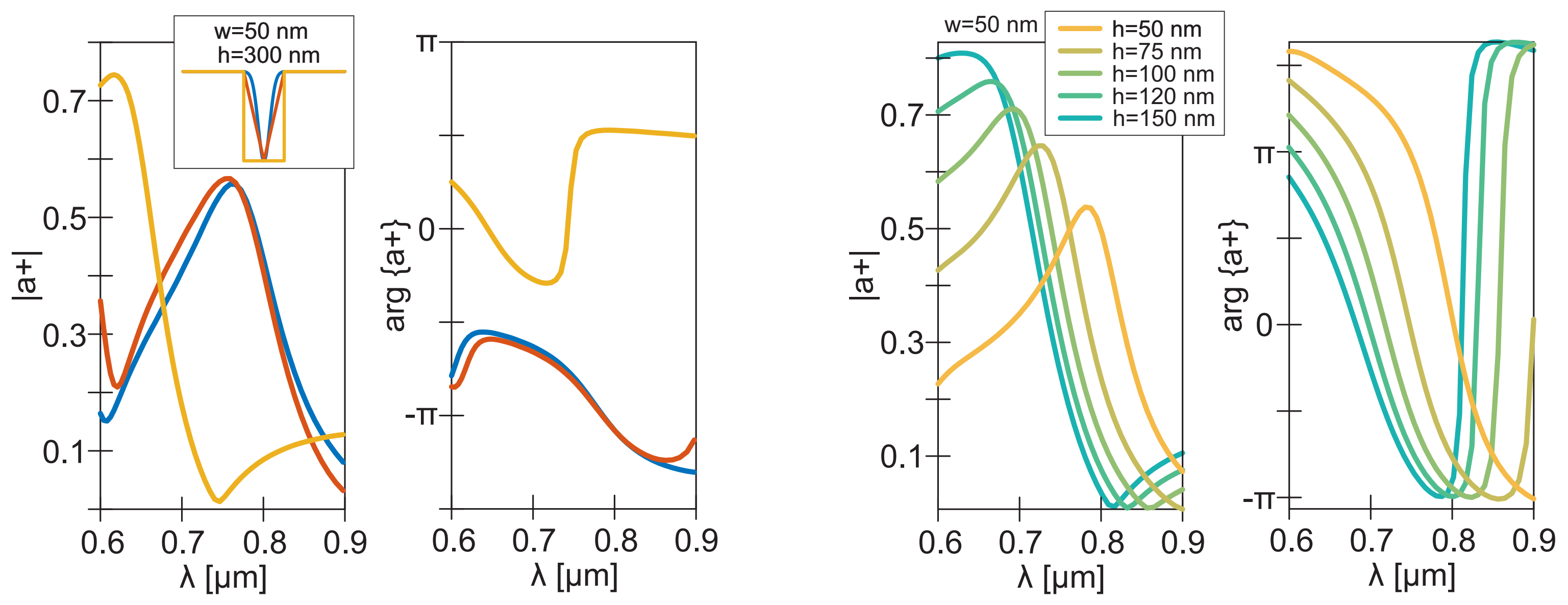
Fields and wavevectors



(x,z) plane at y=1 nm, θ=65°

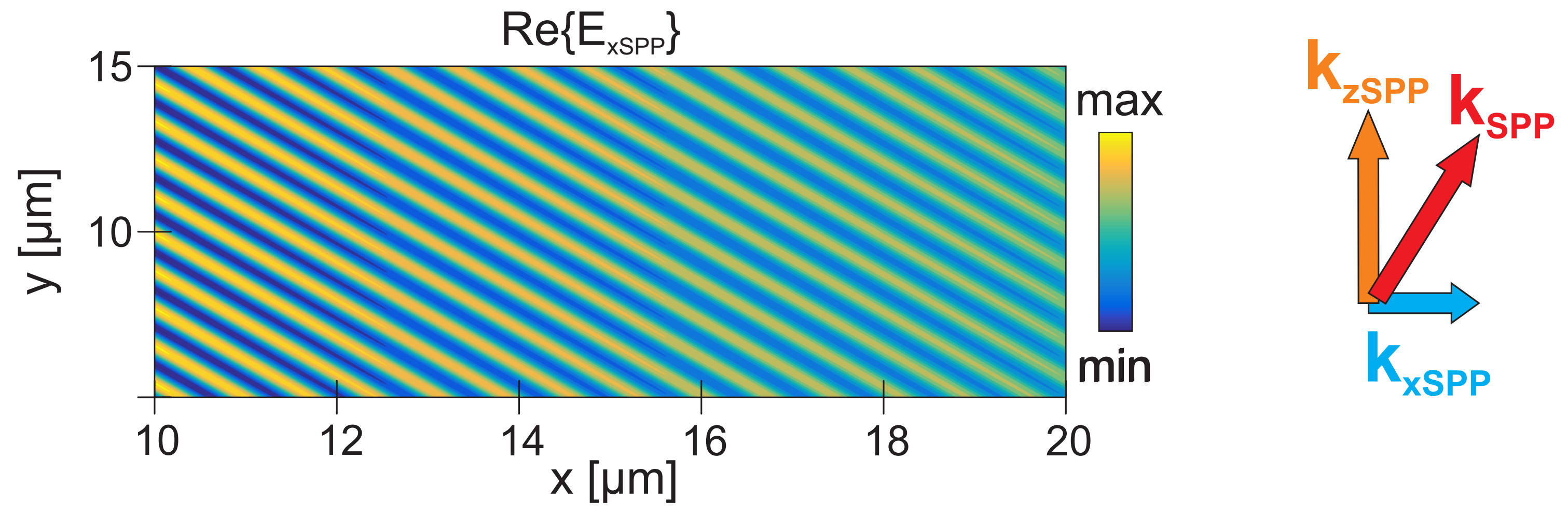
φ=0 SPPs, $k_{zSPP}=0$, $k_{xSPP} \in C$, $k_{ySPP} \in C$

Scattering coefficient tuning - groove shape and height



Oblique SPPs

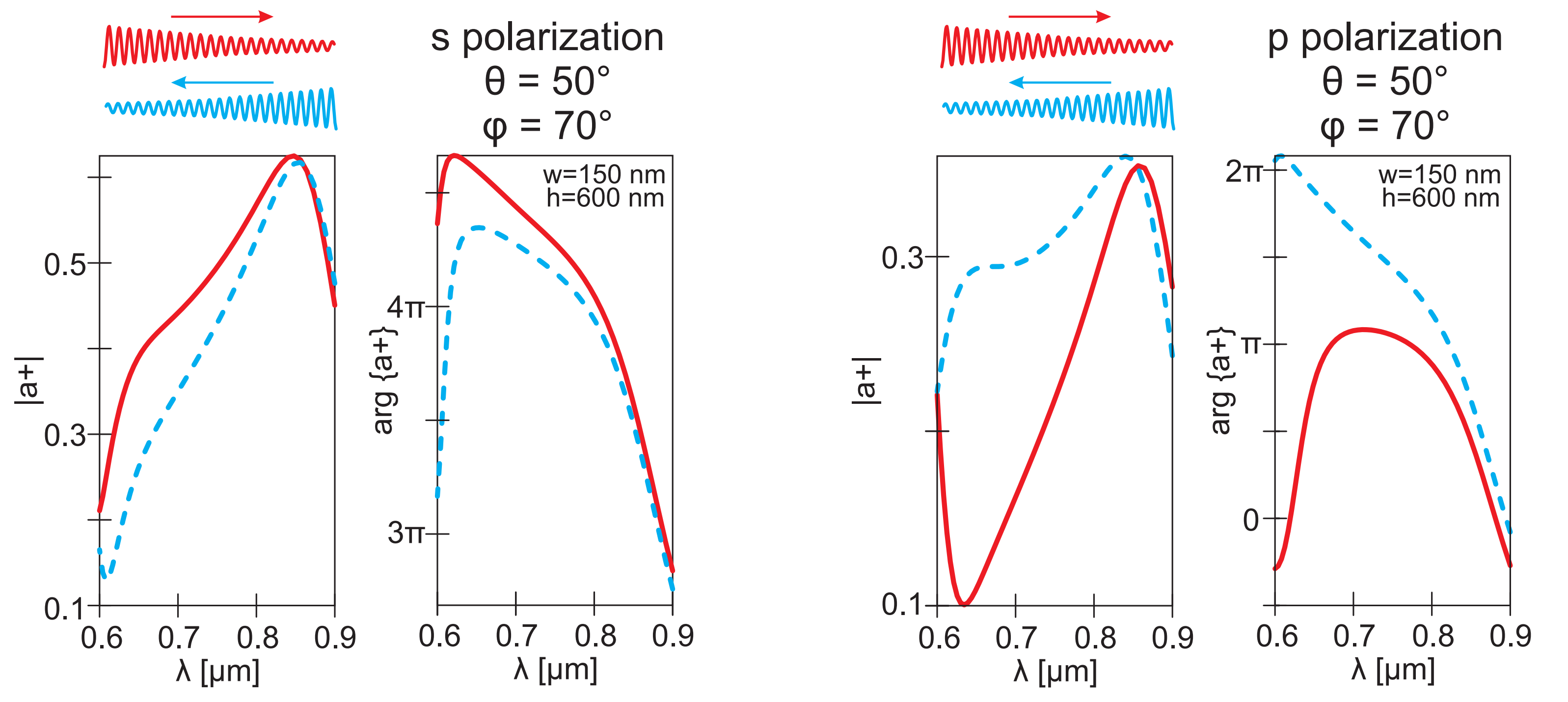
Fields and wavevectors



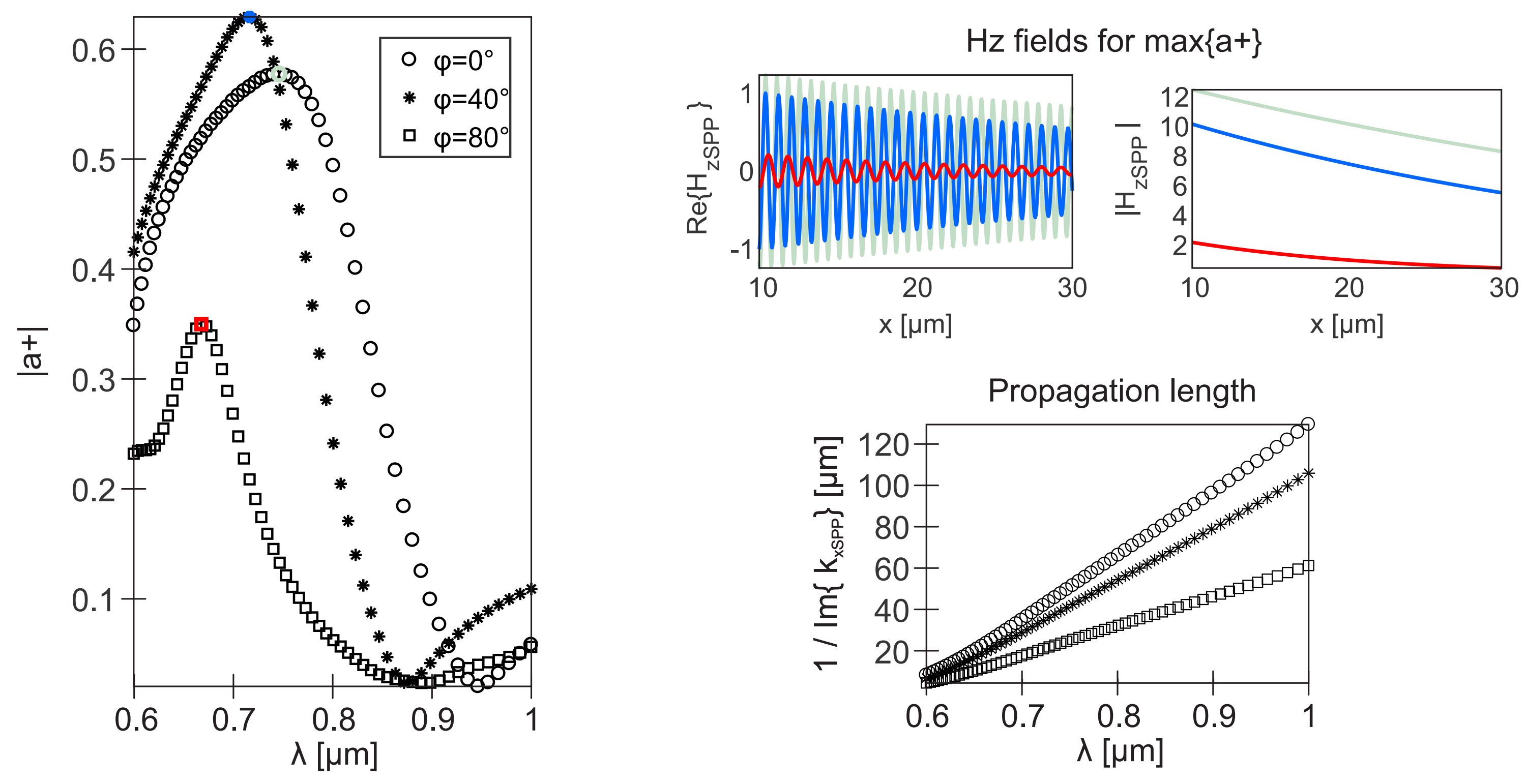
(x,z) plane at y=1 nm, θ=65°

φ=40° SPPs, $k_{zSPP}=k_{zINC} \in R$, $k_{xSPP} \in C$, $k_{ySPP} \in C$

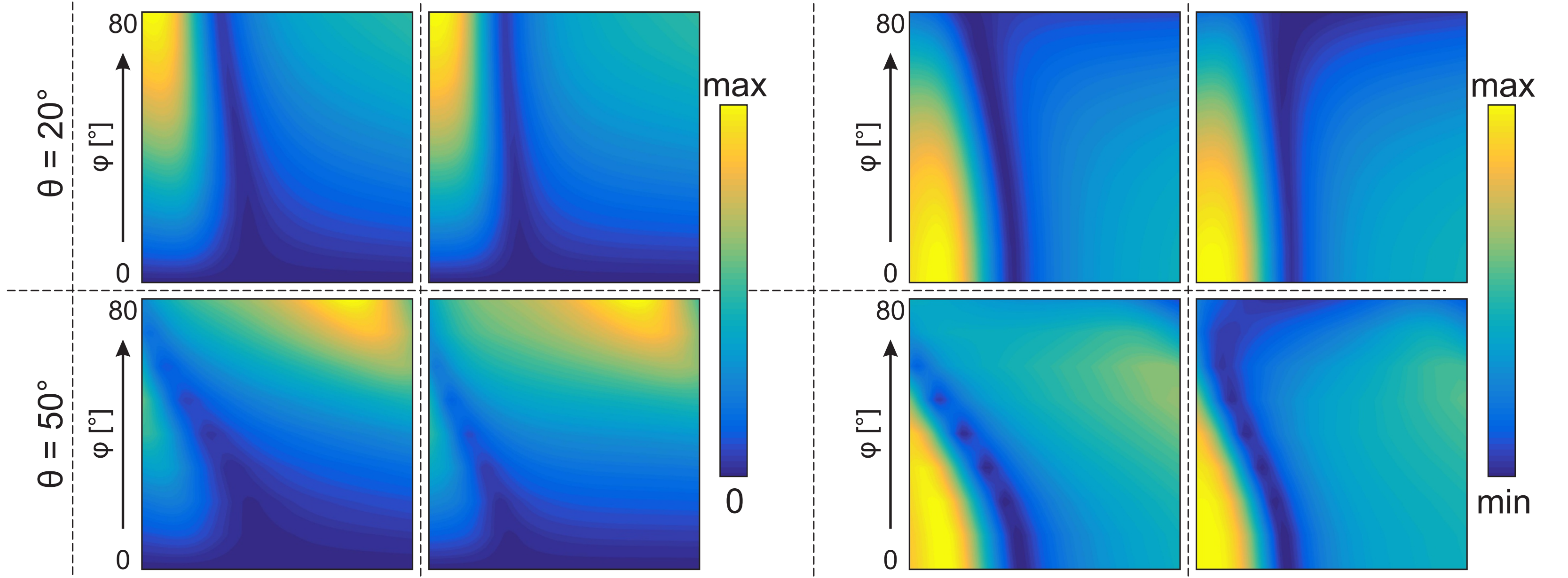
Scattering coefficient tuning - polarisation and angles I



SPPs Vs Oblique SPPs



Scattering coefficient tuning - polarisation and angles II



References

[1] W.L. Barnes, A. Dereux, T.W. Ebbesen, Nature 424, 824 (2003)

[2] H. J. Lezec, A. Degiron, E. Devaux, R. A. Linke, L. Martin-Moreno, F. J. Garcia-Vidal, T. W. Ebbesen, Science, 297, 820 (2002)

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