Maximal Violation of Kirchhoff's Law in Planar Heterostructures (DOI:)

–code package–

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2 Introduction

This code serves as the numerical package for the publication: "Maximal Violation of Kirchhoff's Law in Planar Heterostructures" ... Details relating to the underline physics can be found in the supplementary material . The path of the files is indicated by ".../...", and the variables are referred to by variable. All the numbers are in SI units. This code is developed based on the transfer-matrix method for planar heterostructures. It is valid for:

1. incidence wave vectors both within and beyond the light cone i.e. decaying and propagating waves.
2. both reflective and transmissive geometry i.e. with and without a back reflector.
3. material representation with a full tensor $\boldsymbol{\epsilon}$ for every layer i.e. each layer of material can be characterized by 9 tensor elements ϵ_{ij} where $i\,j \in \{x, y, z\}$.

3 Configure the code

The code should work by directly downloading and running on your local computer. To customize the code, please follow the steps below.

3.1 Choose geometry

One needs to define whether the entire structure is transmissive or reflective by modifying the variable geometry_config. The reflective structure is represented by "R", which means the desired structure has a perfectly reflective mirror at the bottom. The transmissive "T" means the desired structure is directly in contact with air ($n = 1$) at the bottom layer. This can be achieved via modifying line 11 in "main.m".

```
1 geometry_config="R";
```

3.2 Choose the number of layers

Define the number of layers in "main.m" line 37 by d_arr as the following

```
1 d_arr=[1e-6,3.2e-6];
```

where the length of the d_arr array represents the number of layers and each array value is the thickness of the corresponding layer. For example, d_arr(1) is the thickness (1e−6 m) of the first layer of material (the first interaction material with the incidence light coming from the air).

3.3 Define the ϵ for each layer

The ϵ for each layer is defined in "my_function/material_select.m" within the "switch" function as the following

```
switch slab_ID
    case 1
       dia=9+0.3*1i;
       off_dia=12*1i;

        meps=C.eps0.*[dia,0,off_dia;...
                      0,  dia,  0; ...
                    -off_dia,0, dia];
        meps=euler_R*meps/(euler_R);

     case 2
       n_die=1.5;
       meps=C.eps0.*[n_die,0,0;...
            0,n_die,0;...
           0,0,n_die].^2;
       meps=euler_R*meps/(euler_R);

% if there is a third layer add
%case 3
%....

    otherwise
        fprintf("no material defined. make sure layer agrees with material number")
end
```

Here two materials are defined in the above example. case 1 corresponds to ϵ of material 1 with the thickness d_arr(1). It is important to notice that the number of materials (number of the case) must be $\geq$ than the size of d_arr. If there are say 5 cases in the material definition and the size of d_arr is 2, then the final heterostructure defined is material 1 with d_arr(1) then material 2 d_arr(2). Materials 3-5 will not be used.

4 Run and save the data

With the above steps done, by opening the "main.m" and clicking run in MATLAB, the code should work directly. The output files will be automatically saved in the path defined in main.m file line 43 filename. The default saving path is "my_output/test_d10.00". If you run the code directly after downloading, you should see the following four figures.

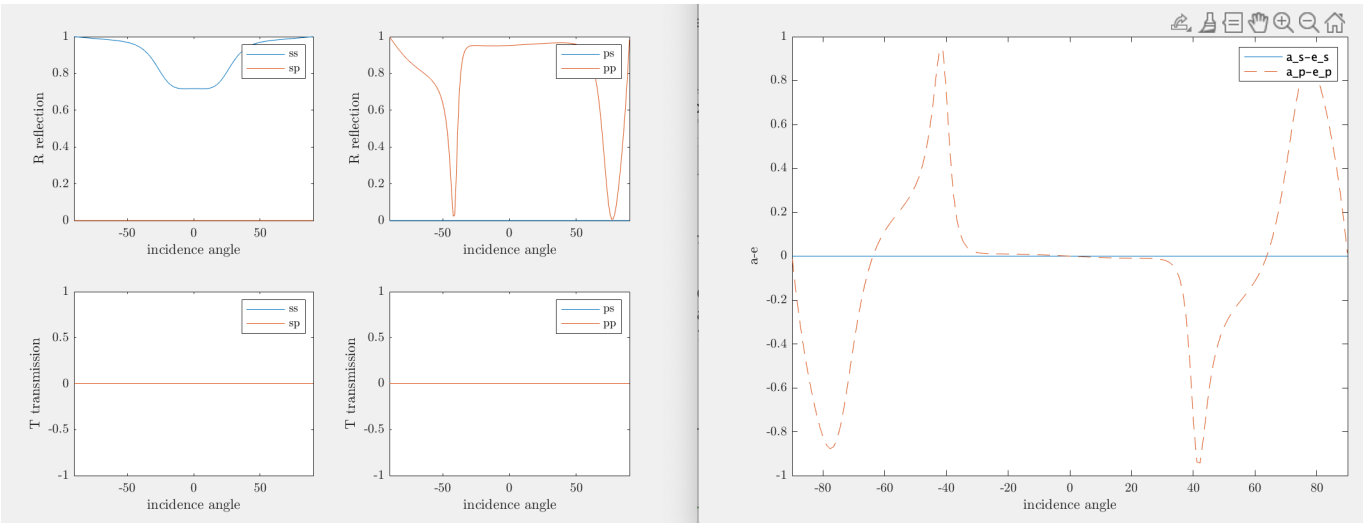

Figure 1: Left: reflection and transmission. Right: nonreciprocity (η) for p- and s- polarized light. The polarization is indicated as subscripts. $\eta = a - e$, where "a" represents absorption and "e" represents emission.

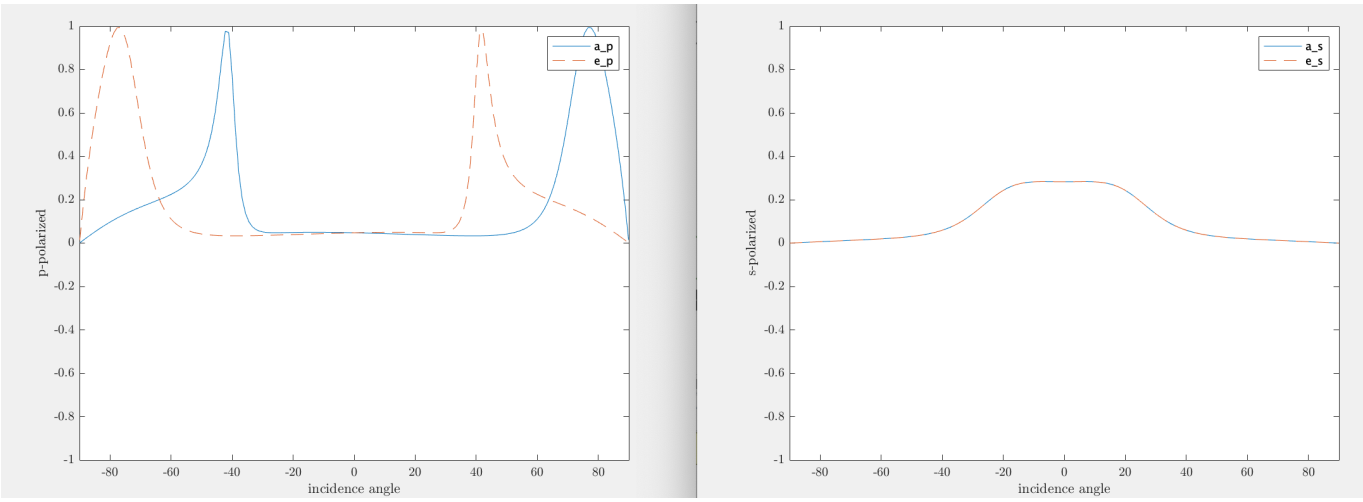

Figure 2: Absorption “a” and emission “e” for p-polarized (left) and s-polarized (right) fields.

Enjoy life and happy coding ♡. Any questions please address to

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