Understanding GMCW

I.   Gaussian Modulated Continues Wave (GMCW) formula and its spectrum

$$GMCW(t) = e^{\left[-\frac{1}{2}\left(\frac{t-t_{offset}}{T}\right)^2 \right]} \sin(\omega_0 t)$$
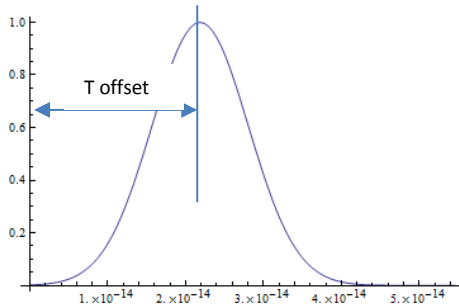
Where
(1) t_{offset} is the time offset of the Gaussian function,
(2) T is the half-width of the Gaussian function; it controls both the both time domain and
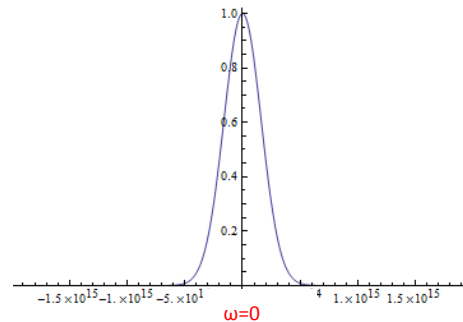   spectrum domain beam size.

$$G(\omega) = e^{-\frac{(\omega-\omega_0)^2}{2W^2}} e^{-j\omega t_{offset}}$$

Where $W = \dfrac{1}{T}$; which determined the spectrum domain bandwidth

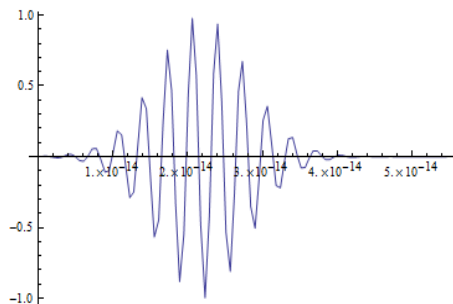II.   GMCW move (modulated) the Gaussian function spectrum to the desired position.
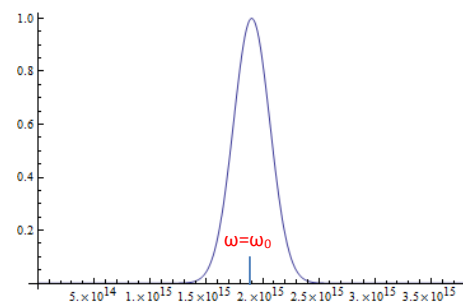

g(t), Original Gaussian function $g(\omega)$ spectrum of g(t)

$$g(t) = \exp[-(t - t_{offset})^2 /(2T^2)] \qquad \leftarrow FT \rightarrow \qquad g(\omega) = e^{-\frac{\omega^2}{2W^2}}$$

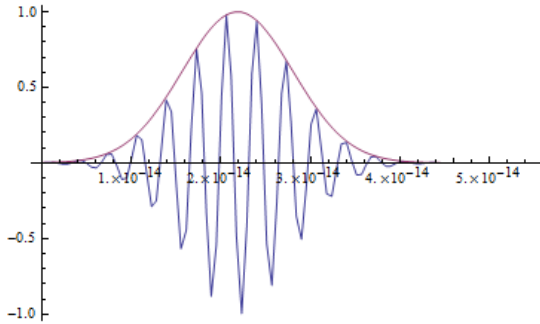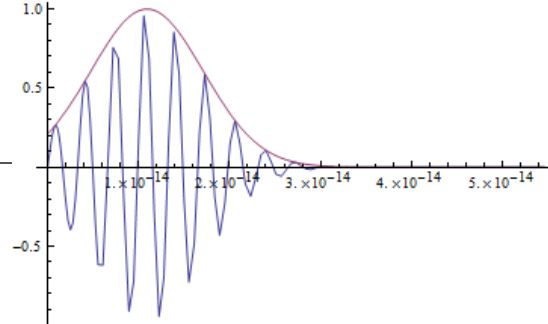GMCW(t)=g(t)*sin(wt) $\leftarrow FT \rightarrow$ $GMCW(\omega) = e^{-\frac{(\omega-\omega_0)^2}{2W^2}} e^{-j\omega t_{offset}}$

III.   Some Rules for Time offset t_{offset} ,time half-width T, and run for simulation steps(iteration number)

(1) Time offset should keep the time domain wave a full pulse, i.e. at time zero ,the corresponding startup beam amplitude should be close to zero
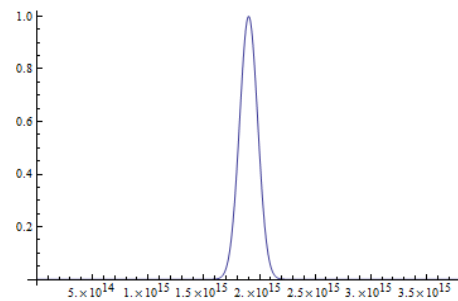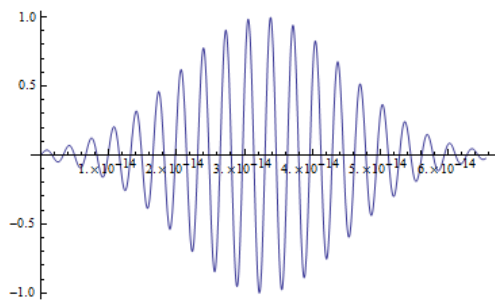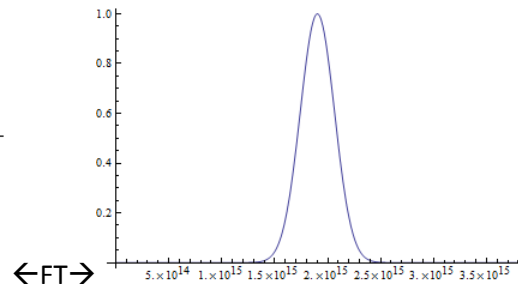

This is a full pulse.   This is not a full pulse

(2) half-width T controls the spectrum bandwidth

←FT→
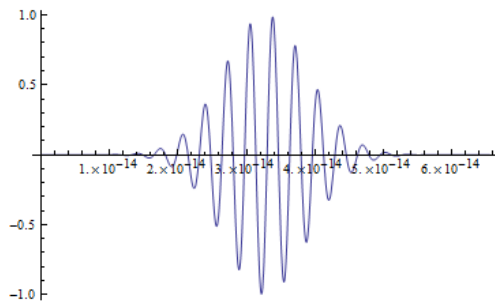
(3) half-width T cannot be too small or too larger

- If half width is too small, the GMCW pulse will become an impulse which will make the FDTD method not so stable, and the corresponding spectrum graph contain zero frequency.
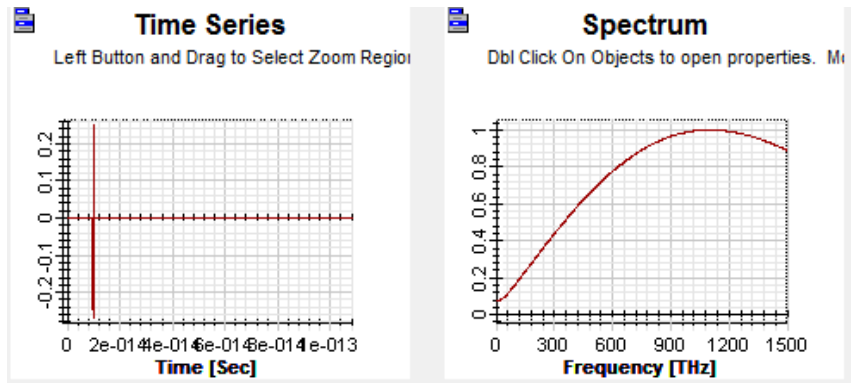
Time half width is too small

- If half width is too big, he GMCW pulse will become continues wave which the corresponding bandwidth is too narrow

Half width is too big

Obviously that GMCW pulse in (b) is an unfinished pulse

IV.   Estimate the time offset and time domain half width by formula

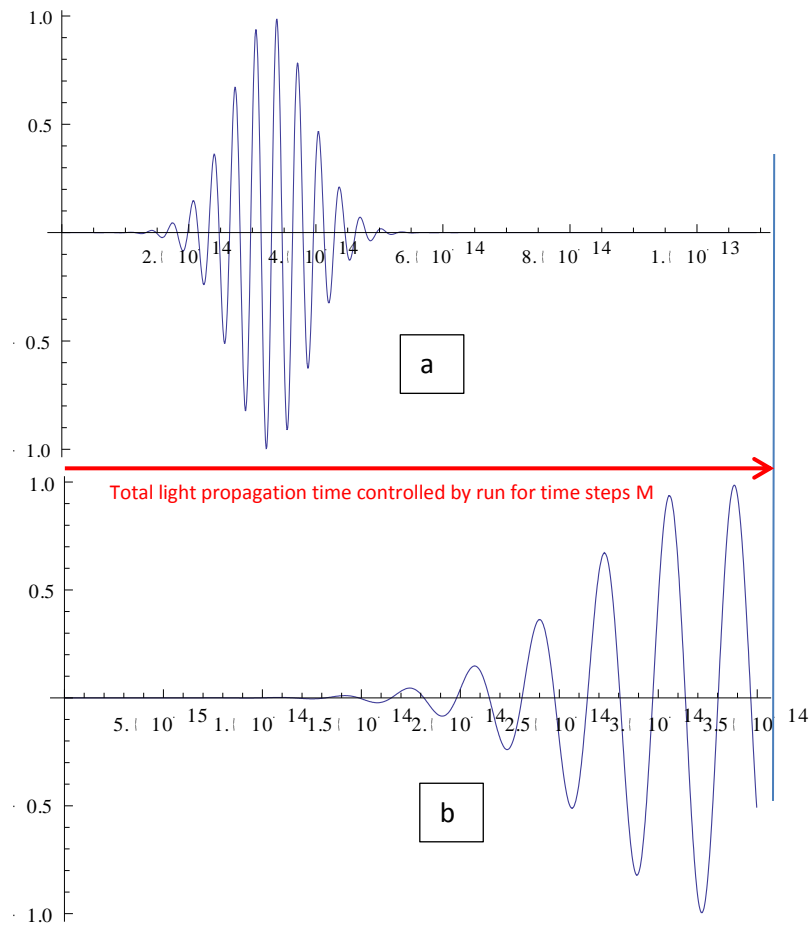(1) If the effective bandwidth (wavelength bandwidth divided the center wavelength) is less than 100%, then you can roughly use the following formula to estimate the time offset and half width

Start wavelength: λ_s

End wavelength: λ_e

Set center wavelength as

$$\lambda 0 = \lambda_s + 0.(1-0.618)*(\lambda_e - \lambda_s)$$

Angle wavelength bandwidth

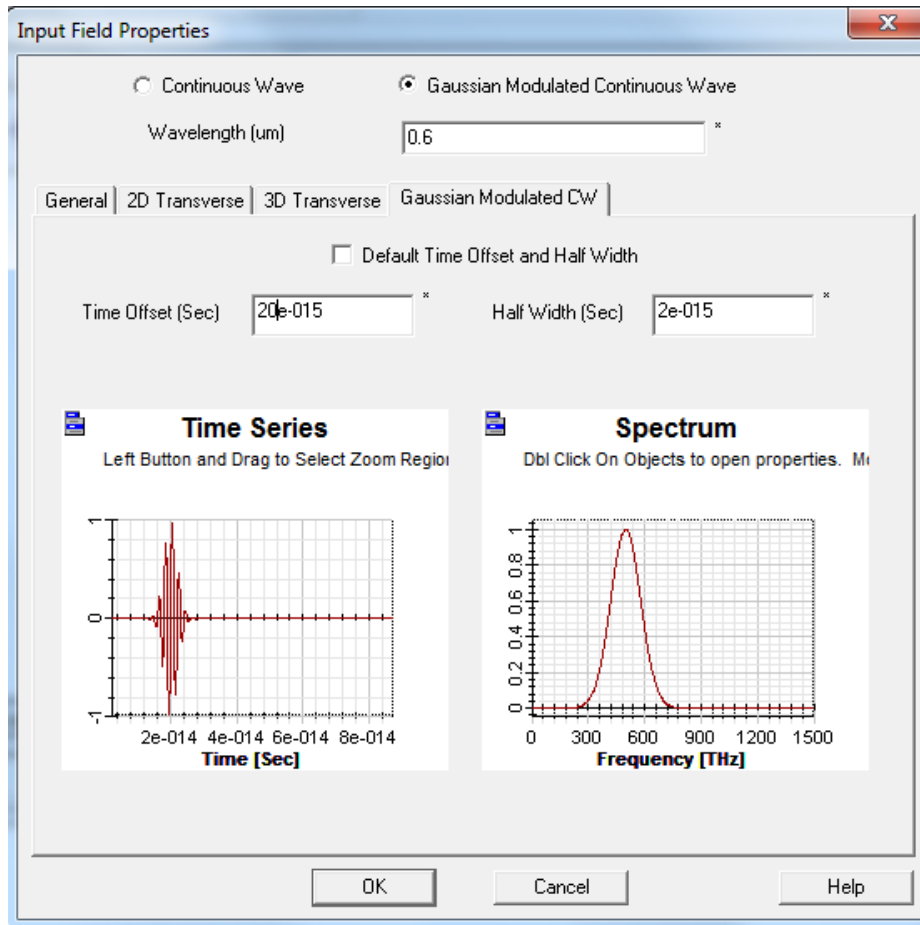$$F = 2\pi c(\frac{1}{\lambda_s} - \frac{1}{\lambda_e})$$ c is the speed of light

Time domain half width:

$$T = \frac{1}{W} = \frac{2\sqrt{2\ln 2}}{F}$$

Time offset

$$t_{offset} \geq= \frac{12\ln 2}{F}$$

V.   Set the time offset and time domain half width in OptiFDTD GUI

Input Field Properties

○ Continuous Wave   ● Gaussian Modulated Continuous Wave

Wavelength (um)   [0.6]

General | 2D Transverse | 3D Transverse | **Gaussian Modulated CW**

☐ Default Time Offset and Half Width

Time Offset (Sec) [20e-015]   Half Width (Sec) [2e-015]

Time Series
Left Button and Drag to Select Zoom Region

Spectrum
Dbl Click On Objects to open properties. Mc

Time [Sec]   Frequency [THz]

[OK]   [Cancel]   [Help]

1) Set the center wavelength.
2) Select "Default time offset and half width" to get some initial value. Default setting can make a 50% of the effective bandwidth.
3) unselect "Default time offset and half width" ,
4) Right click on the spectrum graph and select the zoom tool, Select the zoom in area to calculate the corresponding half width point. Calculate the bandwidth
5) Change the half width value a little bit, read the spectrum bandwidth again, do this step until you can get the desired bandwidth
6) Change the time offset value to make the pulse as a full pulse.