Results

We compared the first five modes of simulation result with the theory result [1] as below:

For all TE modes, we compare the dashed line (magnetic field line) in theory with our result plot of Hz. For all TM modes, we compare the solid line (electric field line) in theory with our result plot of Ez.
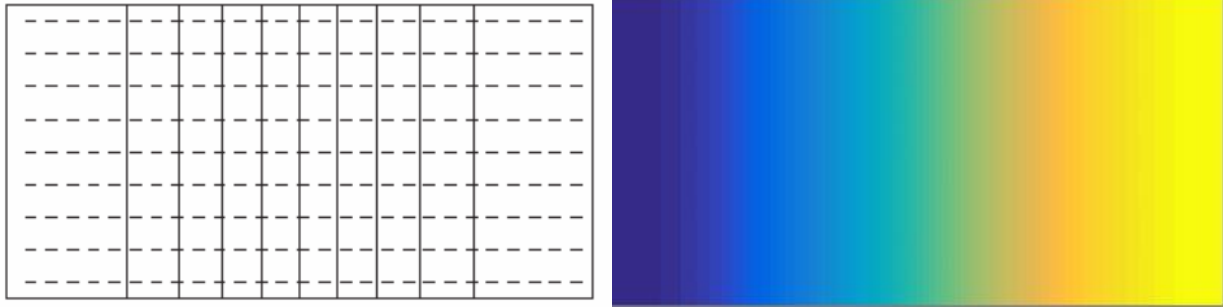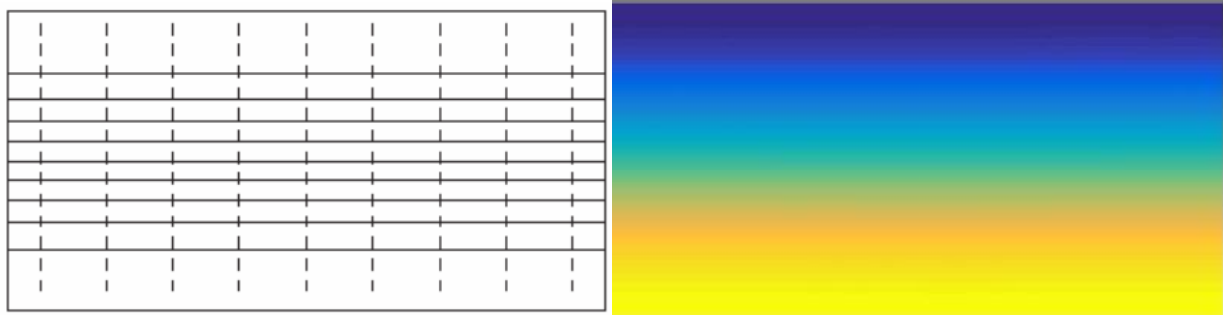
Rectangular waveguide:

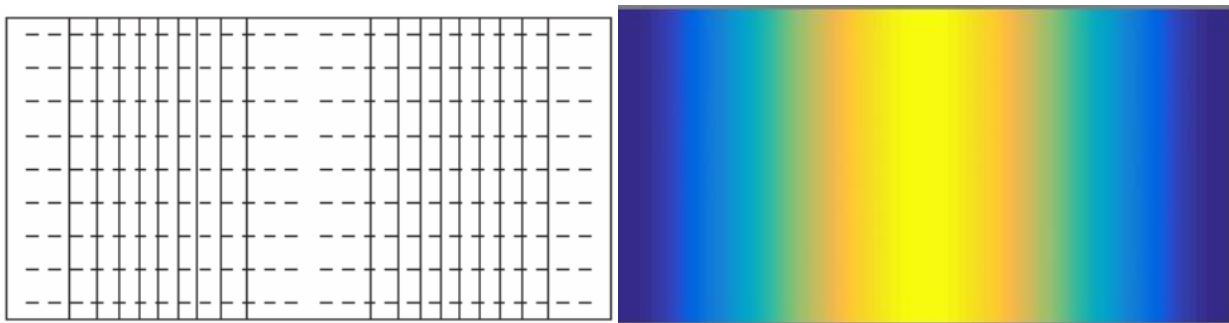*Figure 1. TE$_{10}$*

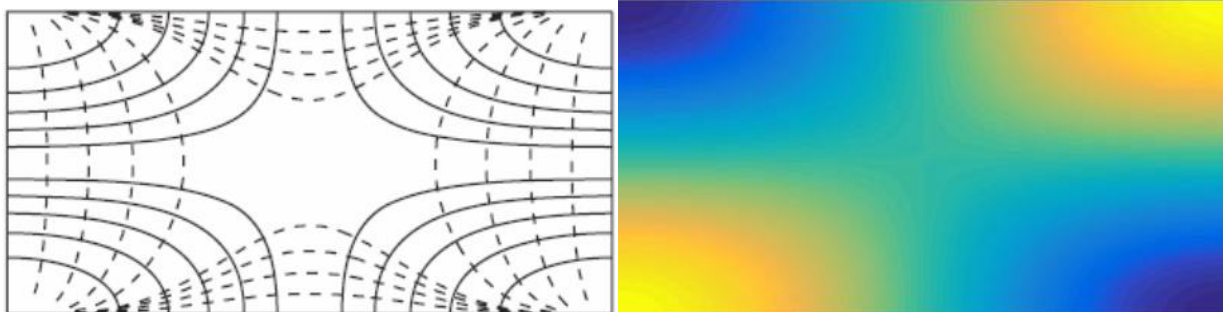*Figure 2. TE$_{01}$*

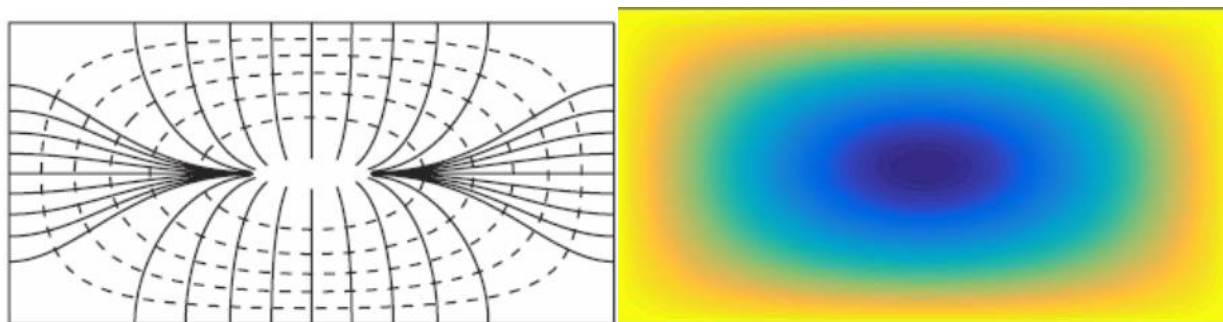*Figure 3. TE$_{20}$*

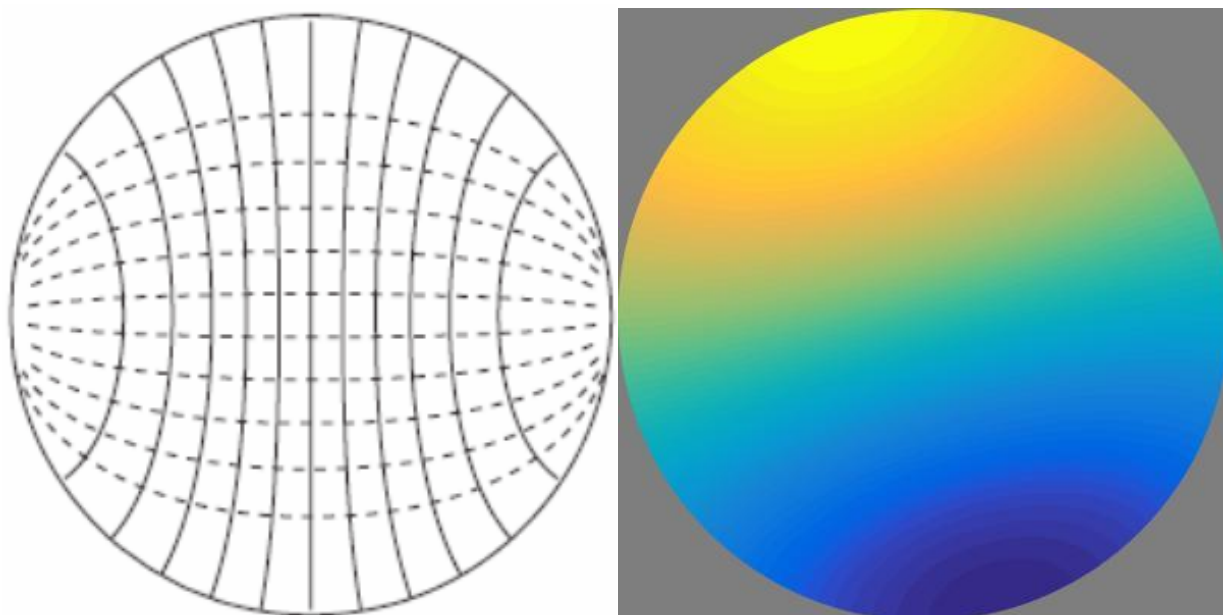*Figure 4. TE$_{11}$*

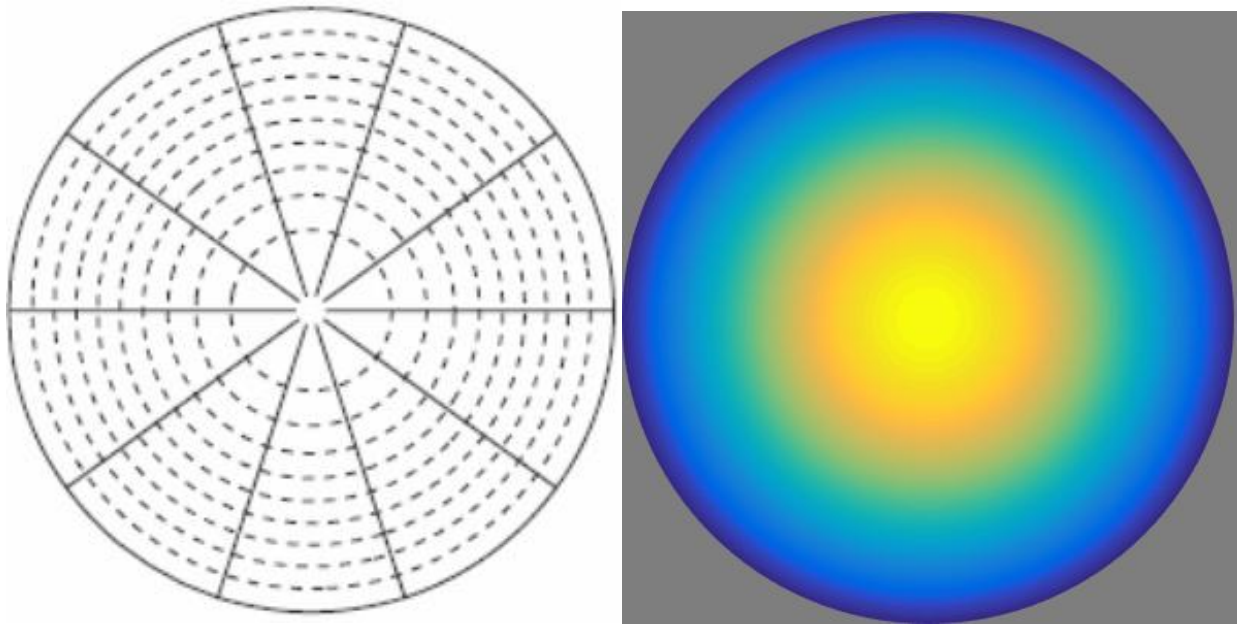*Figure 5. TM$_{11}$*

Circular Waveguide:
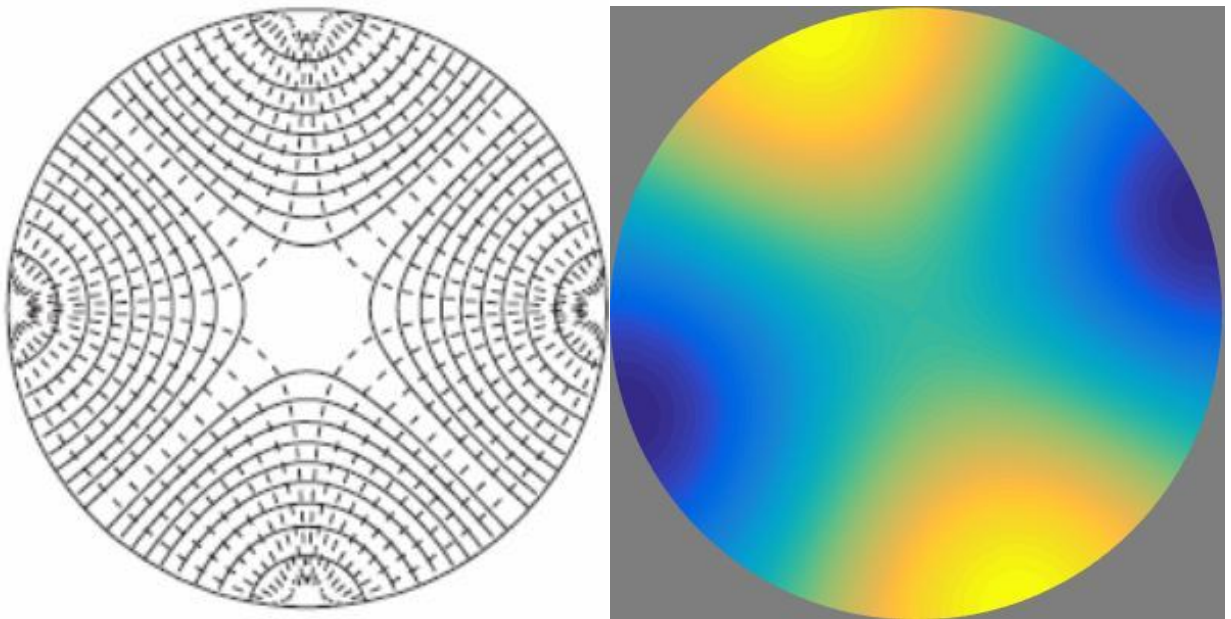

Figure 6. TE$_{11}$

Figure 7. TM$_{01}$
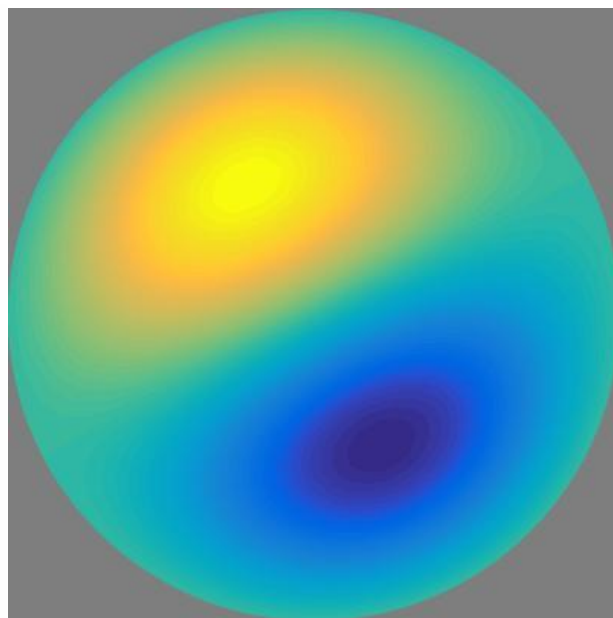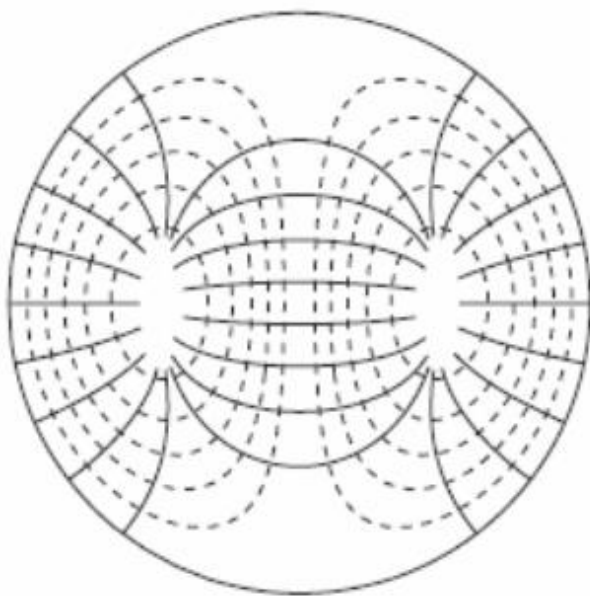

Figure 8. TE$_{21}$

Figure 9. TM$_{11}$
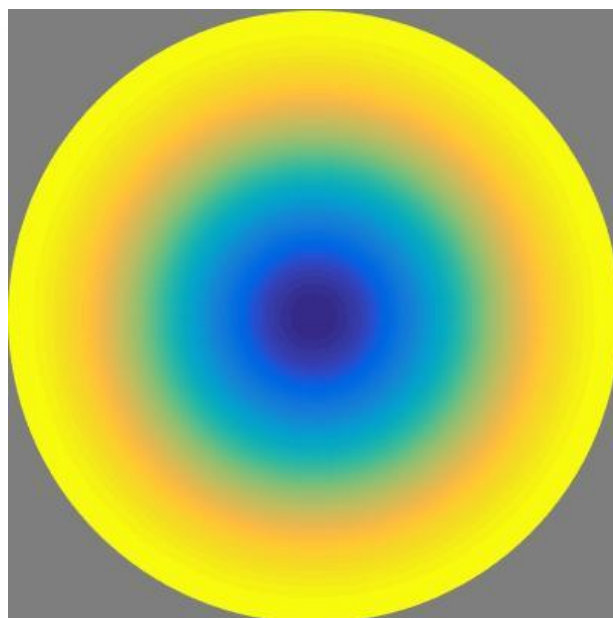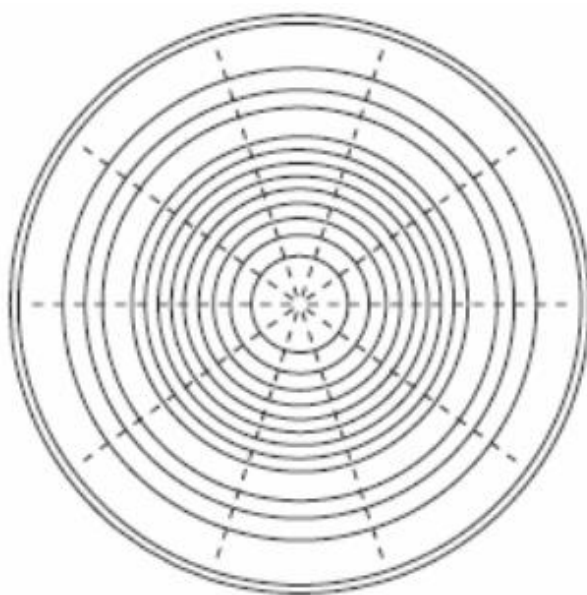
Figure 10. TE$_{01}$

We also compared k_c of the first 20 modes with theory result as below:

m	n	sim	theory
1	0	1.5902	1.5708
0	1	3.1059	3.1416
2	0	3.182	3.1416
1	1	3.4901	3.5124
2	1	4.4492	4.4429
3	0	4.7766	4.7124
3	1	5.7027	5.6636
0	2	6.2228	6.2832
4	0	6.3772	6.2832
1	2	6.4241	6.4766
2	2	6.995	7.0248
4	1	7.0997	7.0248
3	2	7.8577	7.854
5	0	7.9831	7.854
5	1	8.5747	8.459
4	2	8.9291	8.8858
0	3	9.3598	9.4248
6	0	9.495	9.4248
1	3	9.5977	9.5548
2	3	9.8963	9.9346

Figure 11. Rectangular TE

m	n	sim	theory
1	1	3.49014	3.5124
2	1	4.4492	4.4429
3	1	5.70237	5.6636
1	2	6.42419	6.4766
2	2	6.99542	7.0248
4	1	7.09933	7.0248
3	2	7.85779	7.854
5	1	8.57331	8.459
4	2	8.93203	8.8858
1	3	9.49724	9.5548
2	3	9.89631	9.9346
6	1	10.0951	9.9346
5	2	10.1512	10.058
3	3	10.5306	10.537
4	3	11.3641	11.327
6	2	11.4734	11.327
5	3	11.6538	12.268
1	4	12.3532	12.664
2	4	12.6382	12.953
6	3	12.8751	13.329

Figure 12. Rectangular TM

m	n	sim	theory
1	1	1.8418	1.8412
1	1	1.8418	1.8412
2	1	3.0562	3.0542
2	1	3.0563	3.0542
0	1	3.8361	3.8317
3	1	4.2057	4.2012
3	1	4.2059	4.2012
4	1	5.3266	5.3176
4	1	5.3267	5.3176
1	2	5.3419	5.3314
1	2	5.342	5.3314
5	1	6.4313	6.4156
5	1	6.4316	6.4156
2	2	6.7261	6.7061
2	2	6.7266	6.7061
0	2	7.0384	7.0156
6	1	7.5266	7.5013
6	1	7.5267	7.5013
3	2	8.0484	8.0152
3	2	8.0491	8.0152

Figure 13. Circular TE

m	n	sim	theory
0	1	2.4058	2.4048
1	1	3.8352	3.8317
1	1	3.8353	3.8317
2	1	5.1443	5.1356
2	1	5.1443	5.1356
0	2	5.5303	5.5201
3	1	6.3965	6.3802
3	1	6.3968	6.3802
1	2	7.0366	7.0156
1	2	7.0368	7.0156
4	1	7.6158	7.5883
4	1	7.6163	7.5883
2	2	8.4532	8.4172
2	2	8.4549	8.4172
0	3	8.6933	8.6537
5	1	8.8138	8.7715
5	1	8.8149	8.7715
3	2	9.8171	9.761
3	2	9.82	9.761
6	1	9.998	9.9361

Figure 14. Circular TM

From the result figures and k_c, the simulation matches the theory.

References

[1] Jian-Ming Jin. *Theory and Computation of Electromagnetic Fields*. Wiley-IEEE Press, 2015