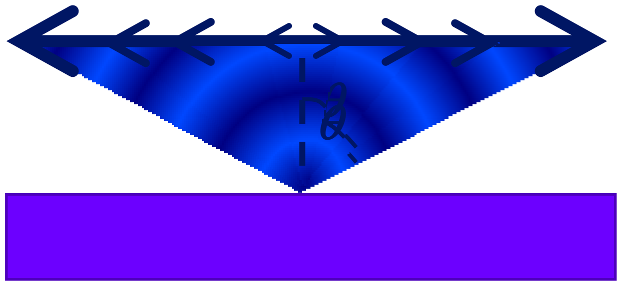
Nova Challenge – OCD microscope

Nova challenge – sub-diffraction microscope

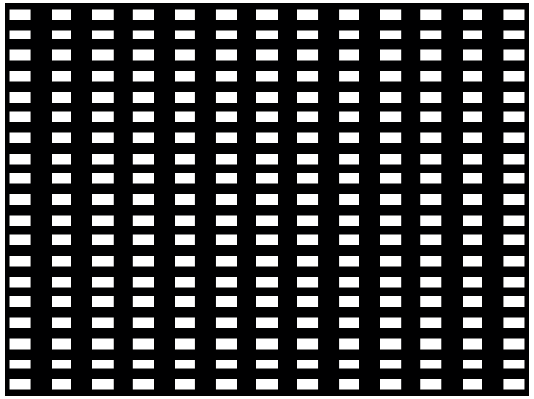
- The diffraction limit presents a stringent limitation on optical imaging systems
- Simply put, it can by stated as follows:

A microscope is a perfect low pass filter



Maximal spatial frequency $= \frac{2\pi}{\lambda}\sin\theta$

Sample



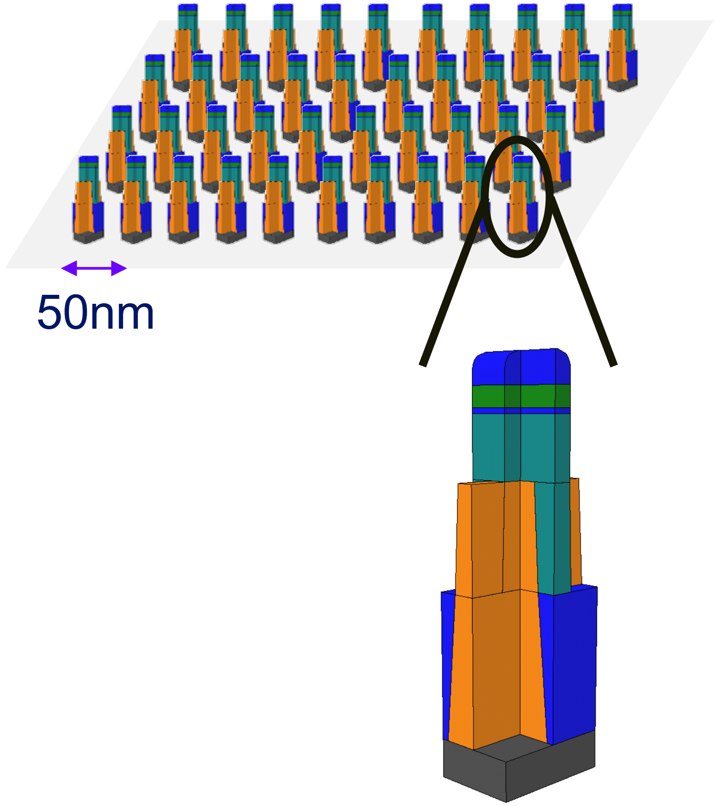
Image

Nova challenge – sub-diffraction microscope

- Consider a periodic array of identical elements
  - Extending indefinitely

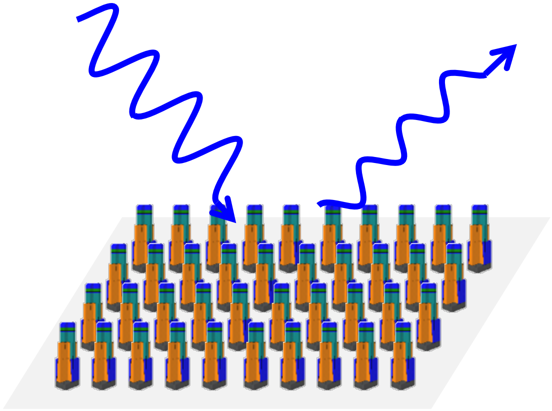
- Each element can have a complicated geometry and made from different materials

- The grating pitch is small, *significantly* below the diffraction limit (~50nm)
- Due to the diffraction limit, a microscope image of the structure will show *no structure*



Nova challenge – sub-diffraction microscope

- However, you have at your disposal a wondrous *optical* measurement system:
  - You can illuminate the structure at any angle, using any polarization and a broad wavelengths range, and measure the reflection at any angle and polarization
  - You can measure both the amplitude and phase of the reflected light
  - You can take as many measurements as you want
  - You have as many identical samples as needed, and you can do whatever to them
  - However, wavelength range is limited to the range $200<\lambda<2000$nm



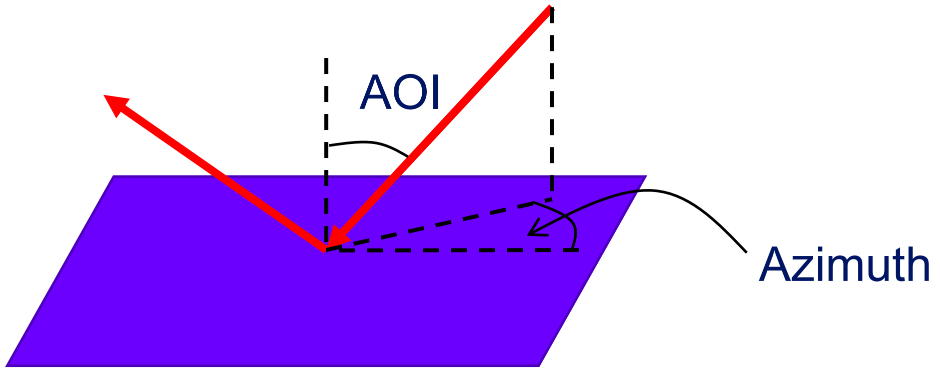
The challenge

- What can you say about the measured structure?
  - Can you say anything about the geometry (outer or internal) and materials?
- You can assume the grating period is known
- If beneficial, you can assume the grating is translationally invariant in one direction

- As an example, you are provided with a set of such reflected fields for the range of wavelengths, two polarizations ('s' and 'p') and various azimuths and AOIs

Explanation of provided data

- Provided are the four elements of the sample Jones matrix
  - These are complex entries, representing the field reflectivity for different incident and reflected polarizations
  - The reflected intensity at any given polarization is given by $|J_{ij}|^2$
- These elements are provided for a range of wavelengths, and different Angles Of Incidence (AOI) and Azimuths
  - The sample is assumed to be periodic, with no reflected high-orders
  - Consequently, only specular reflection exists



Explanation of provided data

- Data is provided in two formats:
  - Excel:
    - Four files, for a each Jones matrix component
    - Each sheet corresponds to a different AOI, and in it are the values of the Jones matrix for different wavelengths and azimuths
  - Matlab:
    - One file, holding the variables:
      - WL: a [1 x n] vector of wavelengths
      - AOI: a [1 x t] vector of angles-of-incidence
      - Azimuths: a [1 x z] vector of azimuths
      - J_ij (with i,j=x or y): four [t x z x n] matrices holding the Jones matrix entries for the different WLs, AOIs and azimuths