Benchmark

by comparison with other tools

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ComPhysics

Symbols and abbreviations used in E2M

Symbol	Meaning
L#	Layer index
T.	Thickness
λ	Wavelength
μ’	Real part of relative permeability
μ’’	Imaginary part of relative permeability
ε’	Real part of relative permittivity
ε’’	Imaginary part of relative permittivity
$\tilde{k}$	Normalized wave vector
GX#	G: Group index X: seperator meaning times #: Repetition num. for the group
θ	The azimuthal angle
φ	The polar angle
TE	Transverse Electric
TM	Transverse Magnetic
R	Reflectance
T	Transmittance
A	Absorptance (R + T + A = 1)
α	Thickness of a period
c	speed of light

- **Introduction**

In this benchmark document, we compare extracted results from E2M and other rigorous tools such as MIT MEEP and MIT MPB for reflectance spectrum and photonic bands.

Extracted results from comparisons show more accurate results of E2M as well known the high accuracy of TMM for analysis of 1D structure within limited investment of computational resources. However, as enough resources and computation time are allocated to MEEP and MPB, the results between E2M and those will be more identical.

Starting on the next page, three comparisons are described below.

1. Reflectance spectrum of a planar interface

2. Reflectance spectrum of two planar interfaces

3. Photonic bands of a 1D structure

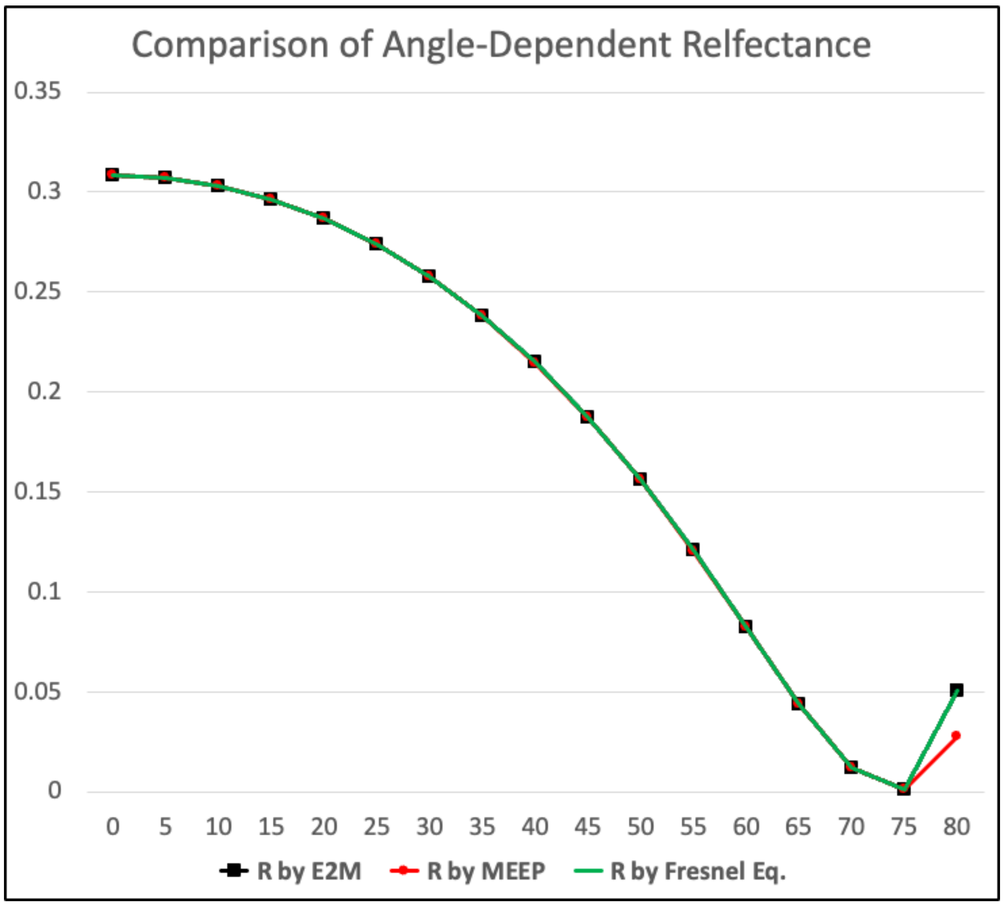
Comparison of the reflectance spectrum of a planar interface

The 1D layer structure used for this comparison is as a table below.

LayerInfo

L#	Name	Thickness [μm]	Wavelength [μm]	Group#	Repetition#
0	n=1	1.0	0.4~0.9939999999999954	0	1
1	n=3.5	1.0	0.4~0.9939999999999954	0	1

A Jupyter notebook file including a Python code for the calculation of the reflectance spectrum within the MEEP environment is uploaded on "https://comphysics.com/index.php/e2m-1d/" for users having interest to recalculation. Comparison result is as below figure.



Here, the x-axis means wave incident angles and the y-axis means the reflectance. From 0 to 75 degrees, the results among E2M, MEEP, and the Fresnel equation are identical. However, at 80 degrees, MEEP's result deviates from the other analytical results, at least within the applied simulation conditions. Of course, by pouring computational resources and time, we can get identical results among the three methods.

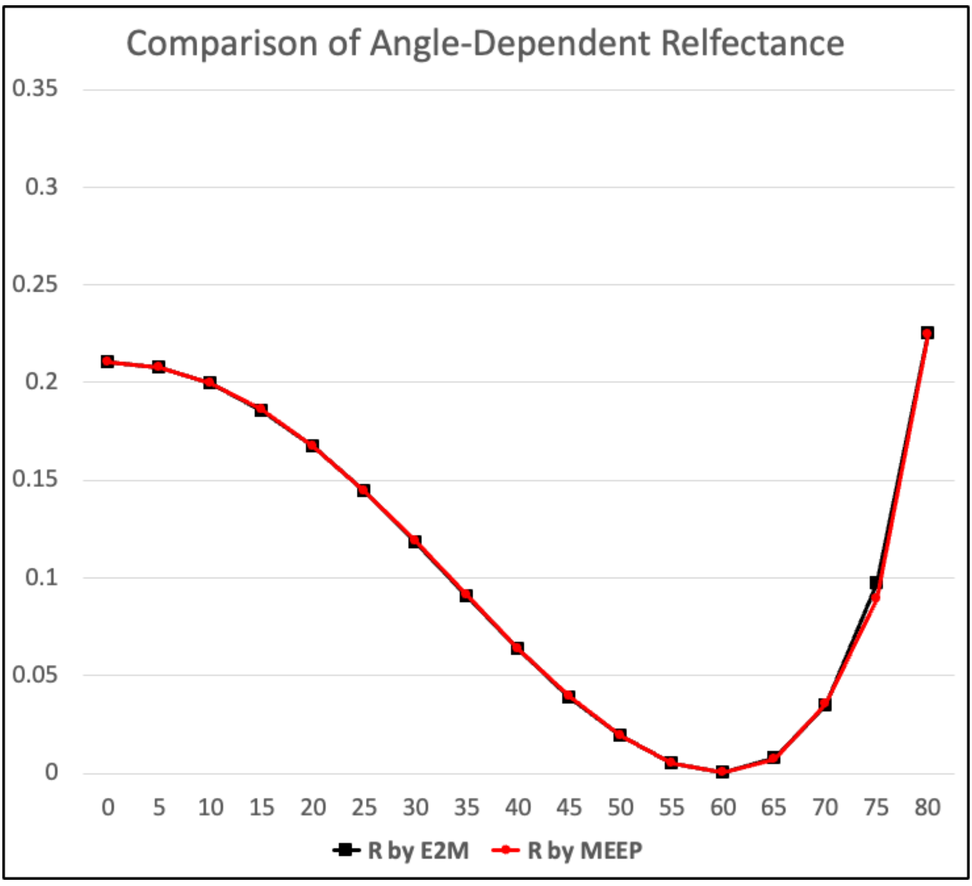
Comparing the reflectance spectrum of a structure that has two planar interfaces

The 1D layer structure used for this comparison is as a table below.

LayerInfo

L#	Name	Thickness [μm]	Wavelength [μm]	Group#	Repetition#
0	Vacuum	1.0	0.4~0.9939999999999954	0	1
1	n=2.5	0.6	0.4~0.9939999999999954	0	1
2	n=3.5	1.0	0.4~0.9939999999999954	0	1

A Jupyter notebook file including a Python code for the calculation of the reflectance spectrum within the MEEP environment is uploaded on "https://comphysics.com/index.php/e2m-1d/" page as the previous subsection. Comparison result is as the figure below.



Here, the x-axis means wave incident angles and the y-axis means the reflectance as identical with before. At the 75-degree point in the result, quite a high difference between E2M and MEEP is observed. Since TMM provides exact analytical precision for 1D systems with small computational resources, users may find a convenience for the exact analysis of 1D structures with this E2M.

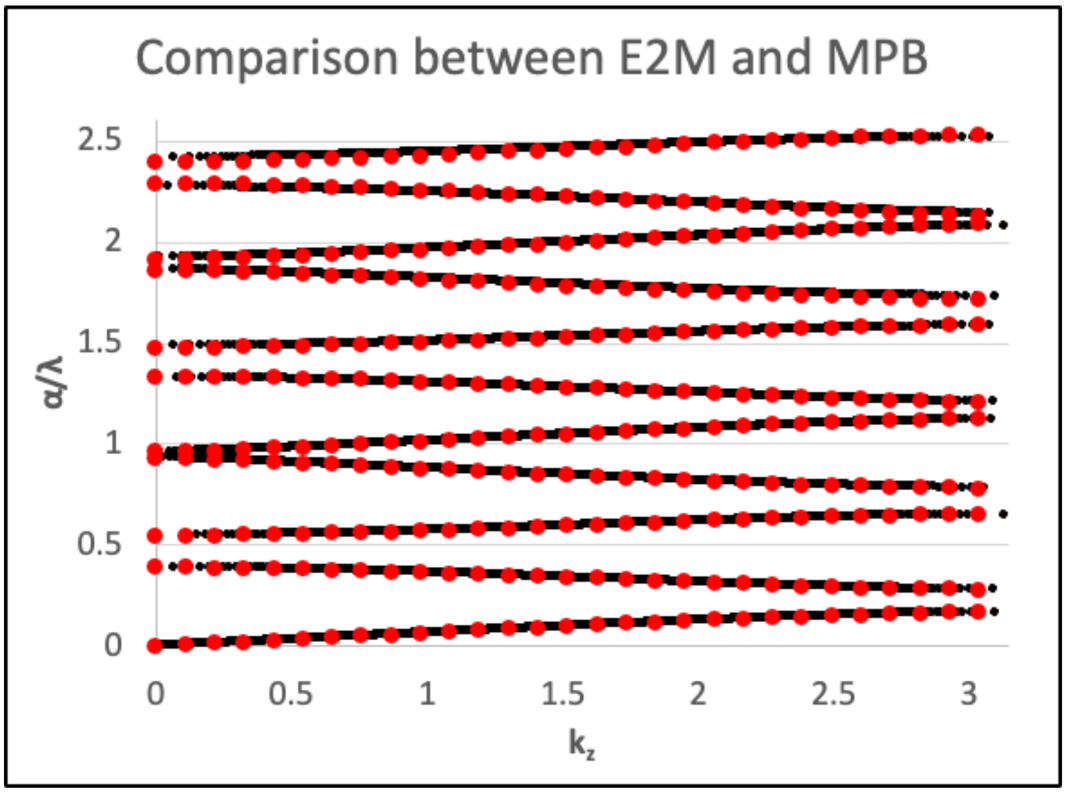
Photonic bands of a 1D structure

The 1D layer structure used for this comparison is as a table below.

LayerInfo

L#	Name	Thickness [μm]	Wavelength [μm]	Group#	Repetition#
0	n=1	0.5	0.00001~100000	0	1
1	n=3.25	0.5	0.00001~100000	0	1

A Jupyter notebook file including a Python code for the calculation of band structure is uploaded on "https://comphysics.com/index.php/e2m-1d/" as the previous subsection. The comparison result is as the figure below.



Here, black and red points show the results from E2M and MPB, respectively.

For the long wavelength points, the results of E2M and MPB are very similar to each other in this figure. However, as the wavelength range becomes shorter and shorter, the deviation between the two results is more easily distinguished, at least within the applied simulation condition.