CROSSLIGHT

# Crosslight PICS3D Demonstration of DBR laser photon-photon resonance (PPR) effects

Nov. 2025

# Theory for I

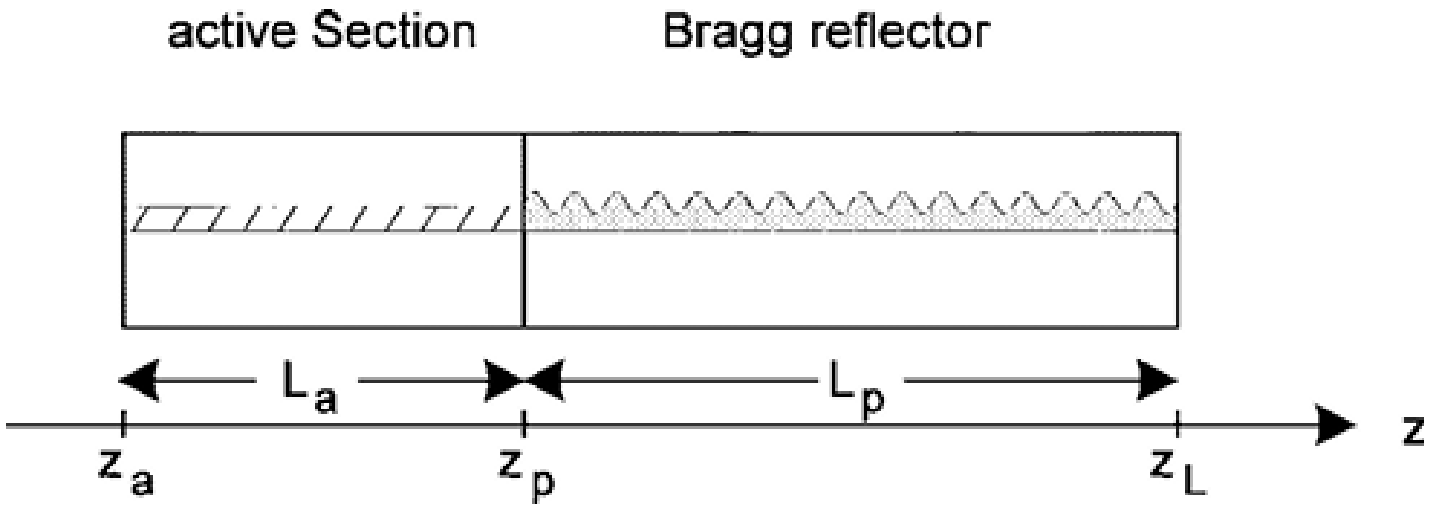
$$\Delta\hat{H}(k_a) := \hat{H}(k_a) - \hat{H}_0$$

$$\hat{H}_0\Phi_m^r = \Omega_m^r\Phi_m^r, \qquad m = 0, 1, 2, \cdots.$$

$$\sum_m \frac{df_m}{dt}\Phi_m^r = \sum_m [i\Omega_m^r f_m(t)\Phi_m^r + i f_m(t)\Delta\hat{H}\Phi_m^r].$$

$$\frac{df_n}{dt} = i\Omega_n^r f_n(t) + \sum_m K_{nm}^r f_m(t), \quad n = 0, 1, 2, \cdots$$

$$K_{nm}^r = i\langle\Phi_n^r|\Delta\hat{H}\Phi_m^r\rangle.$$

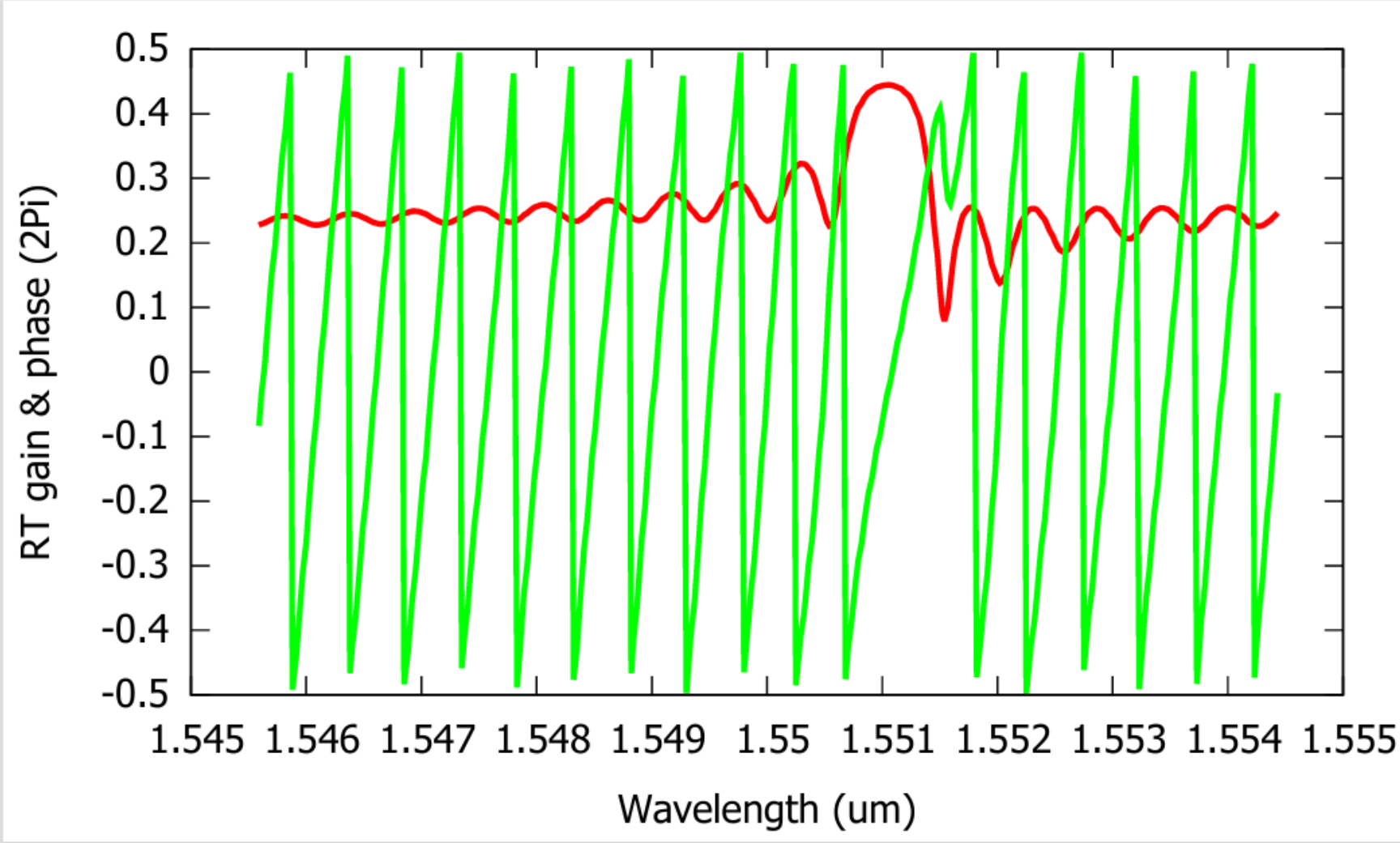



Where f is state occupation faction. H0 is based on steady state solution of DBR without longitudinal mode beating with each other.

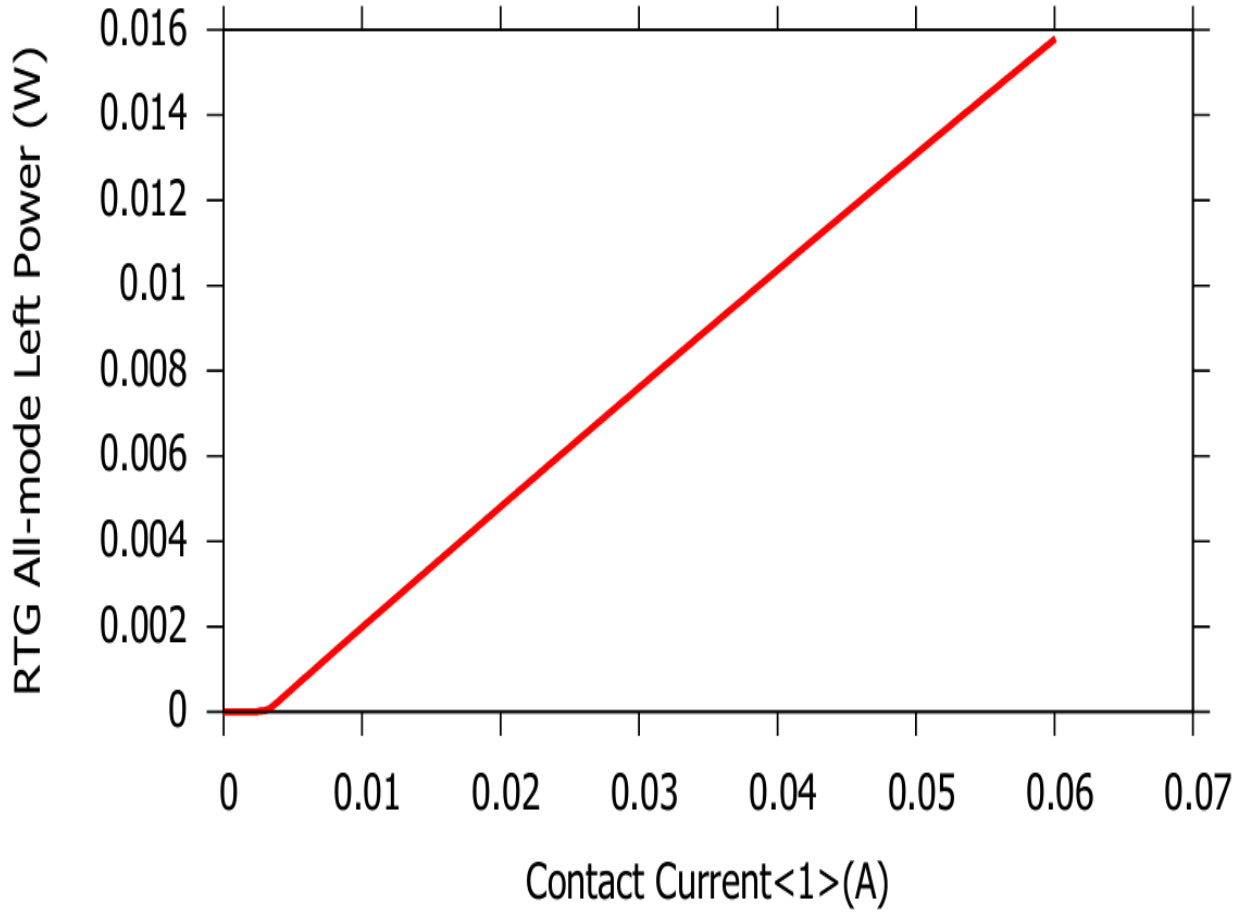
Perturbation theory is used to introduce mode-mode interaction.

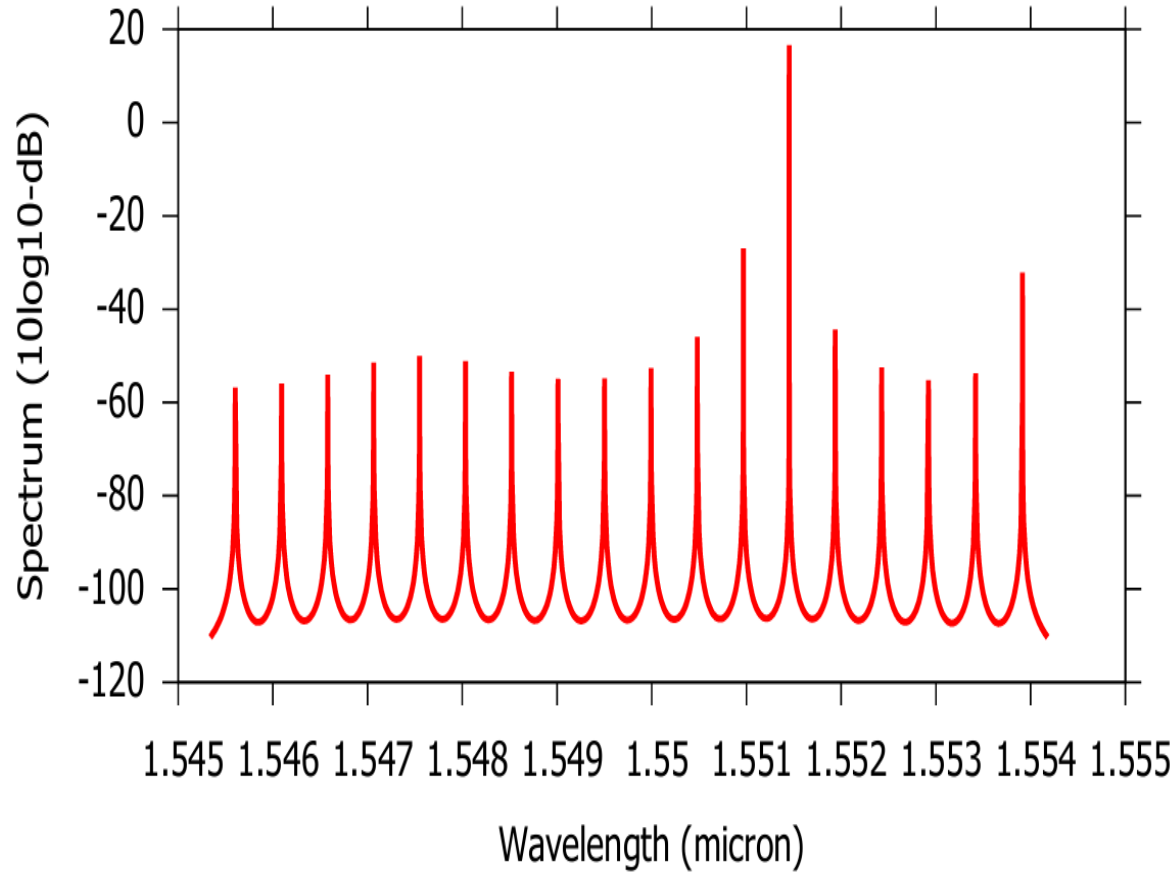
Simulation method: we perform PICS3D simulation as usual to find the modes without longitudinal mode interaction. Then, perturbation theory is used to introduce mode-mode interaction in AC analysis.

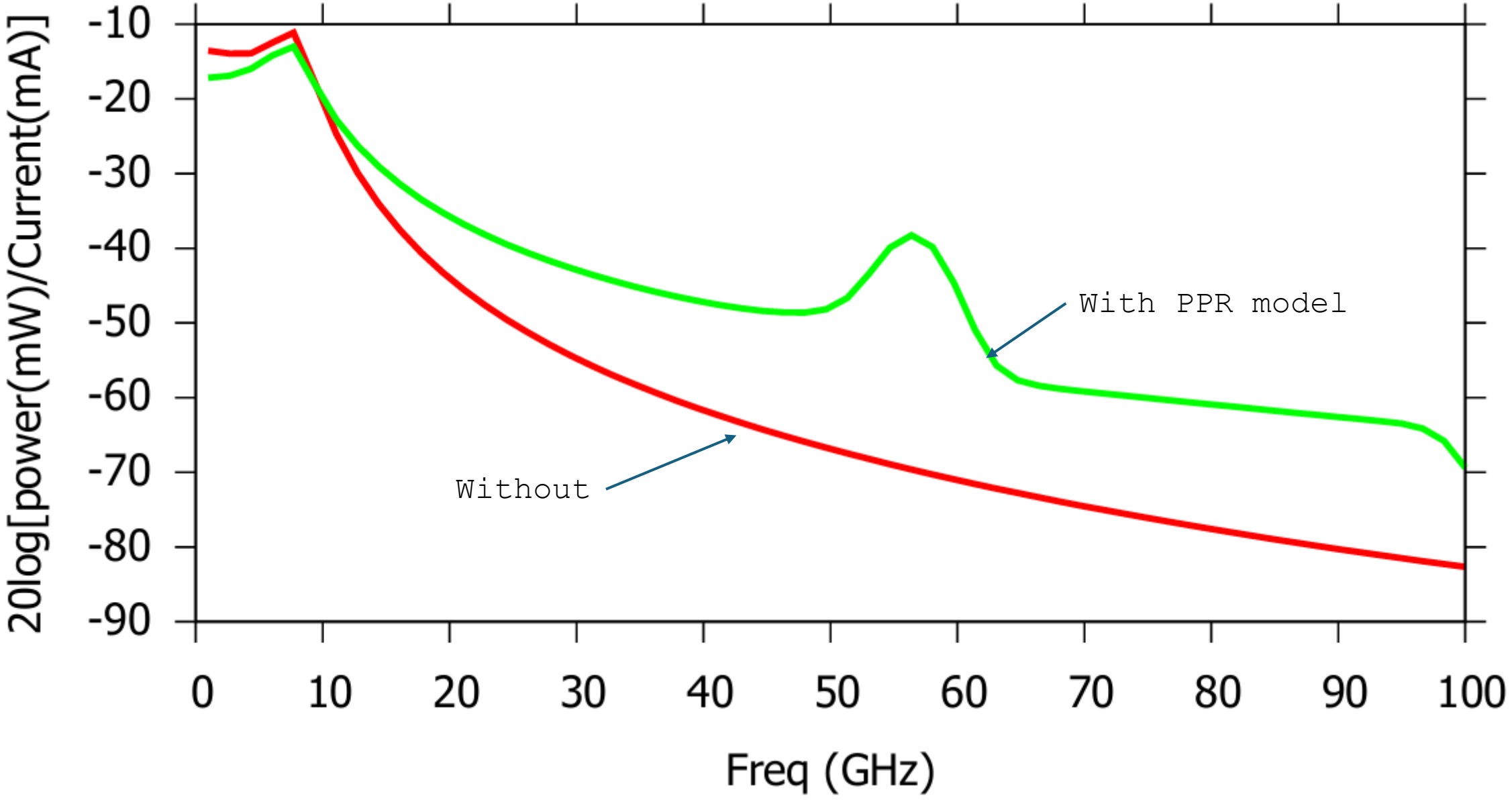
Ref:
IEEE JOURNAL OF QUANTUM ELECTRONICS, VOL. 34, NO. 12, DECEMBER 1998, p2371
"Optimization of Modulation Bandwidth in DBR Lasers with Detuned Bragg Reflectors," Uwe Feist




Important to tune the facet phase such that there is sufficient detuning from the DBR peak to allow side mode to interact with main mode.


RTG All-mode Left Power (W)
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
Contact Current<1>(A)


Spectrum (10log10-dB)
20
0
-20
-40
-60
-80
-100
-120
1.545
1.546
1.547
1.548
1.549
1.55
1.551
1.552
1.553
1.554
1.555
Wavelength (micron)


20log[power(mW)/Current(mA)]
-10
-20
-30
-40
-50
-60
-70
-80
-90
0
10
20
30
40
50
60
70
80
90
100
Freq (GHz)
With PPR model
Without