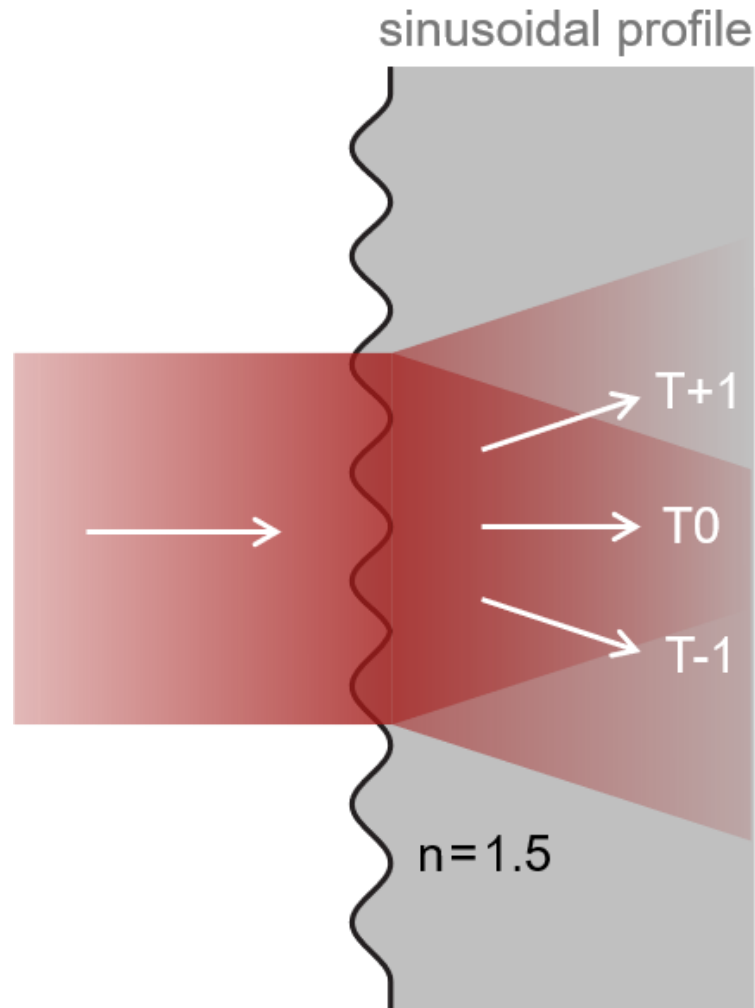


Thin Element Approximation (TEA) vs. Fourier Modal Method (FMM) for Grating Modeling

Abstract

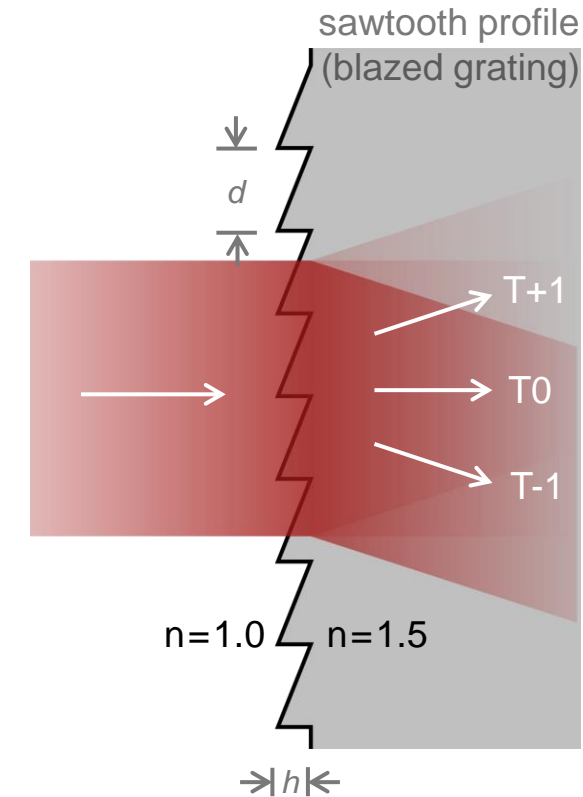
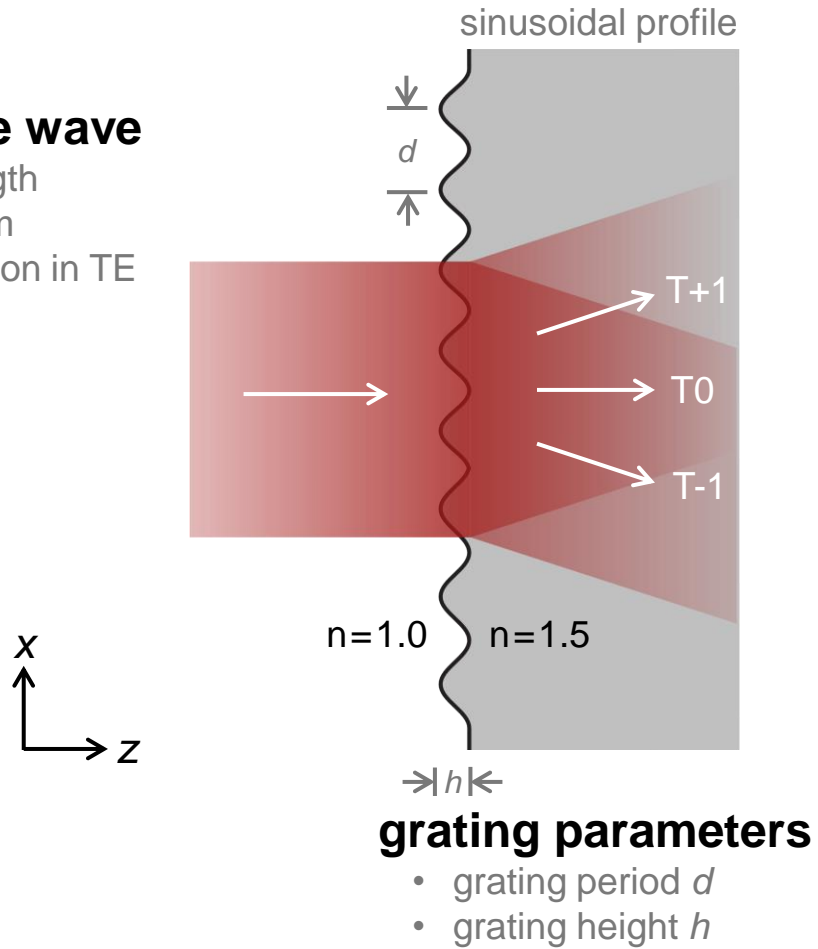


The Thin Element Approximation (TEA) is a widely-used method in Fourier optics to calculate the diffraction efficiency of gratings. However, it is also known that the approximation becomes inaccurate for smaller grating periods, means closer to the wavelength of light. In this example, two types of transmission gratings are selected to showcase this effect: sinusoidal and blazed. We use both TEA and FMM (also known as RWCA, which is rigorous) to analyze such gratings with varying period, and by comparing the results, we investigate the behavior of the two methods.

Modeling Task

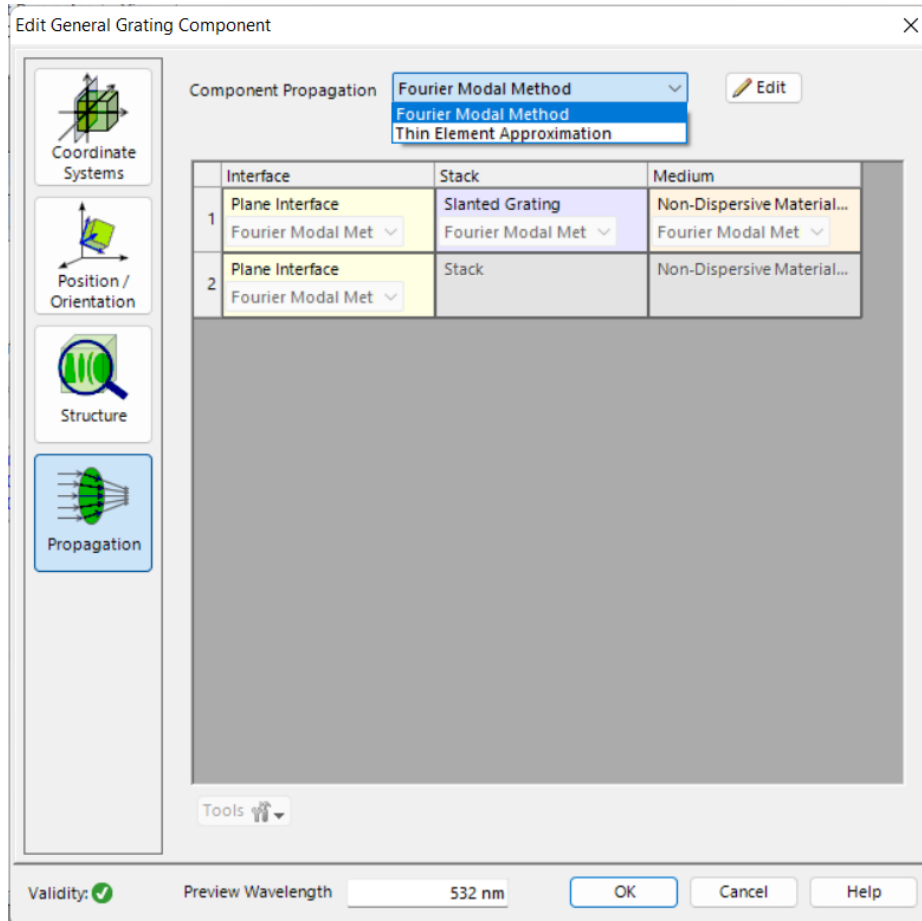
input plane wave

- wavelength $\lambda = 532\text{nm}$
- polarization in TE



For both the sinusoidal and the blazed gratings, the diffraction efficiency is analyzed by applying TEA and FMM.

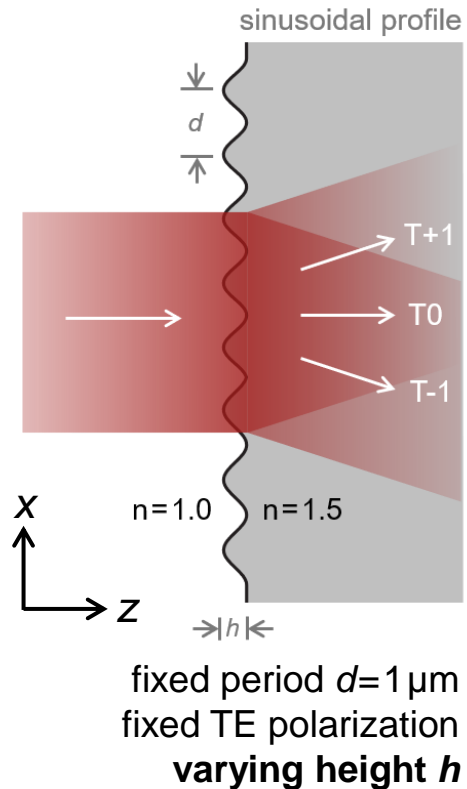
Grating Component



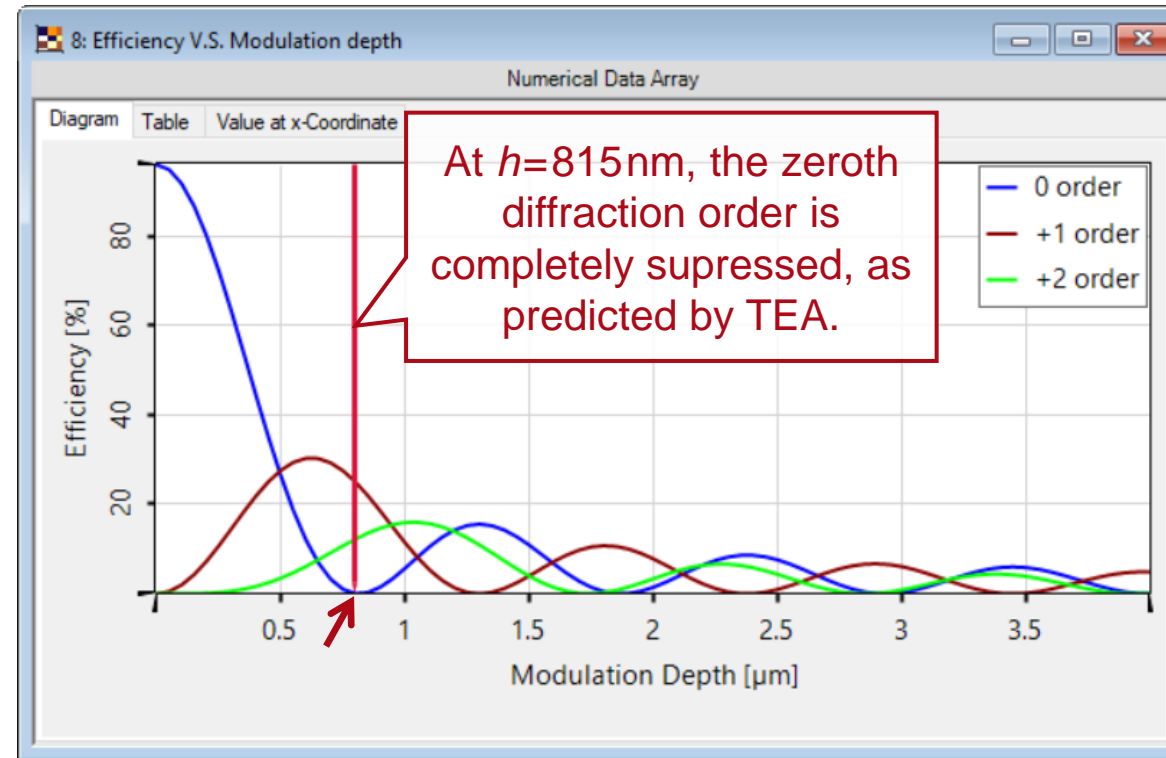
The *General Grating Component* allows the user to choose different solver algorithm in the simulation. The user can choose between the rigorous *Fourier Modal Method* (FMM) and the approximated, but faster *Thin Element Approximation* (TEA). More information about the solvers can be found here:

- [FMM/RCWA](#)
- [Diffractive Lens Component](#)

Sinusoidal Grating – Efficiency vs. Height (TEA Only)

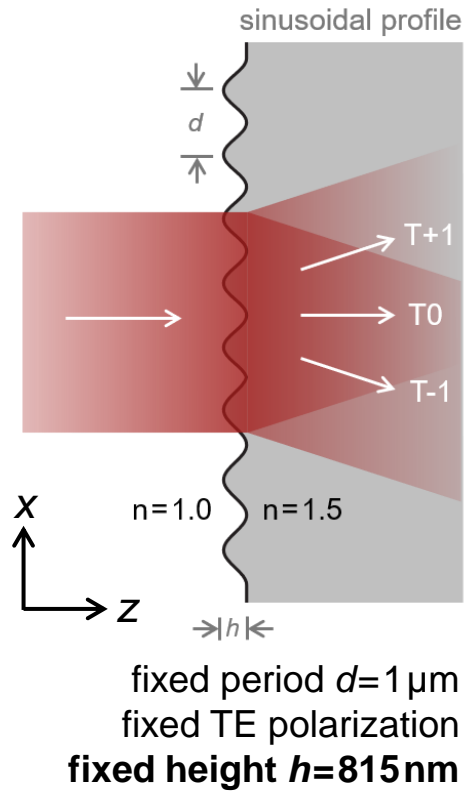


It is often efficient to use TEA as a fast design tool for searching proper grating parameters. However, the limitation of the method shall be noticed.

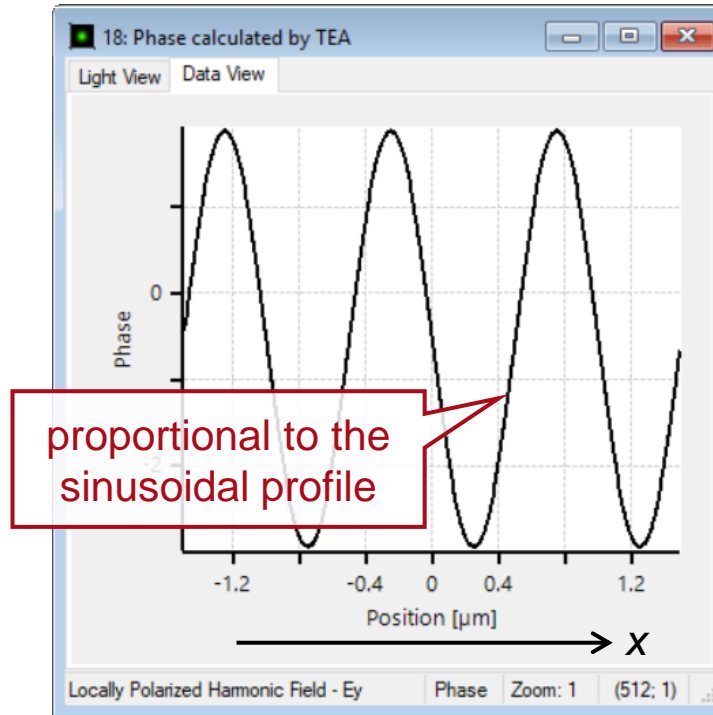


To have symmetric diffraction effect without zeroth order, we pick up $h=815\text{nm}$ as the grating height.

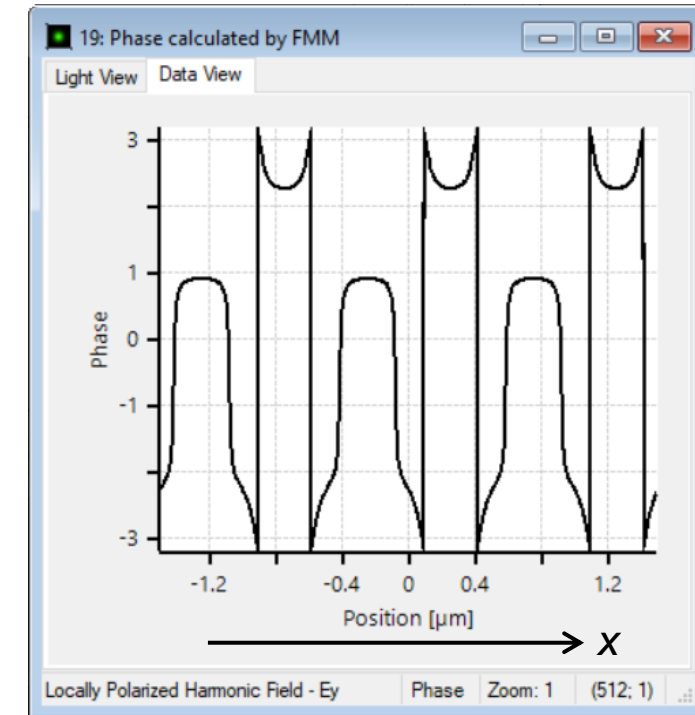
Sinusoidal Grating – Transmitted Phase Profiles



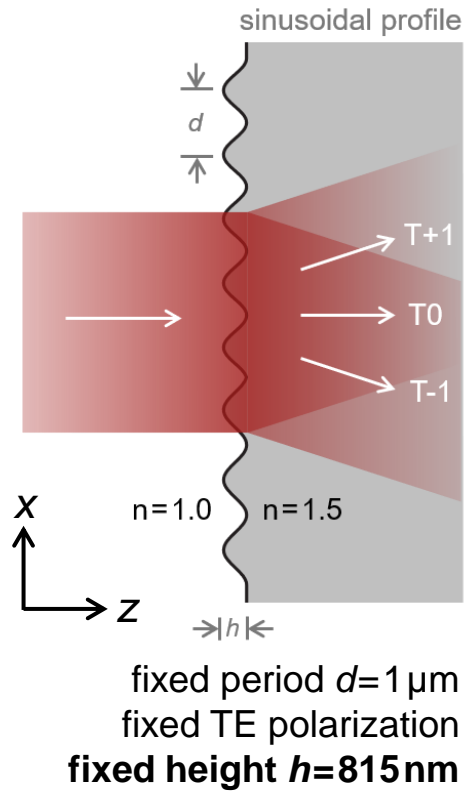
phase behind grating (TEA)



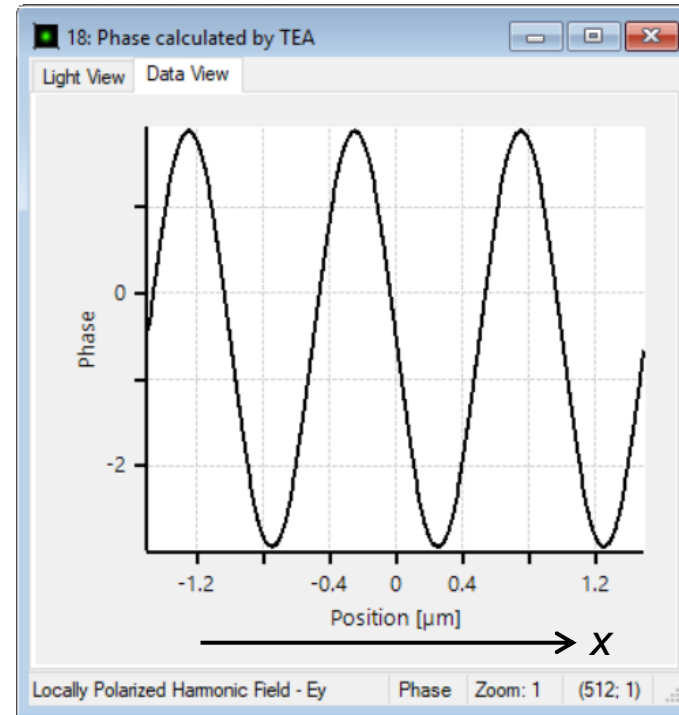
phase behind grating (FMM)



Sinusoidal Grating – Transmitted Phase Profiles

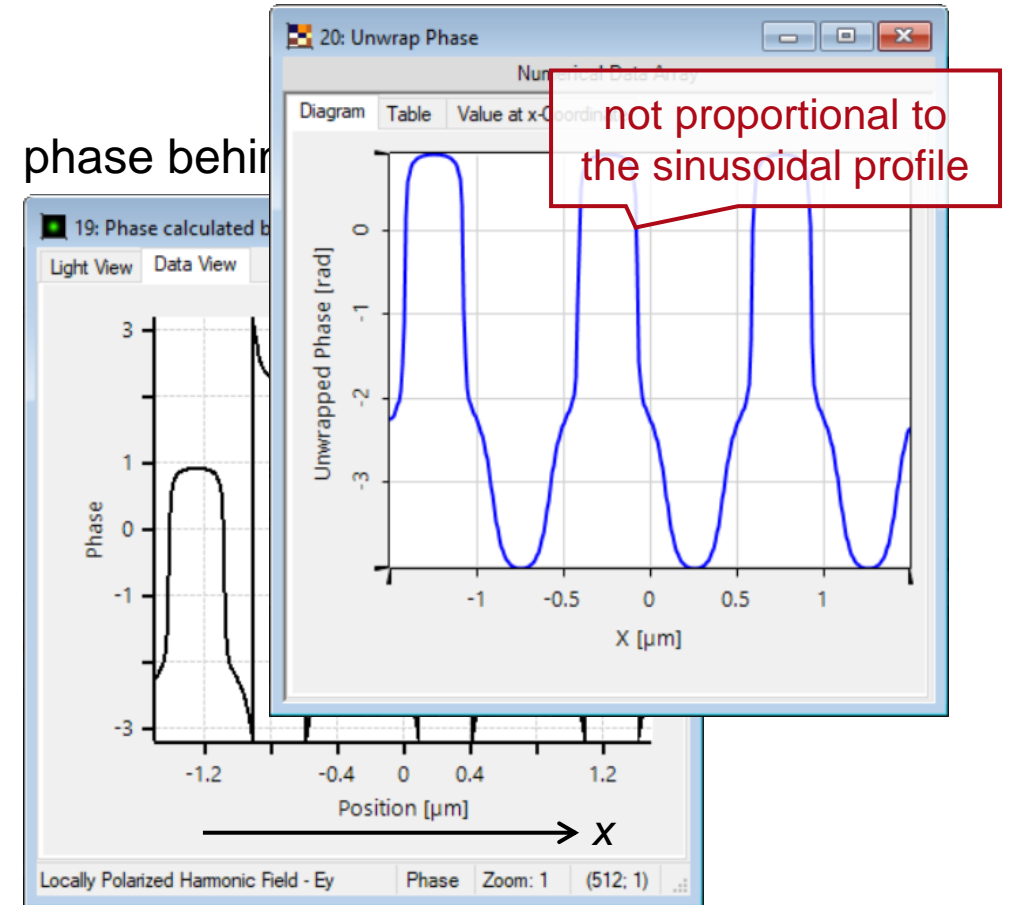


phase behind grating (TEA)

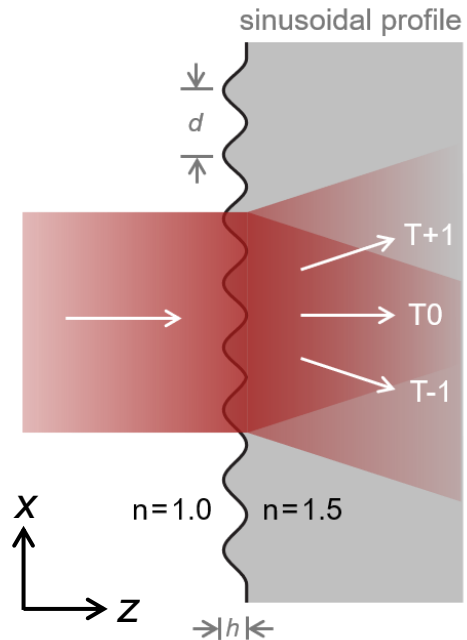


unwrapped phase (FMM)

phase behind

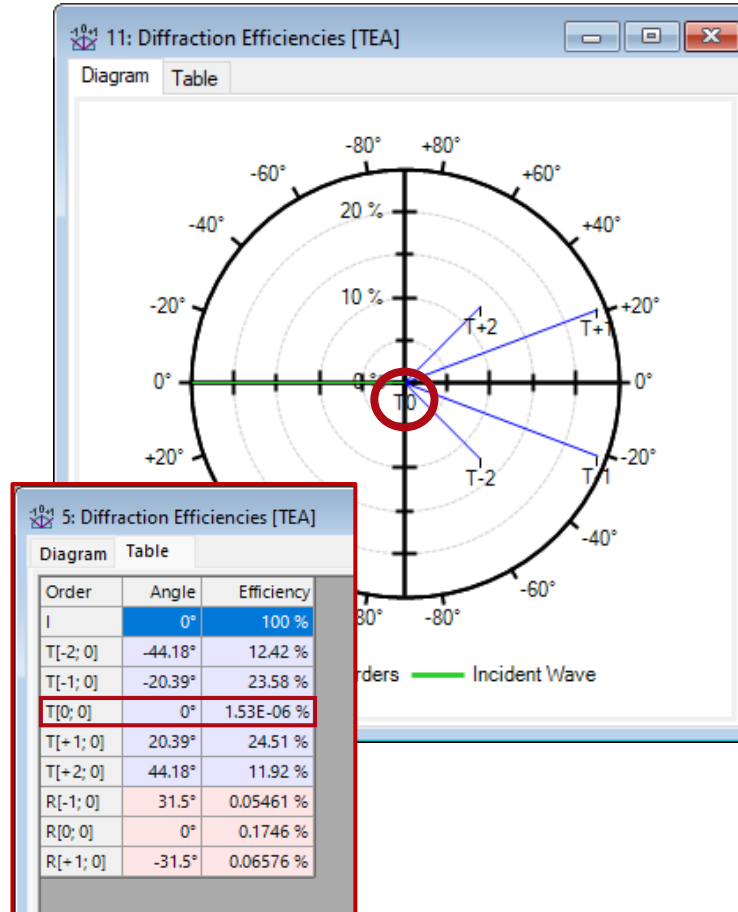


Sinusoidal Grating – Diffraction Efficiencies

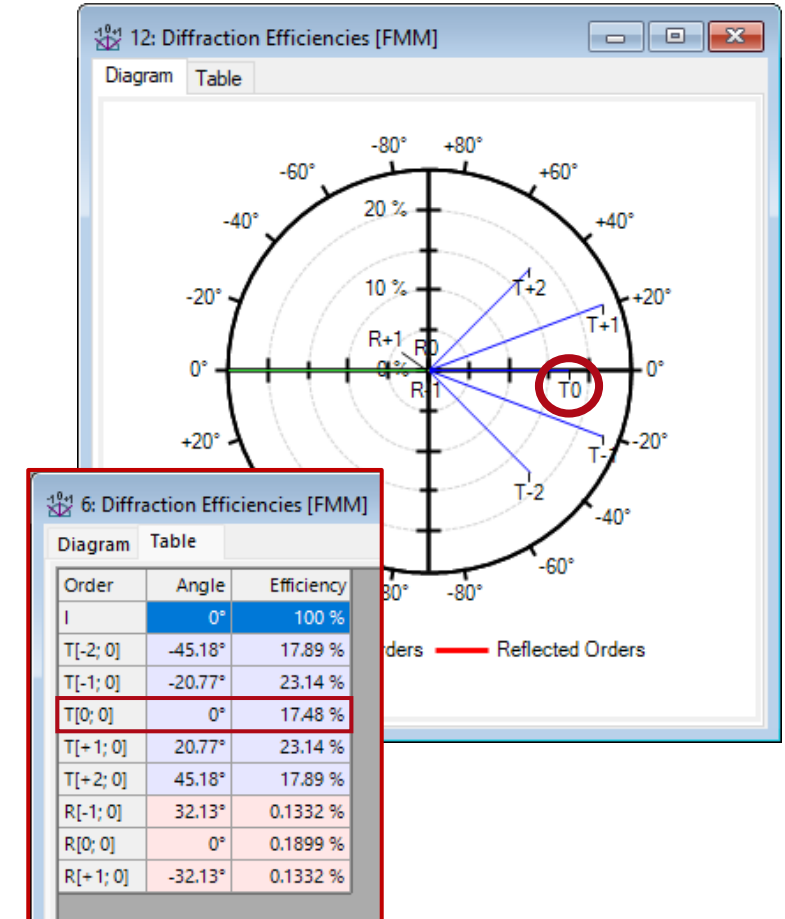


fixed period $d=1\ \mu\text{m}$
fixed TE polarization
fixed height $h=815\text{nm}$

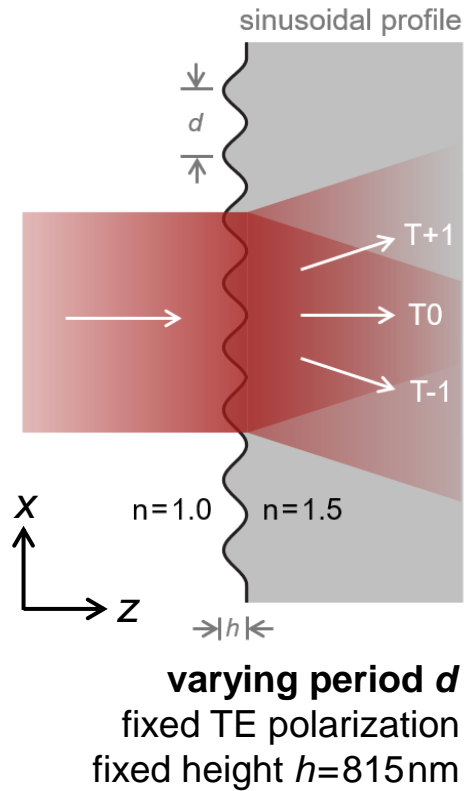
diffraction efficiencies (TEA)



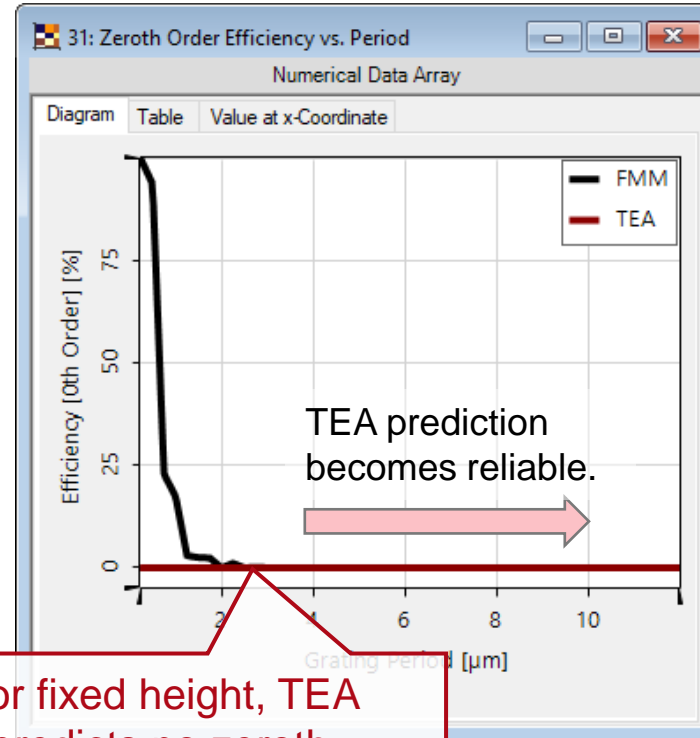
diffraction efficiencies (FMM)



Sinusoidal Grating – Efficiencies vs. Period

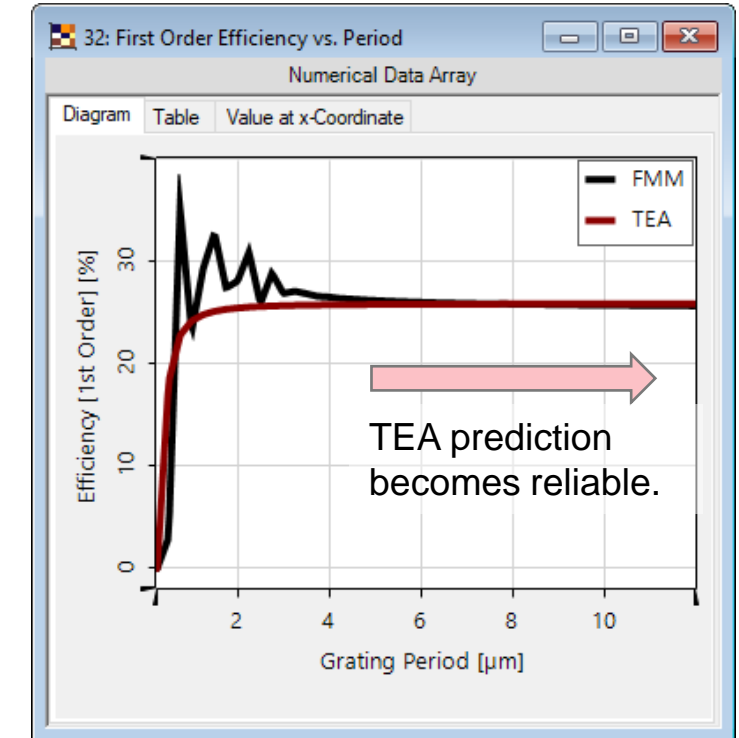


diffraction efficiencies – 0th order

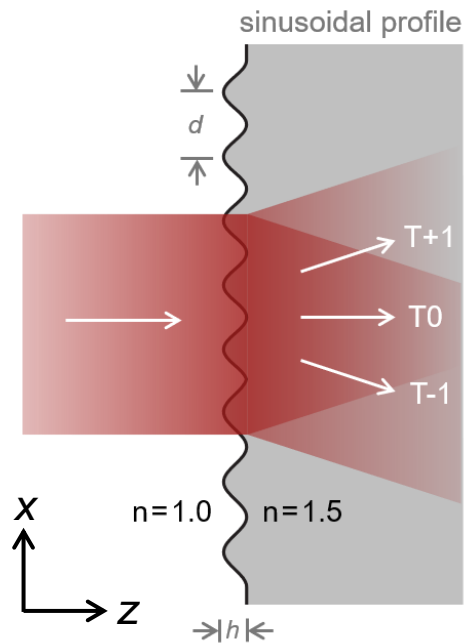


For fixed height, TEA predicts no zeroth diffraction order regardless of the grating period.

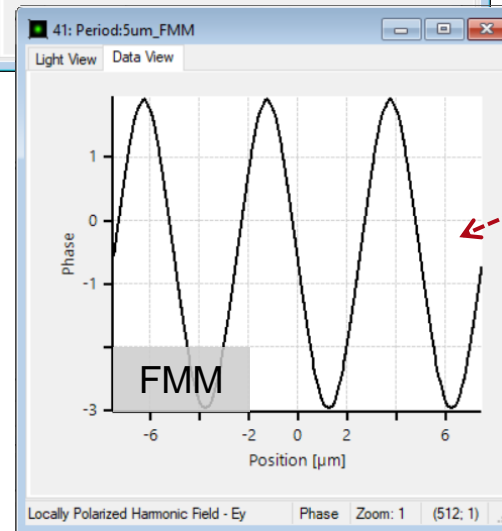
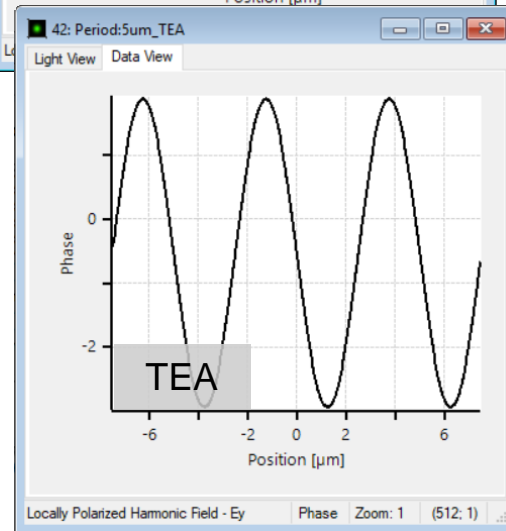
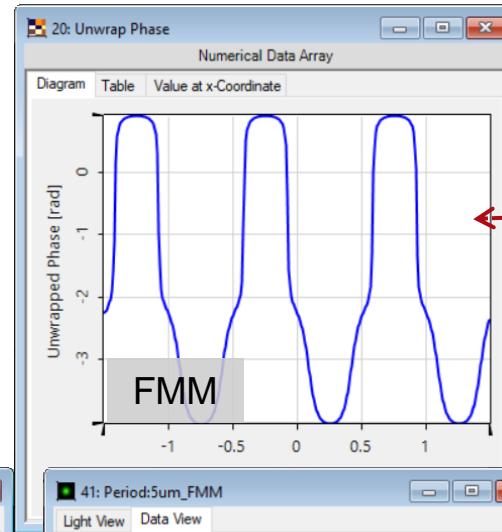
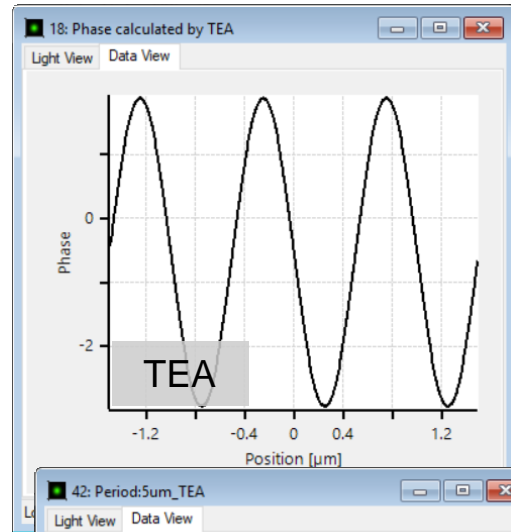
diffraction efficiencies – 1st order



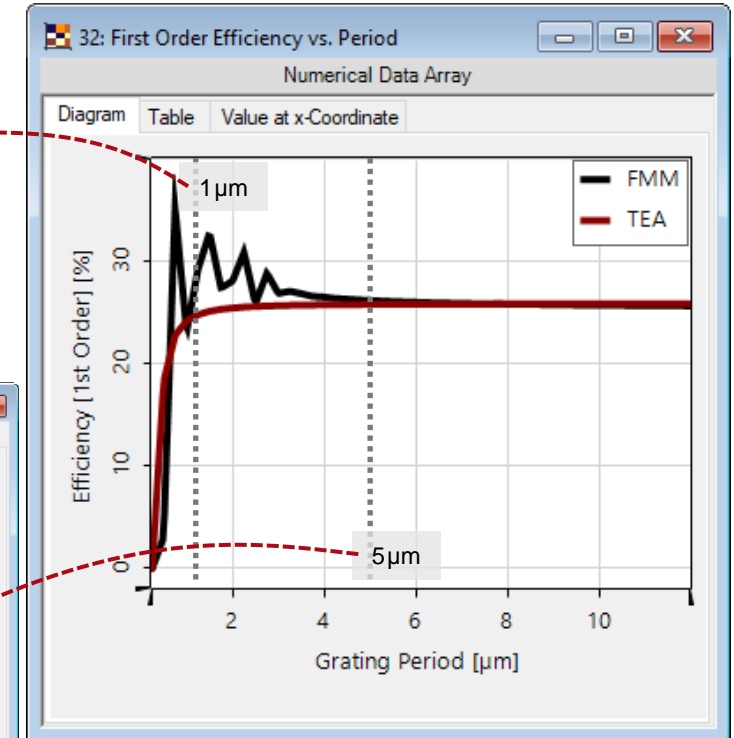
Sinusoidal Grating – Phase Profiles at Selected Periods



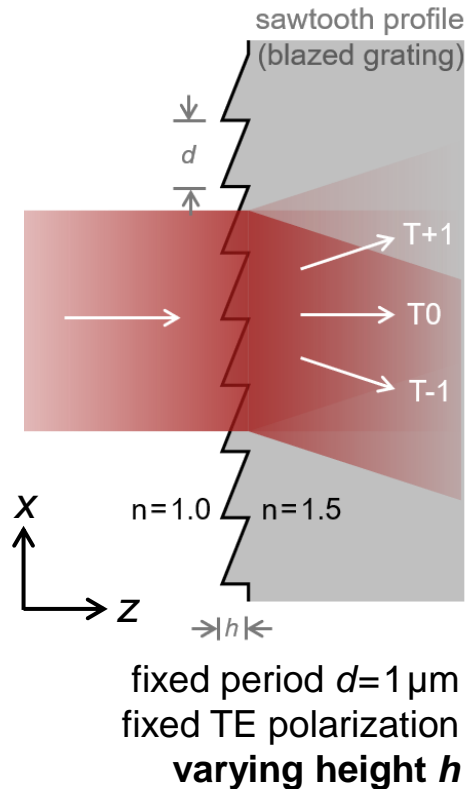
period $d=1\mu\text{m}$ or $5\mu\text{m}$
fixed TE polarization
fixed height $h=815\text{nm}$



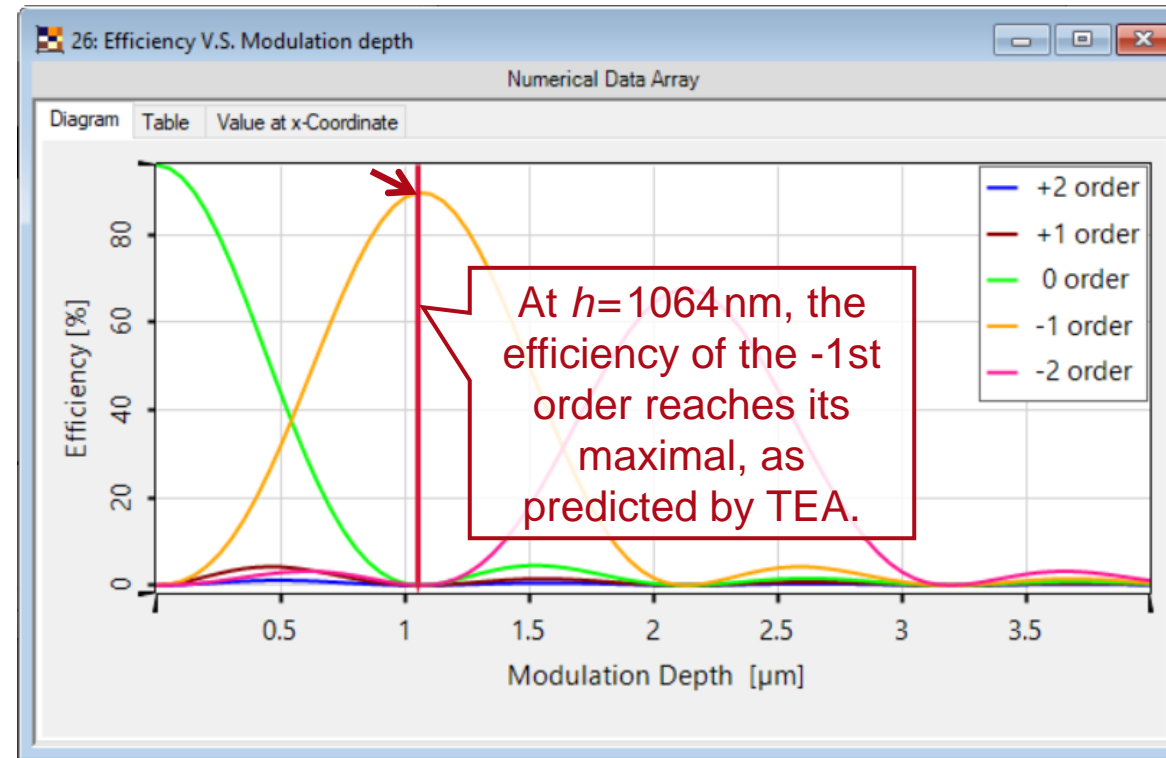
diffraction efficiencies – 1st order



Blazed Grating – Efficiency vs. Height (TEA Only)

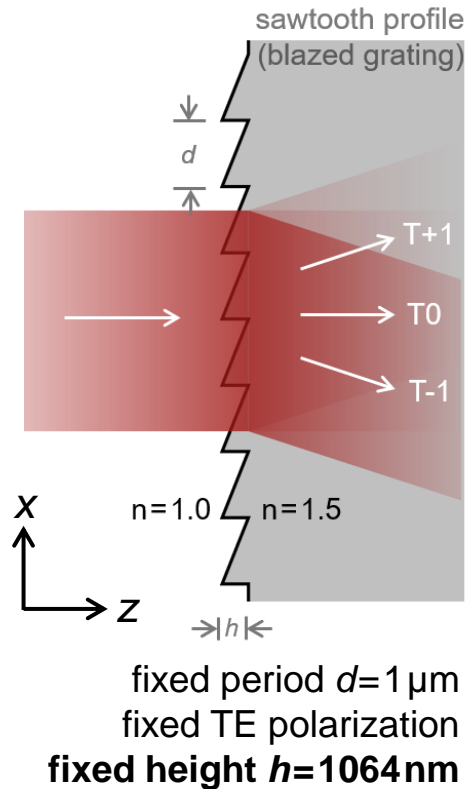


It is often efficient to use TEA as a fast design tool for searching proper grating parameters. However, the limitation of the method shall be noticed.

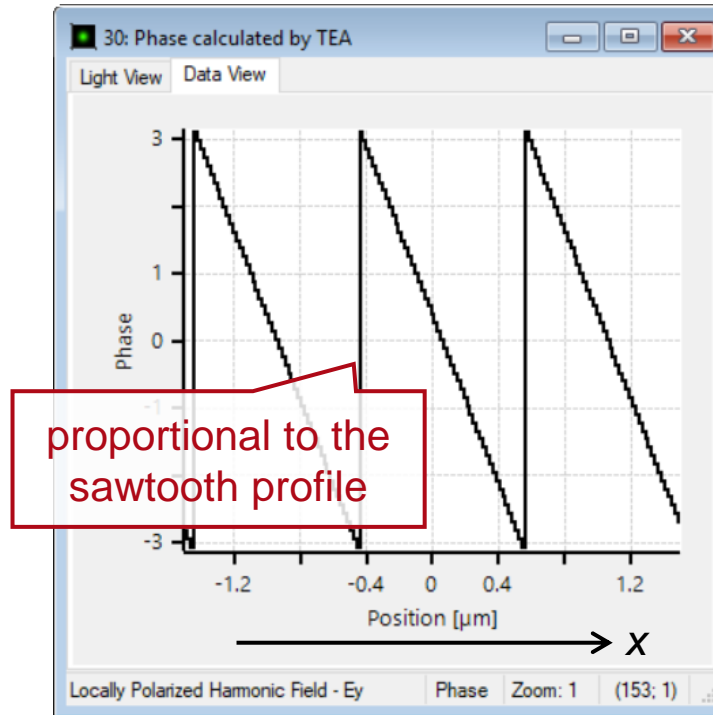


To maximize the diffraction efficiency of the -1st order, we pick up $h=1064\text{ nm}$ as the grating height.

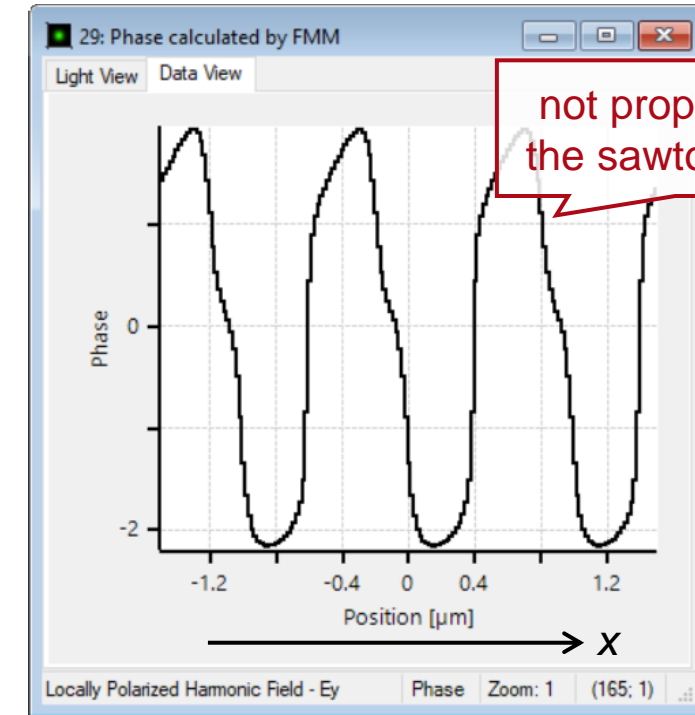
Blazed Grating – Transmitted Phase Profiles



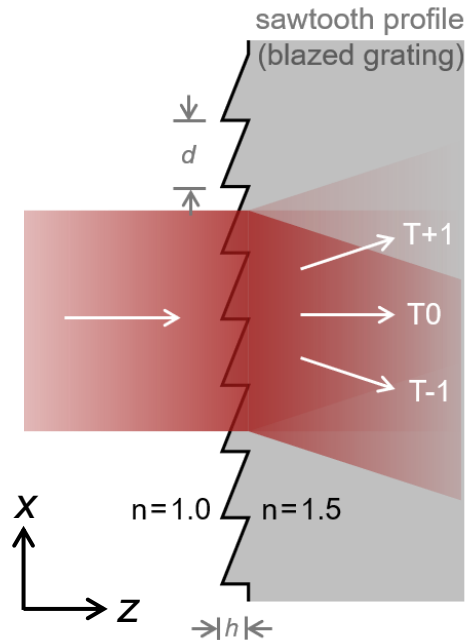
phase behind grating (TEA)



phase behind grating (FMM)

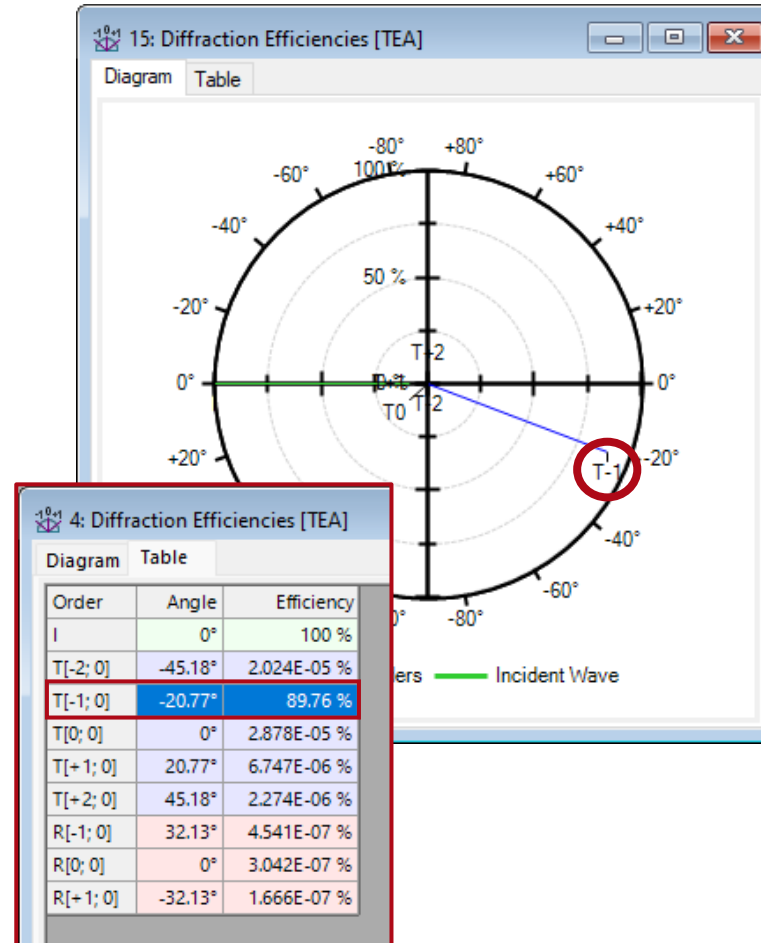


Blazed Grating – Diffraction Efficiencies

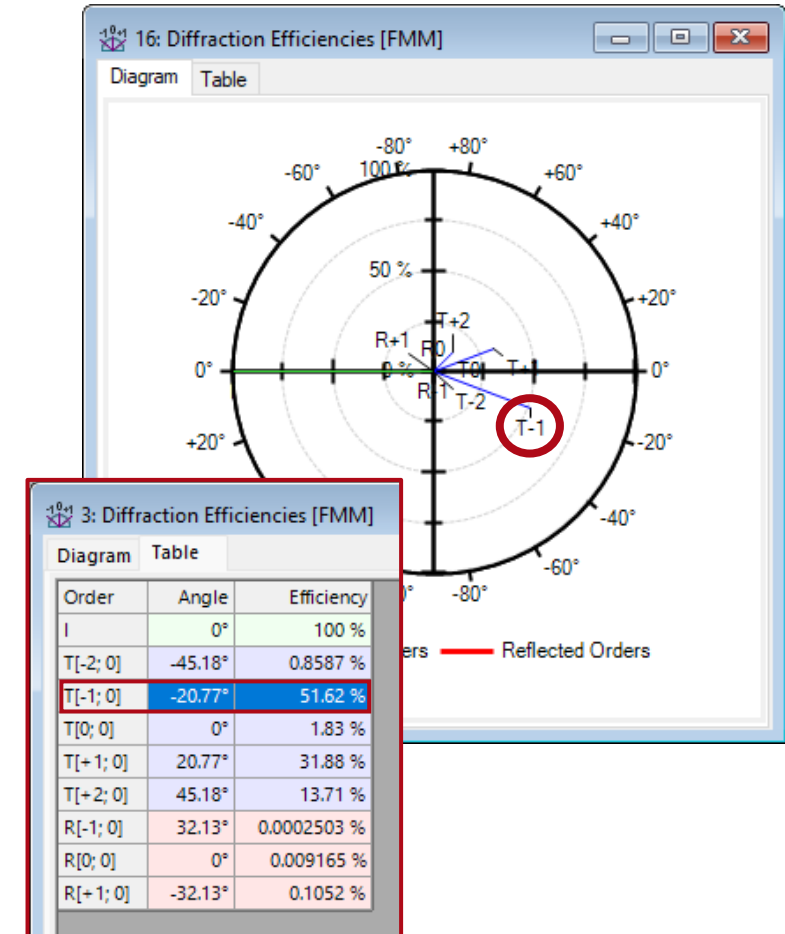


fixed period $d=1\ \mu\text{m}$
fixed TE polarization
fixed height $h=1064\text{nm}$

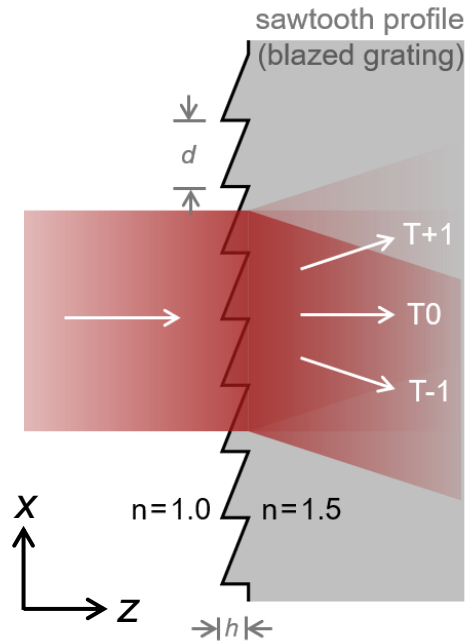
diffraction efficiencies (TEA)



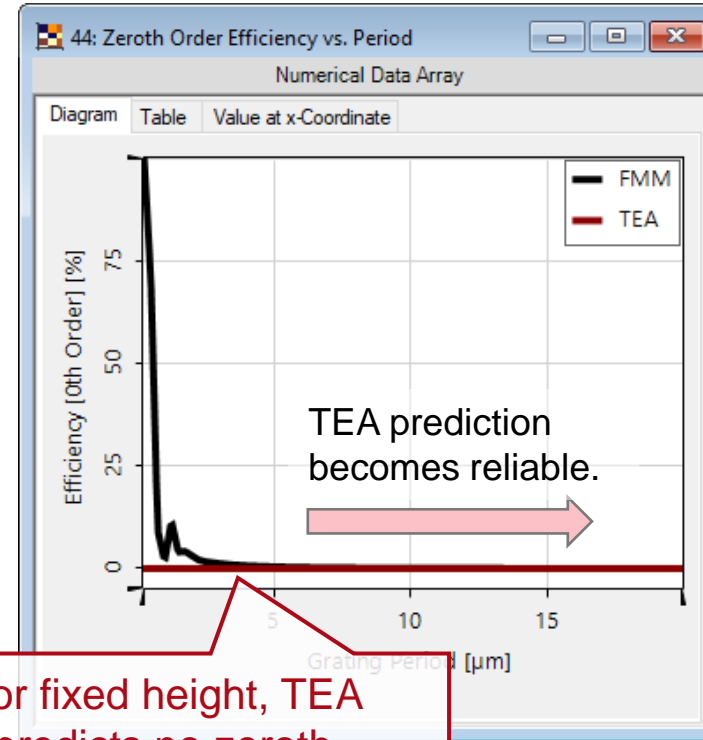
diffraction efficiencies (FMM)



Blazed Grating – Efficiencies vs. Period

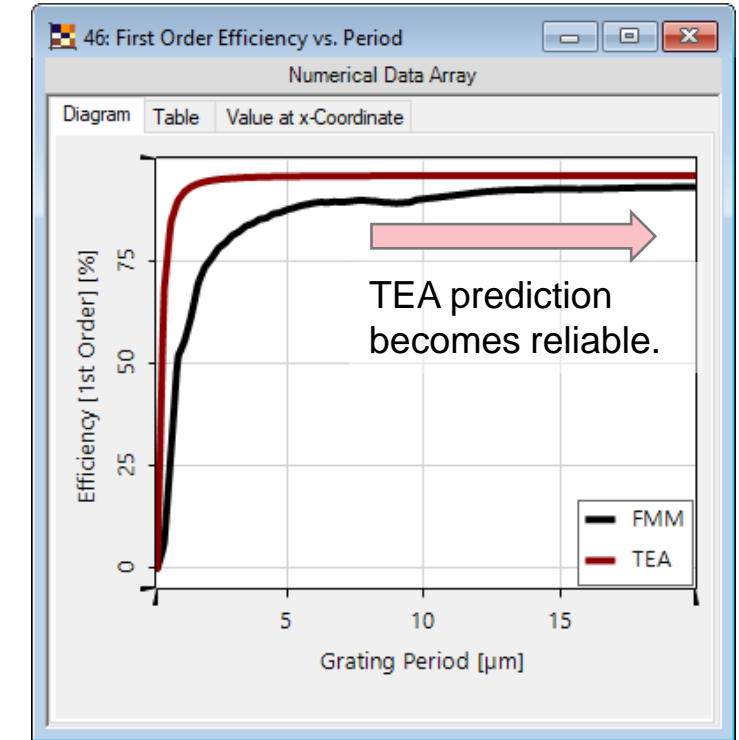


diffraction efficiencies – 0th order

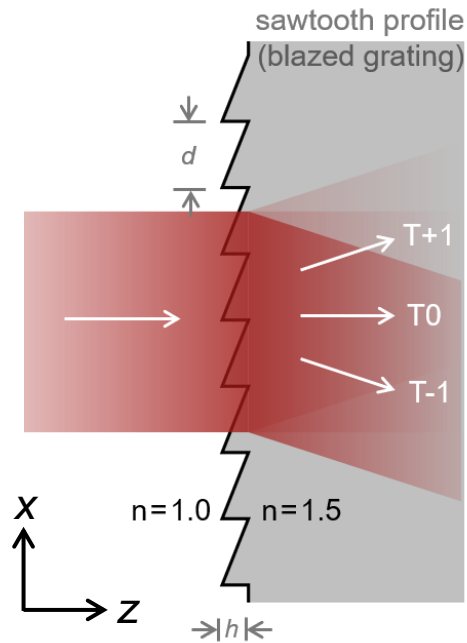


For fixed height, TEA predicts no zeroth diffraction order regardless of the grating period.

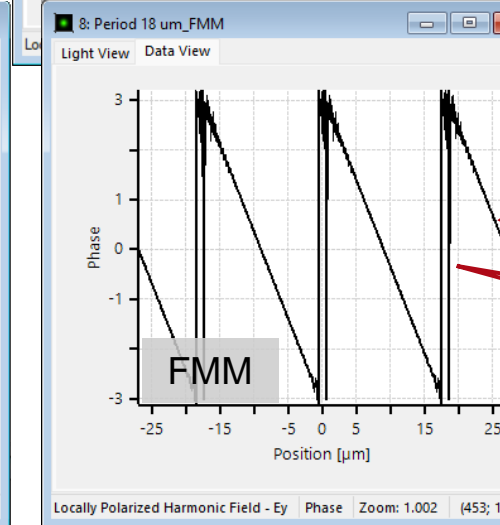
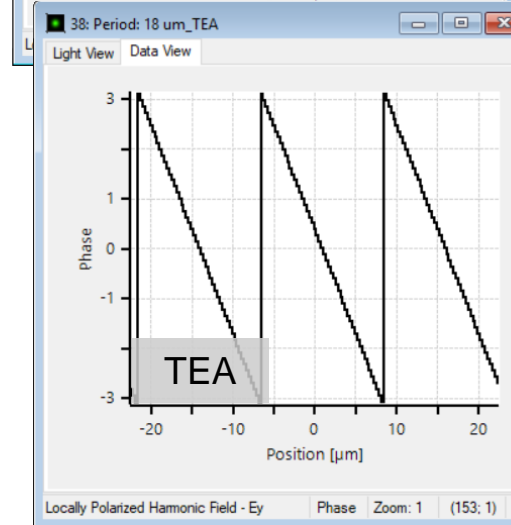
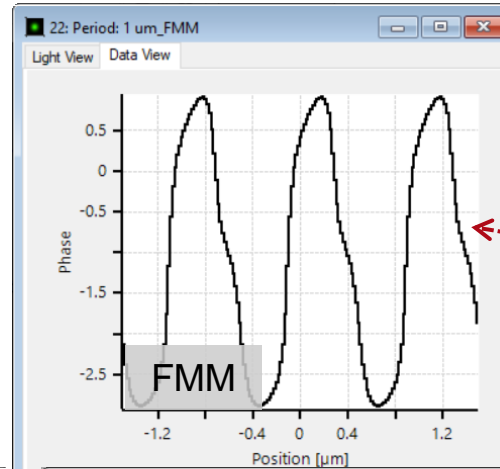
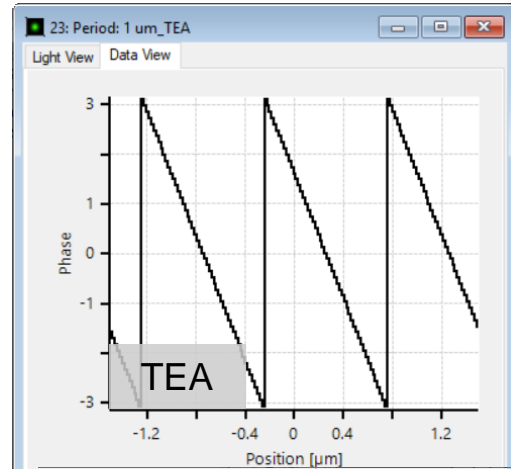
diffraction efficiencies – 1st order



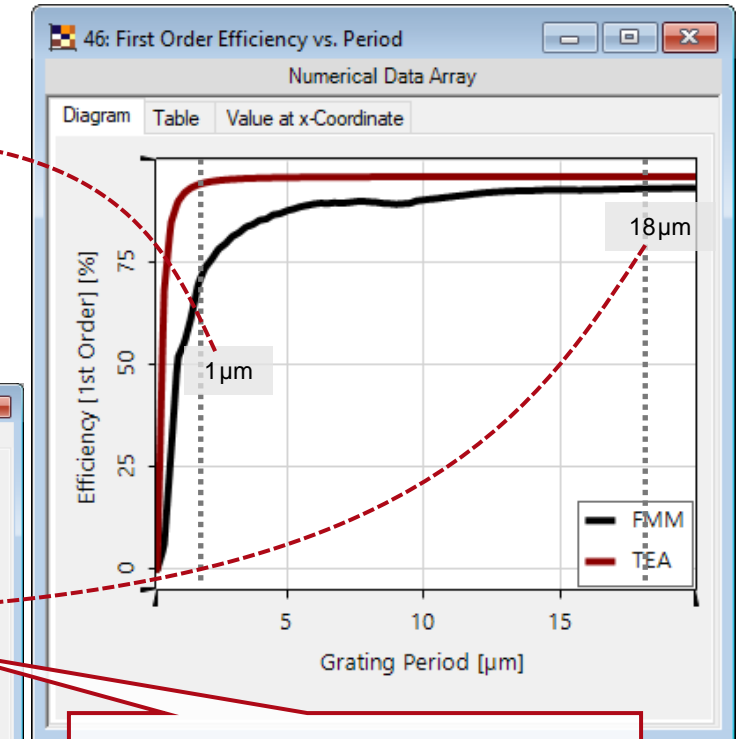
Blazed Grating – Phase Profiles at Selected Periods



period $d=1\mu\text{m}$ or $18\mu\text{m}$
fixed TE polarization
fixed height $h=1064\text{nm}$

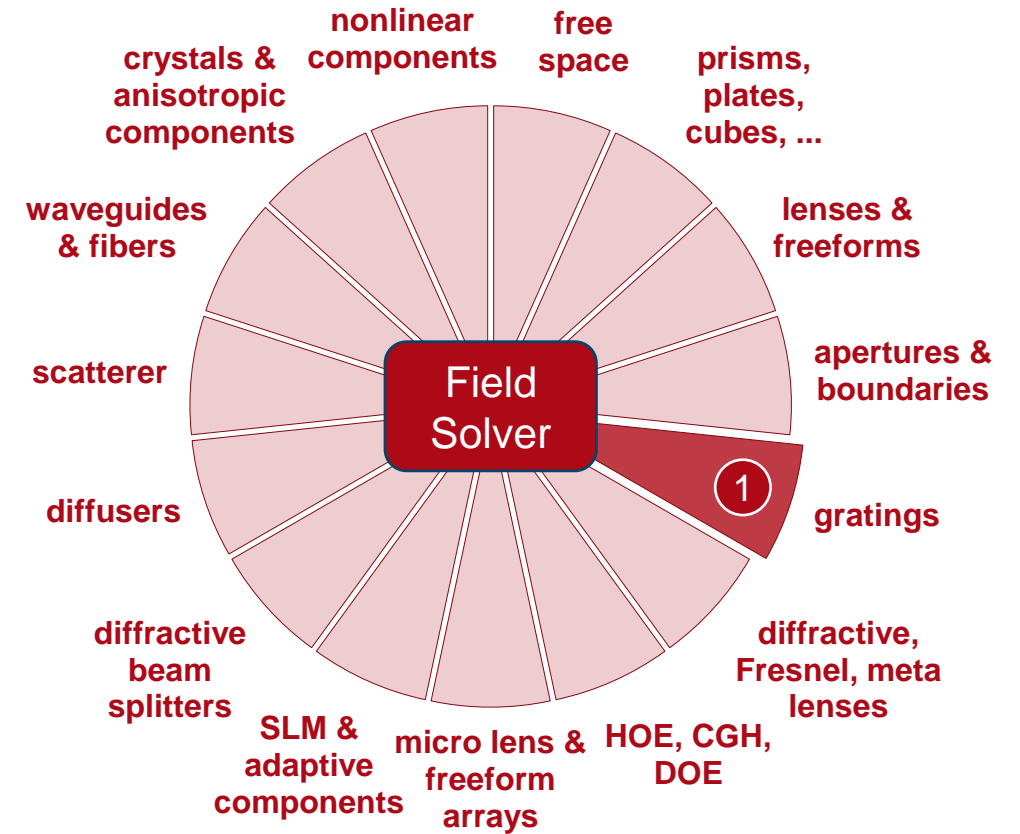
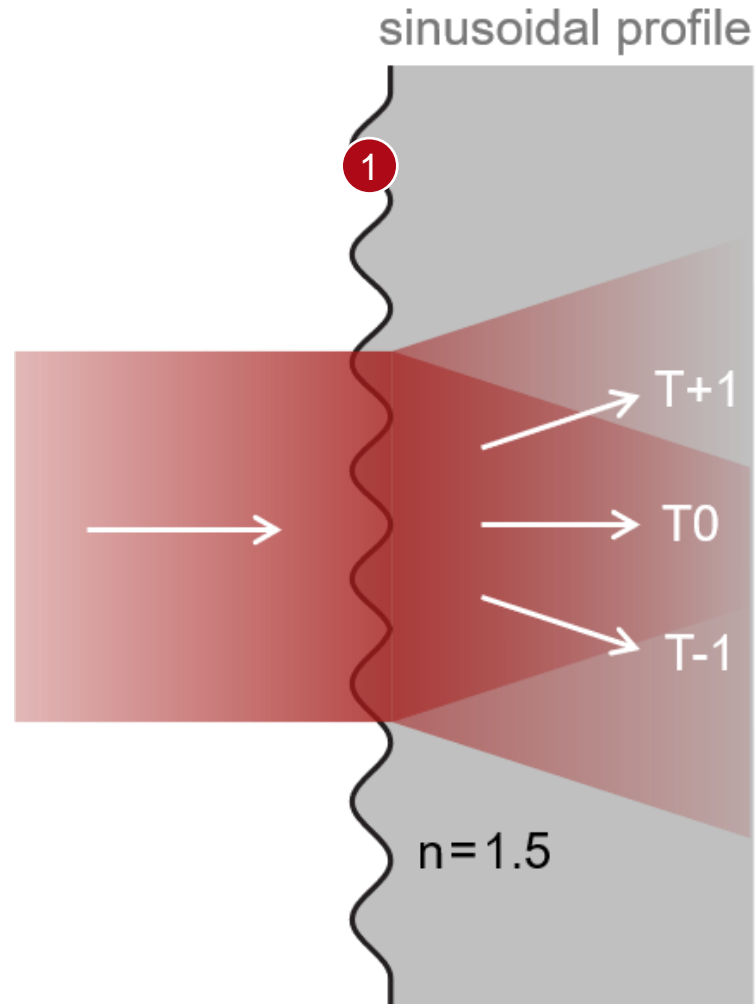


diffraction efficiencies – 1st order



Fluctuations are introduced by the sharp tip of the grating structure.

VirtualLab Fusion Technologies



Document Information

title	Thin Element Approximation (TEA) vs. Fourier Modal Method (FMM) for Grating Modeling
document code	GRT.0019
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software version	2021.1 (Build 1.180)
category	Application Use Case
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