CrystalWave Examples

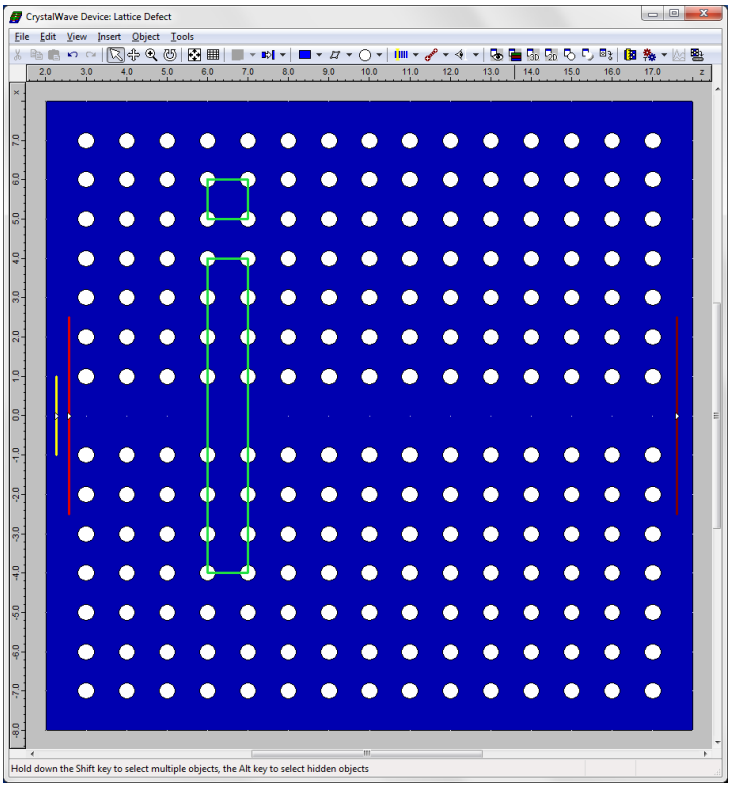
Calculating the Modes of a Line Defect in a Photonic Crystal

PCLineDefectMode.prj

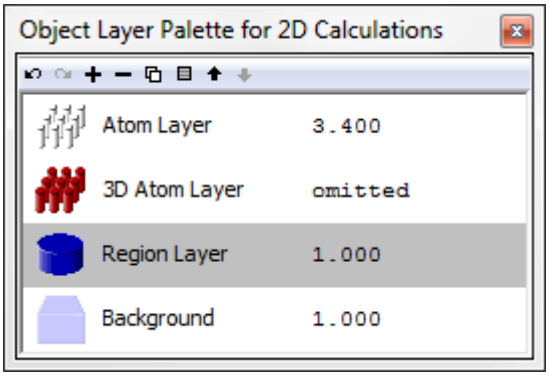
Calculating the modes of a line defect in a photonic crystal with Crystalwave

➢ Open the project PCLineDefectMode.prj in CrystalWave and double-click on "Lattice Defect".

The CrystalWave Device will open. The structure is a photonic crystal with a square 2D lattice of AlGaAs rods in which a line defect has been created. The lattice period is set to 1um and the hole diameter to 0. 4um, providing a large band gap for the TM polarisation.



➢ Go to the menu and select /View/Object Layer Palette for 2D calculations.



This palette tells you how the structure is defined for 2D calculations. In this case the dark blue areas have a refractive index of 1.0 whilst the white holes have a refractive index of 3.4.

The yellow line is a plane wave excitor from which a pulse of light centred on a wavelength of 1.55um will be launched. The red lines are sensors, which will monitor the field during the calculation.

There are two unit cells (green cells) in the lattice, the first one surrounding the unit cell of the lattice and the second one centred on the lattice defect.

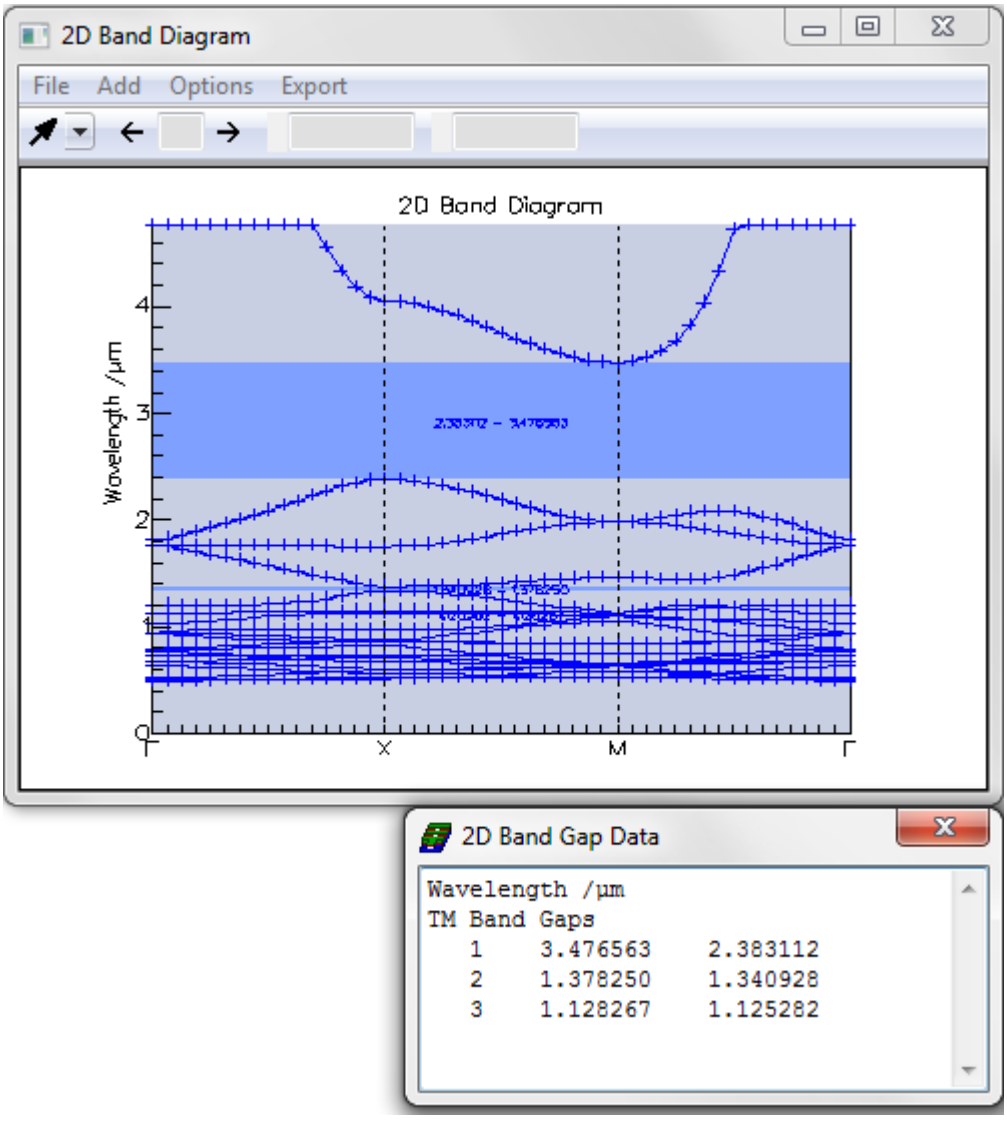
We will first calculate the band structure for the lattice.

- In the CrystalWave Device, right-click on the small green unit cell at the top and select \Band Solver…

The "Band Solver for 2D Lattices" will open. It is set up to calculate 20 bands for the TM polarisation.

- In the "Controls" tab, select "wavelength" then click on "Calculate".

After a little while, a 2D Band Diagram will appear, showing a large TM band gap (blue area) between 2.381um and 3.477um.

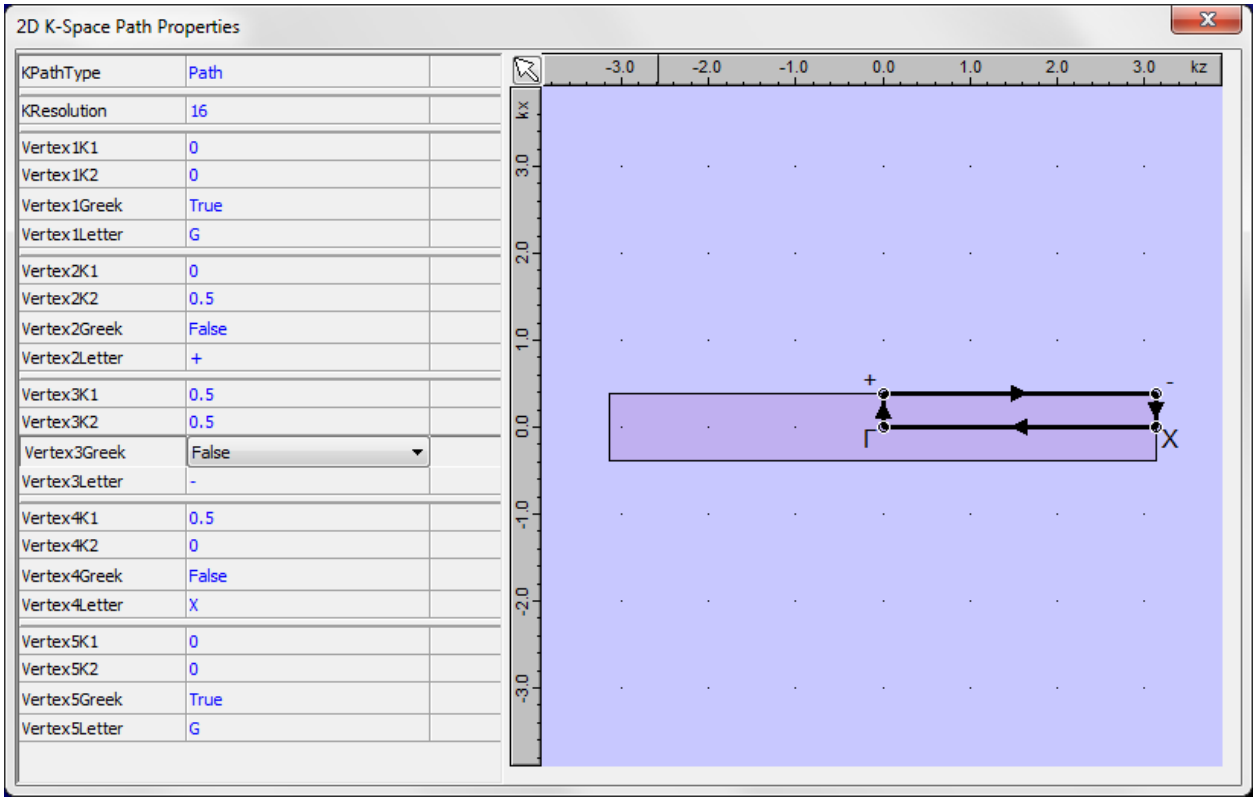


We will now calculate the band structure for the line defect.

- In the CrystalWave Device, right-click on the large unit cell in the centre of the structure and select \Band Solver…

The "Band Solver for 2D Lattices" will open. It is set up to calculate 20 bands for the TM polarisation; note that the resolution has been adjusted to account for the length of the unit cell along the X and Z directions.

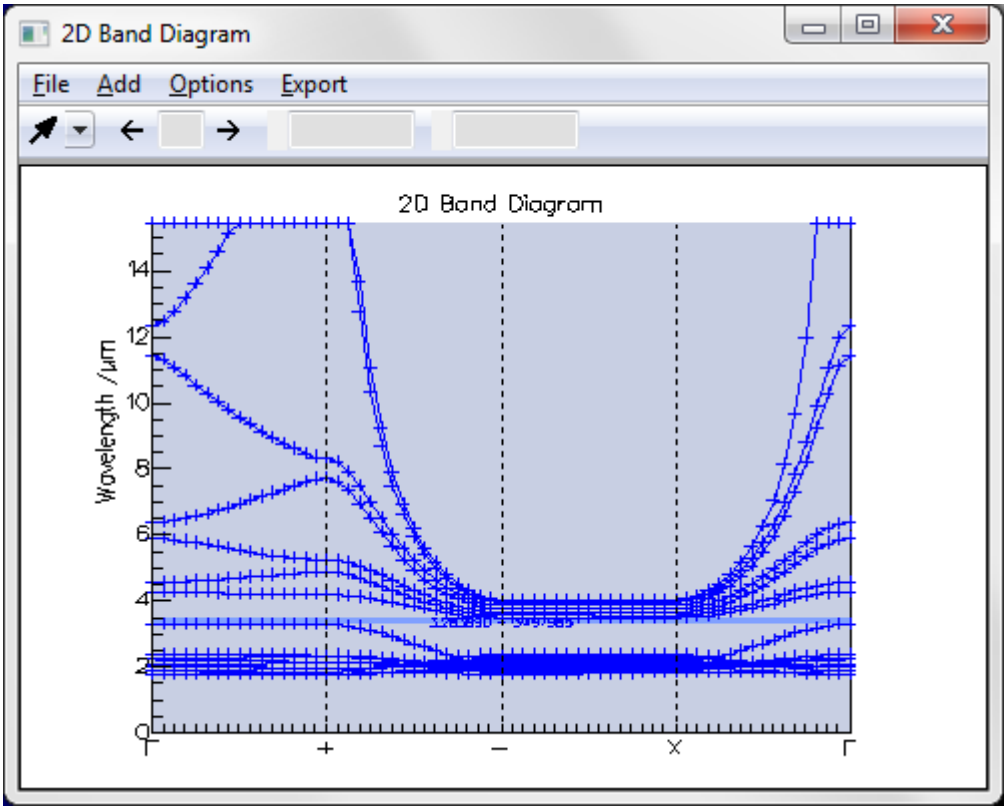
- Double-click on the box next to "KPath". The 2D K-Space Path Properties will appear.



You can see that the K-Path has been set to cover the irreducible Brillouin zone. As we are interested in modes propagating along the lattice defect along the Z-direction, we will not consider the band points for which kz = 0, i,e, the part of the band diagram located between the points "Γ" and "+".

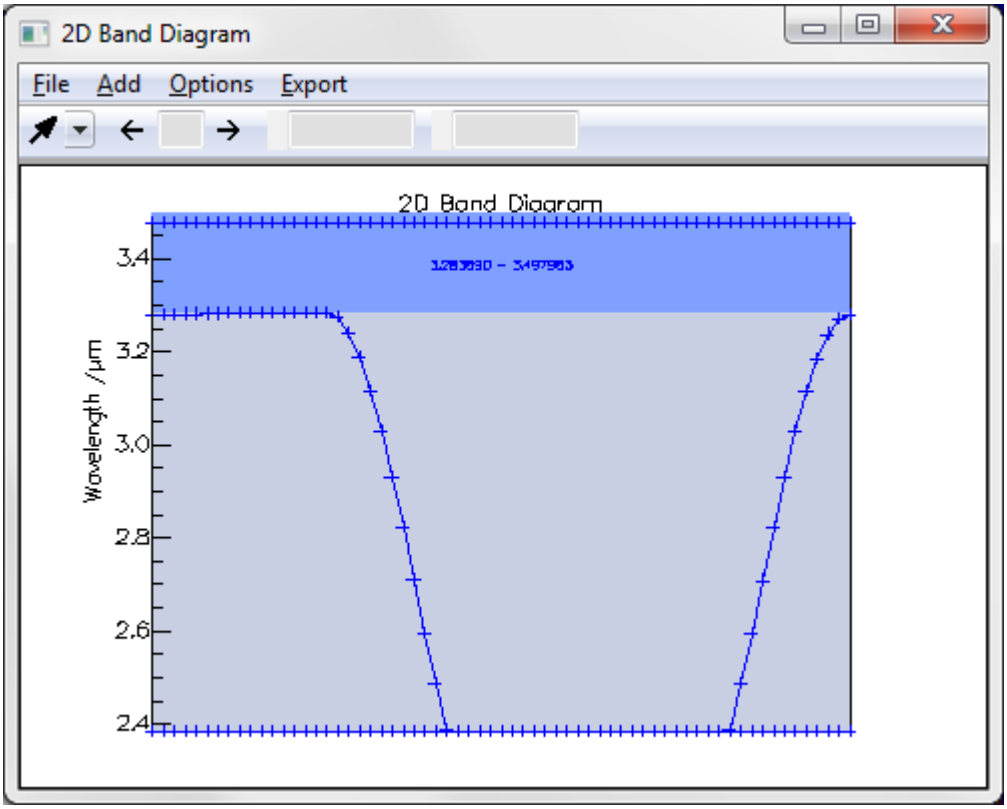
- Close this dialog.
- In the "Controls" tab, select "wavelength" then click on "Calculate".

After a while, a 2D Band Diagram will appear. We will want to inspect the part of the band diagram that overlaps with the band gap from the lattice.



- Right-click on the Band Diagram chart and select "\Options\Chart…", then click on the "Edit" button next to the first data line "Y1".
- Set Minimum to 2.383 and Maximum to 3.477, then click "OK" and "OK" again.

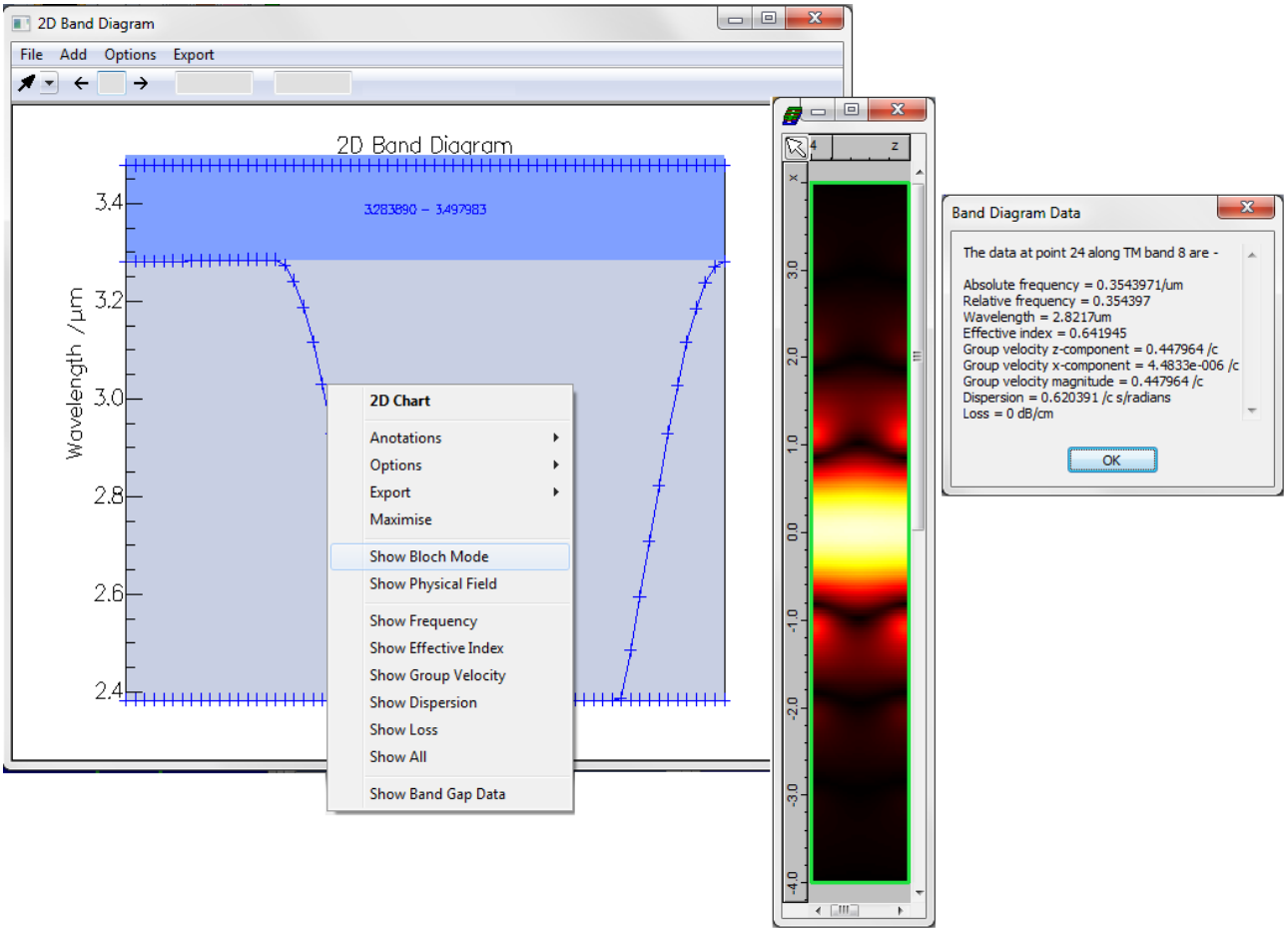
You should now see the following:



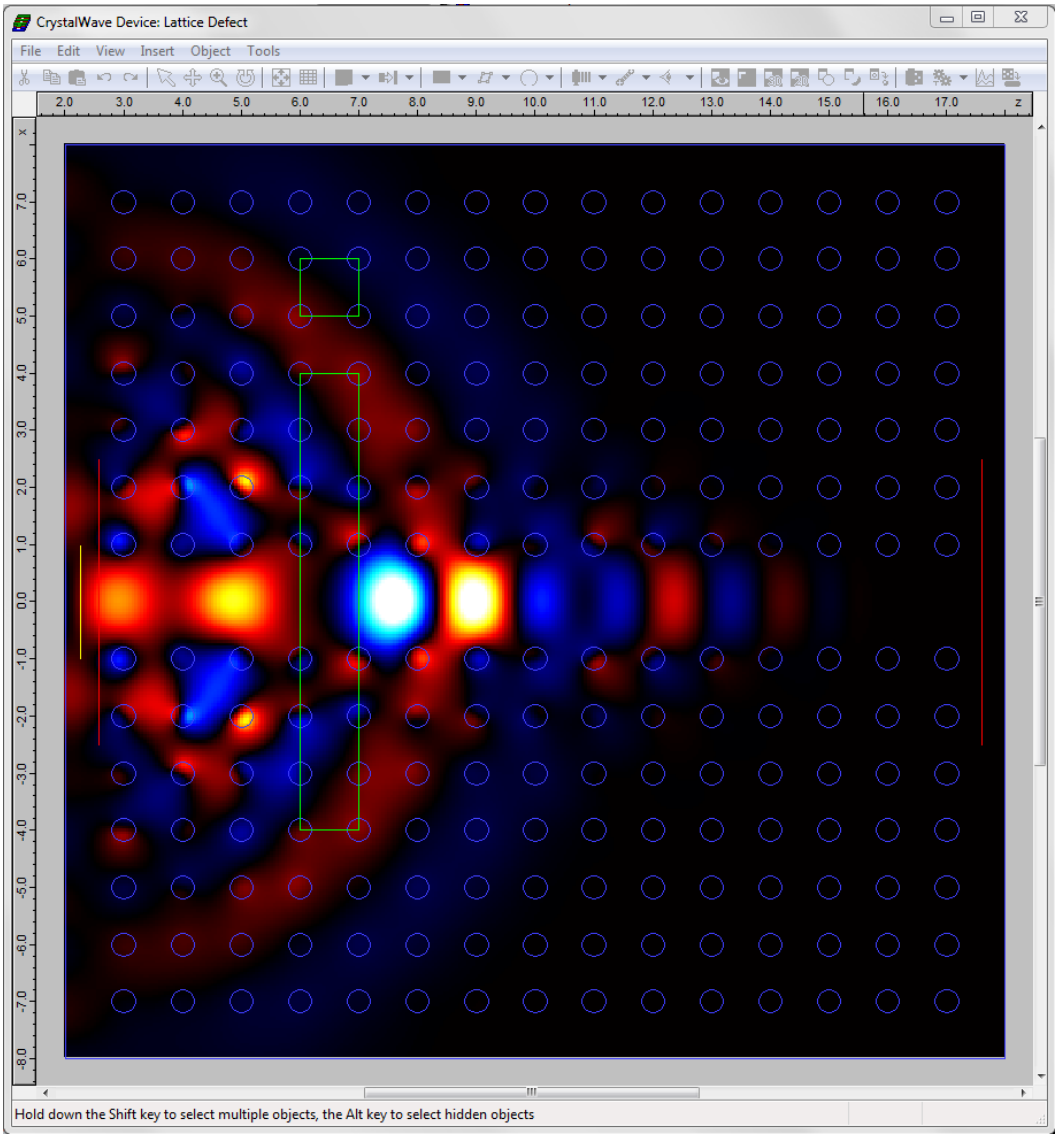
This reveals the band along which the guided modes can be found. The first quarter of the data corresponds to kz=0, i.e. to the evanescent modes. In the second and fourth quarter of the band you can find the guided Bloch modes, which are supported for wavelengths varying between 2.3831um and 3.2839um, the lower limits of the band gap of the first and second unit cells, respectively.

- Right-click on a point of the band and select "\Show Bloch mode" and "\Show All".

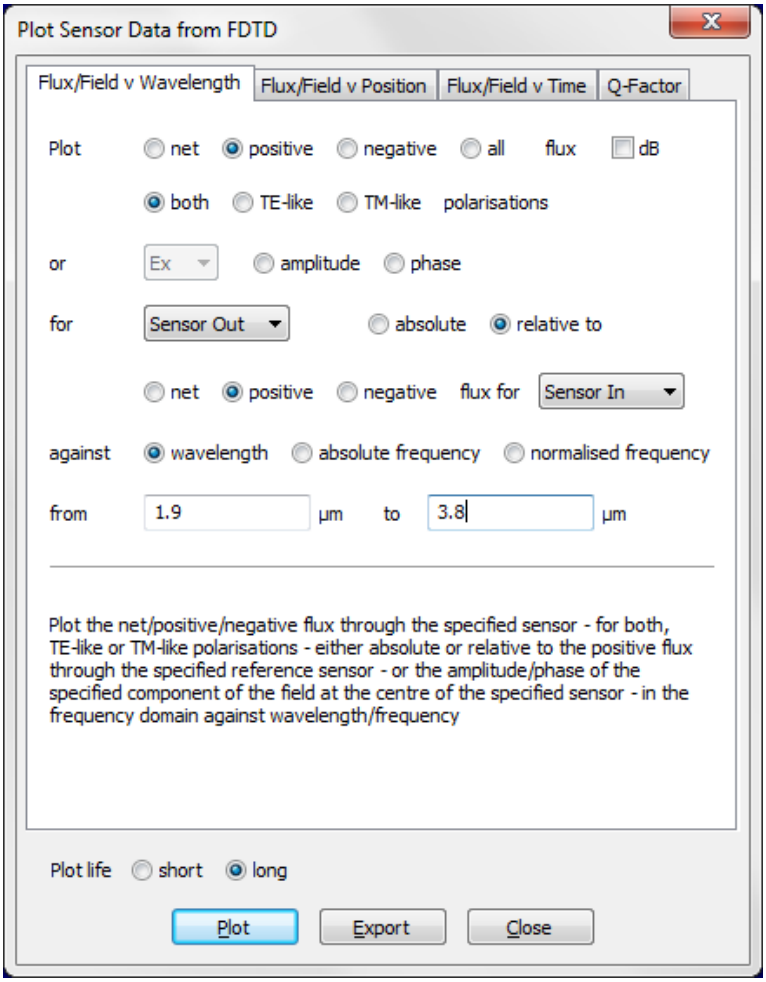
This will display the Ey field profile of the Bloch mode and the band point data for this point in the band, including the effective index of 0.641945, the group velocity and the dispersion.



- Close the band solver, right-click on the excitor and select "\Edit Properties…": you can see that the excitation is a sinusoidal pulse centred on the middle of the wavelength range that supports modes and width a bandwidth that is twice as wide.
- Open the FDTD Calculator and run the FDTD Calculation. If you plot the Ey field during the calculation, you will be able to see the light guided in the lattice defect and the light propagating in the photonic crystal lattice.



- Once the calculation is completed, close the FDTD Calculator.
- Right-click on one of the sensors and select "\Plot Data". In the tab "Flux/Field v Wavelength", choose the settings as below and click "Plot".



The chart below will appear, showing a high transmission for the range of wavelength 2.3831um to 3.2839um for which guided modes are supported.