Modeling and simulation of interface problems in plasmonic metamaterials

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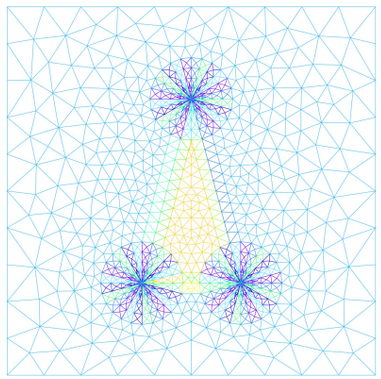
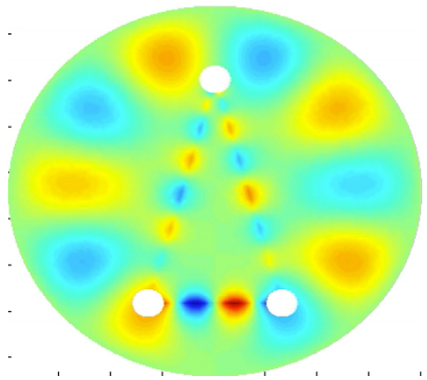
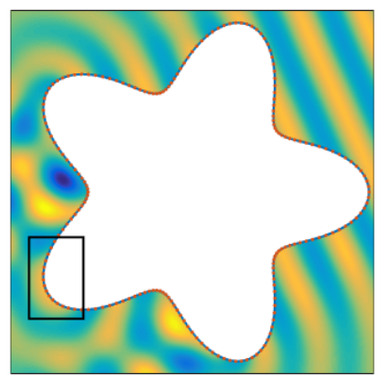
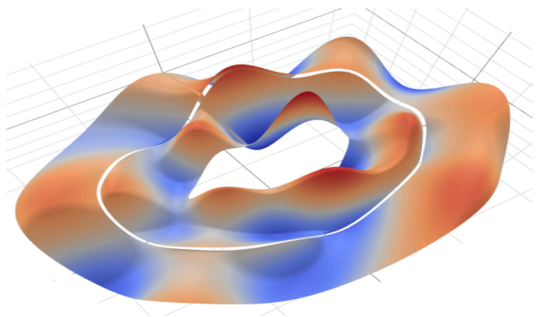
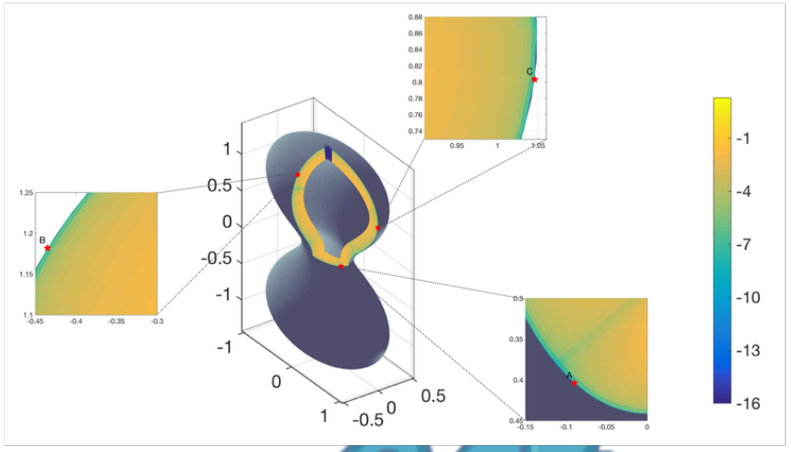










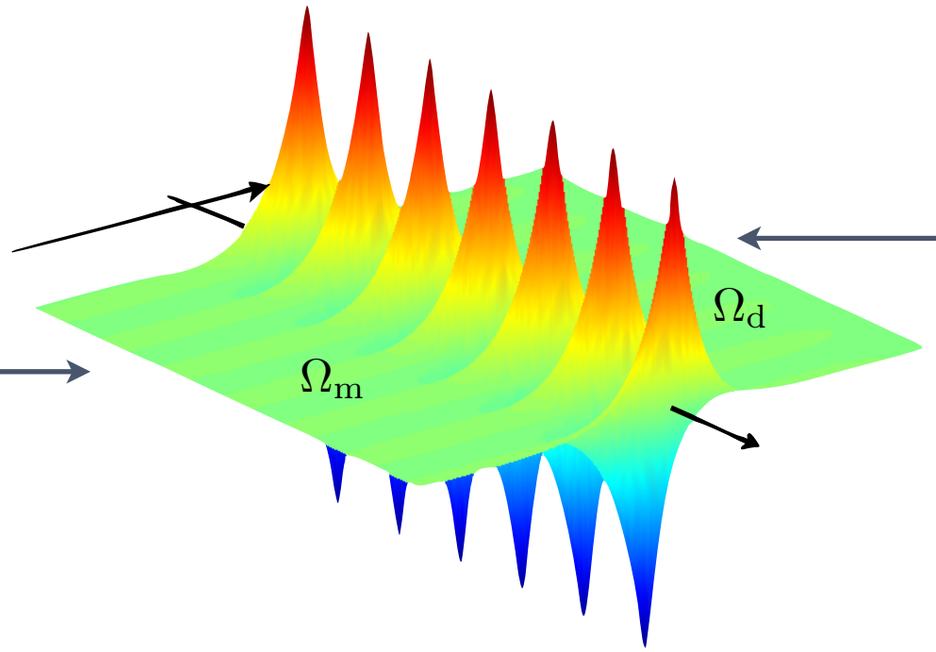
Modeling Surface Plasmons

Surface plasmons are confined electromagnetic waves at the interface between a negative material and a positive material.

Negative material

$\varepsilon < 0$

$\mu > 0$



Positive material

$\varepsilon > 0$

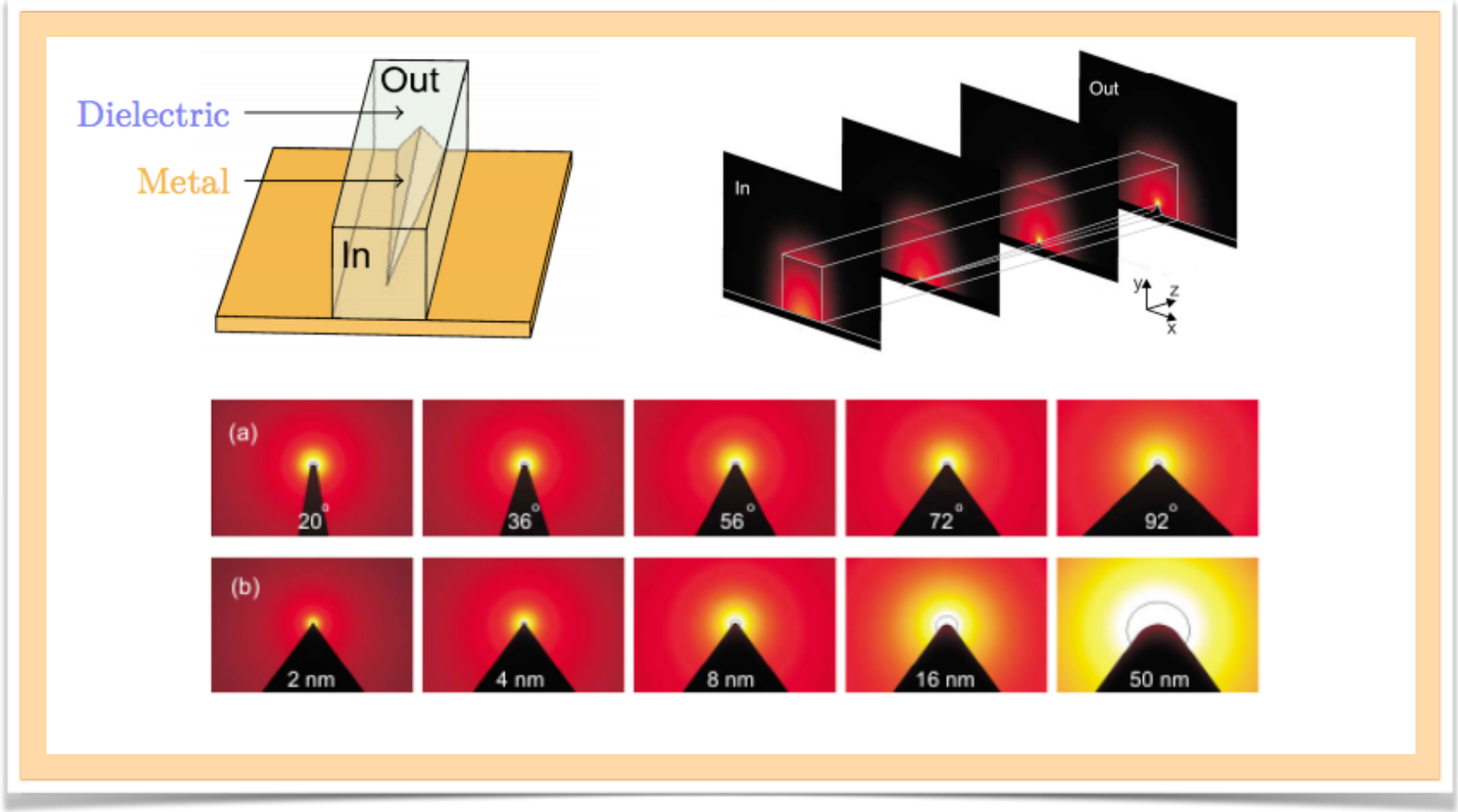
$\mu > 0$

Negative materials:

metals at optical frequencies (gold, silver, etc.), and negative index metamaterials

Applications

Guiding or confining surface plasmons in nanophotonic devices reveals a great interest in order to overcome the diffraction limit (optical antennas, high resolution imaging in near field, ...).



O'Connor et al., (2009)

However these waves are very sensitive to the geometry of the interface between the two media.

Need for efficient numerical methods to avoid inaccurate predictions of measurements.

Multi-scale problems

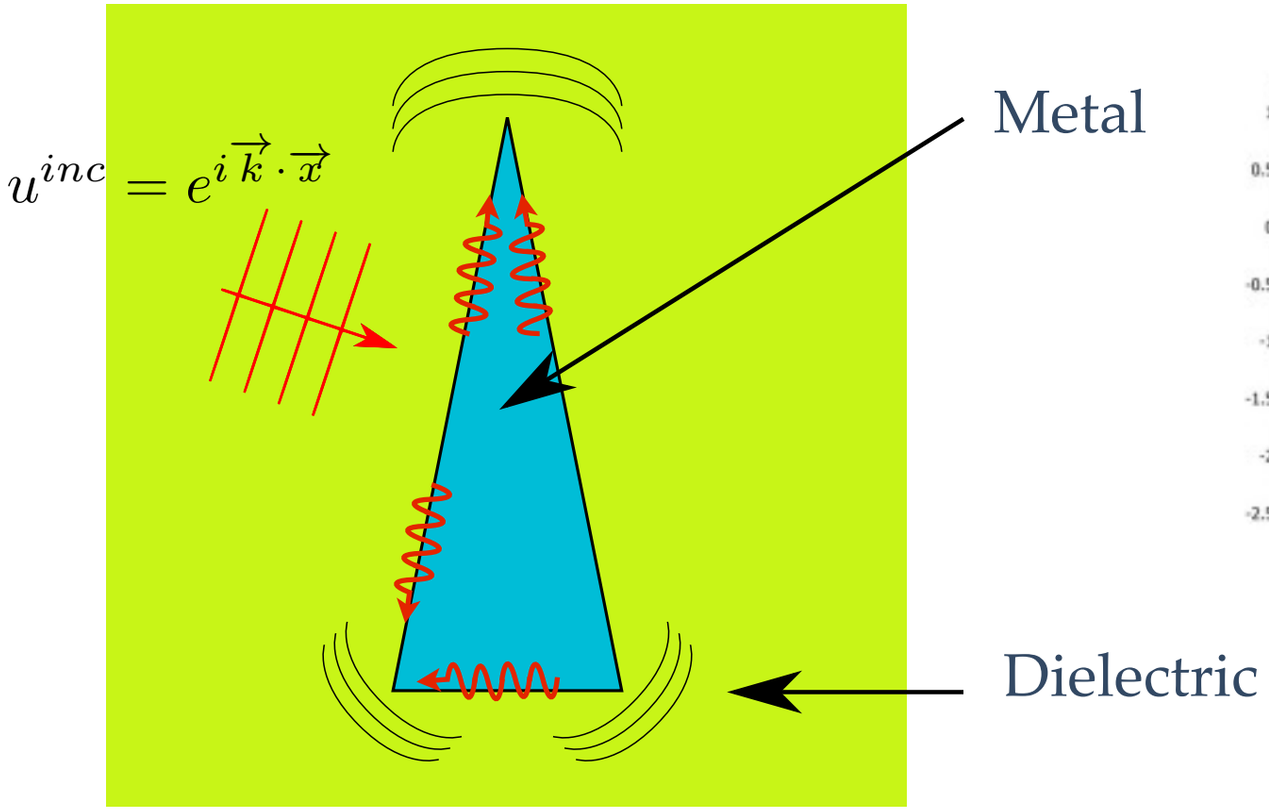
Challenges:

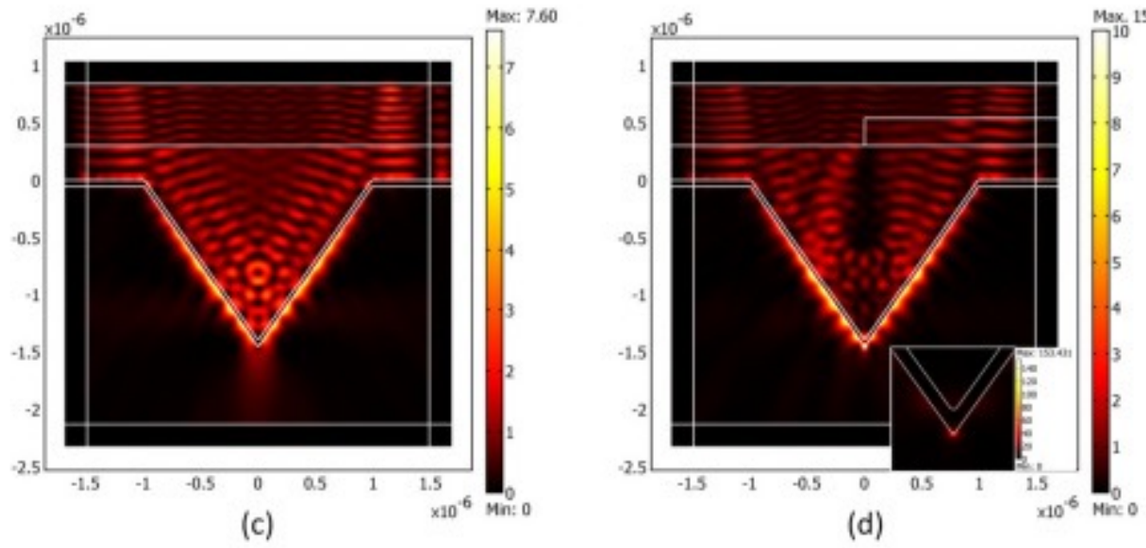
-dealing with PDEs with sign-changing coefficients (mathematical challenges)

-for non regular geometry singular behaviors appear

-phenomenon of nanofocusing at sub-wavelength (multiple scales to handle)

-model dependent (linear effects, non linear, multi-layered domains)



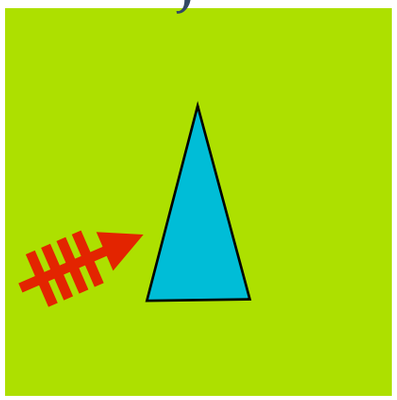


Garoli et al., (2015)

Goal: develop accurate methods that take into account the multiple scales inherent.

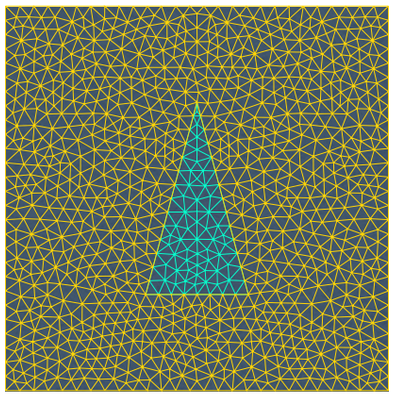
Research overview: Time-harmonic, 2D problems, linear Models (Drude)

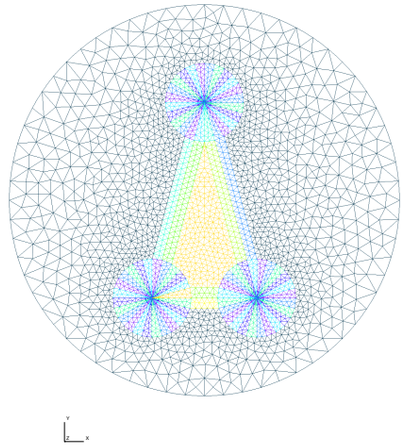
Project I

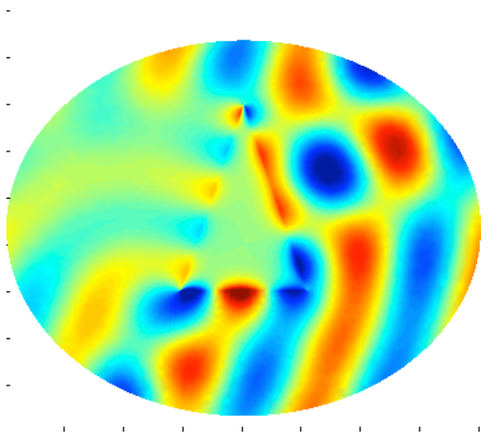


Variational-based approach

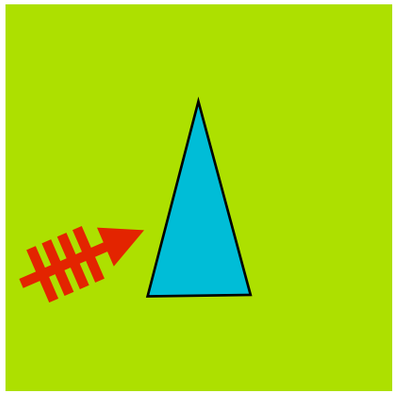
(FEM capturing multiscales)





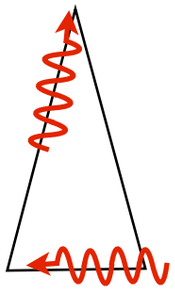


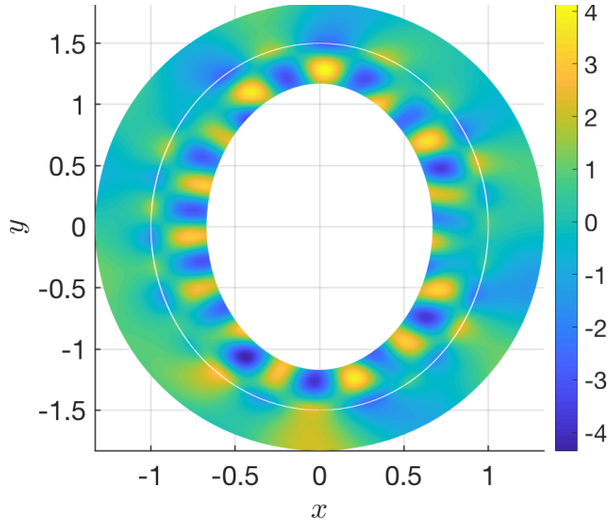
Project II



Multiscale asymptotic boundary integral approach

(Layer potentials with deferred correction)





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Future work:

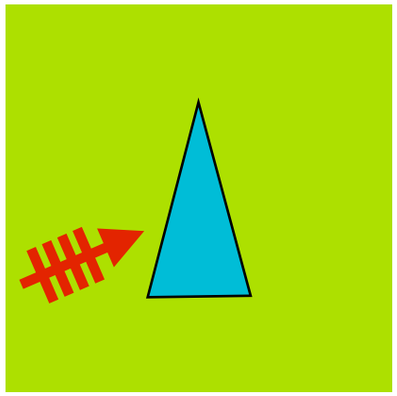
-arbitrary 2D geometries

-2,5D and 3D problems

-other models (Lorentz, Hydrodynamic Drude, Kerr, Duffing, multiferroics)

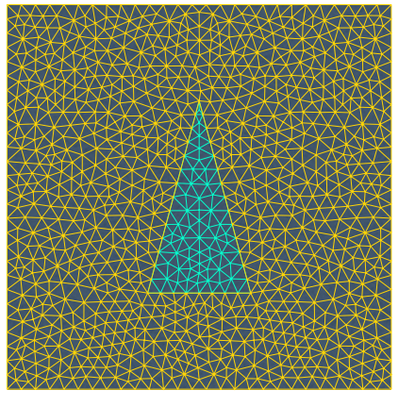
Research overview: Time-dependent, 2D problems, linear Metamaterials

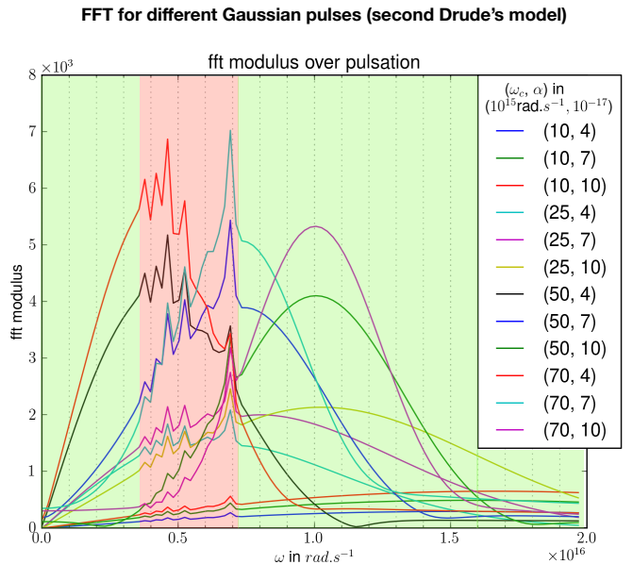
Project III



Limiting amplitude principle

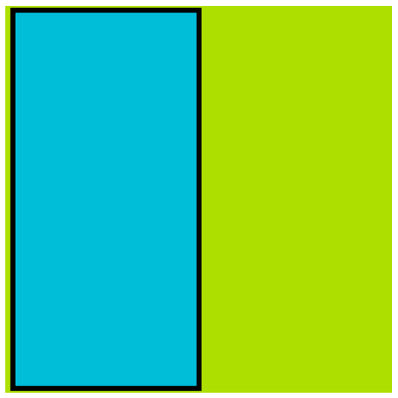
Time-dependent
VS Time-harmonic



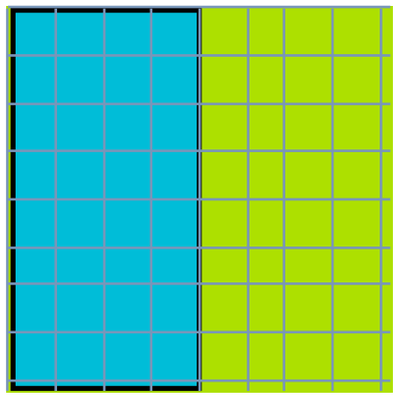


Future work:
-3D problems
-other models (Lorentz, Hydrodynamic Drude, Kerr, Duffing, multiferroics)

Project IV



High Order FDTD
Maxwell in metamaterials



Future work:
-interface
-3D problems
-other models (Lorentz, Hydrodynamic Drude, Kerr, Duffing, multiferroics)

References

Project I

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Project IV

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