Super-resolution microscopy

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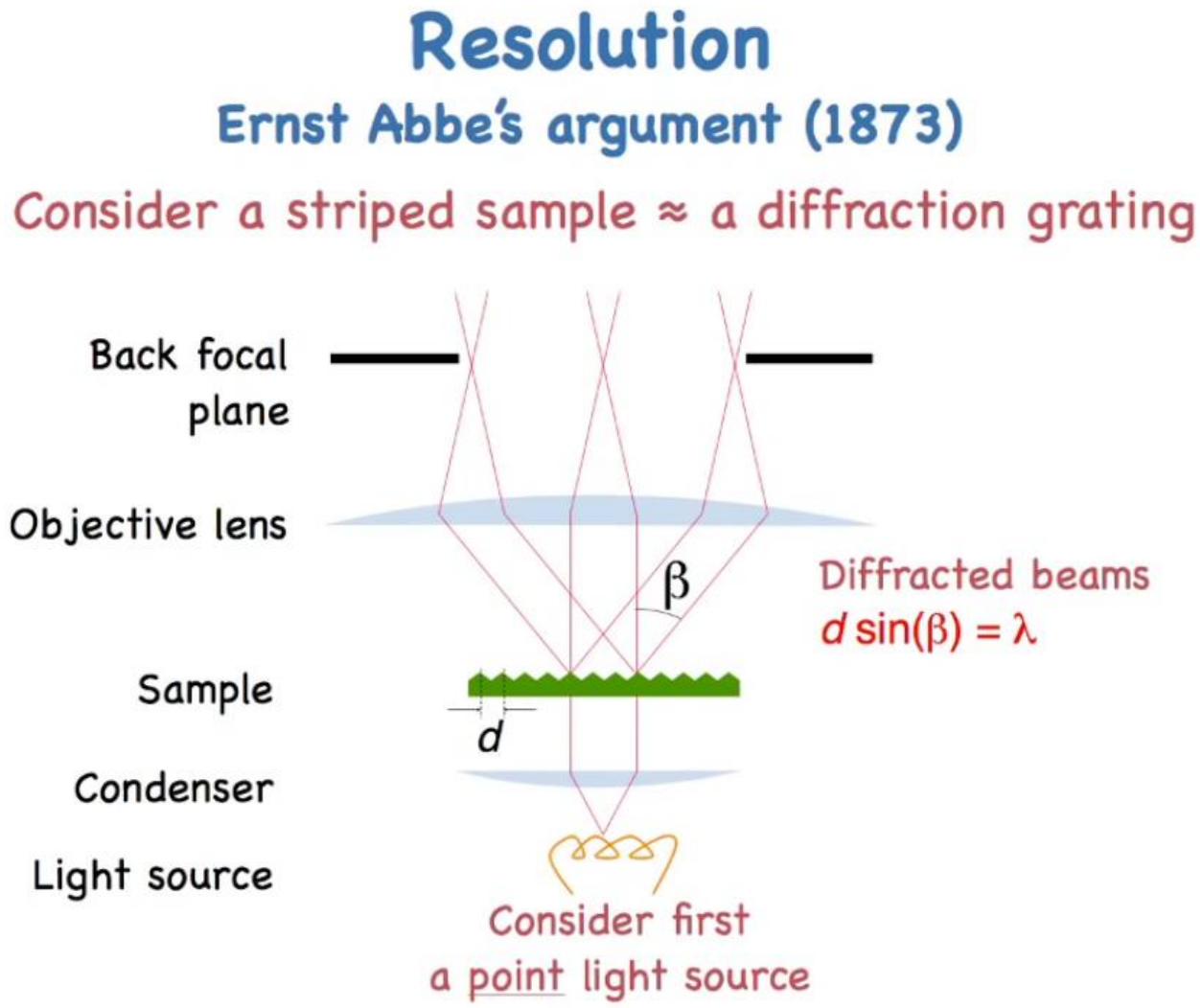
The Abbe diffraction experiment

Ernst Abbe
(1840-1905)

The Abbe diffraction experiment

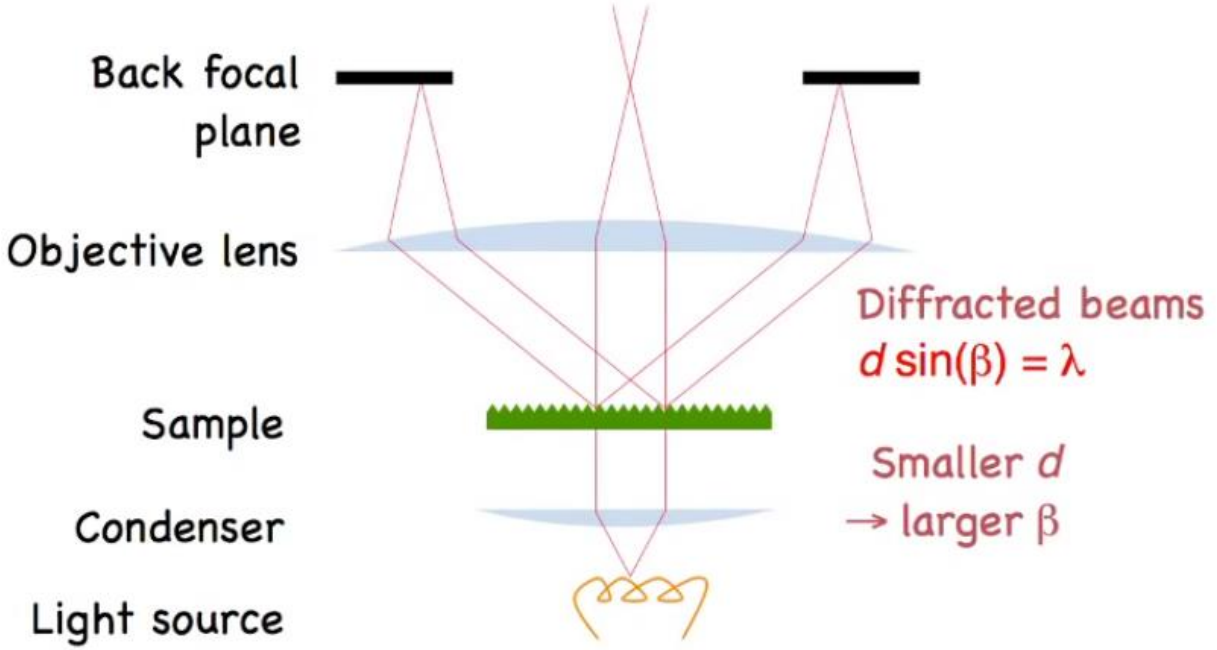


The Abbe diffraction experiment

Resolution

Ernst Abbe's argument (1873)

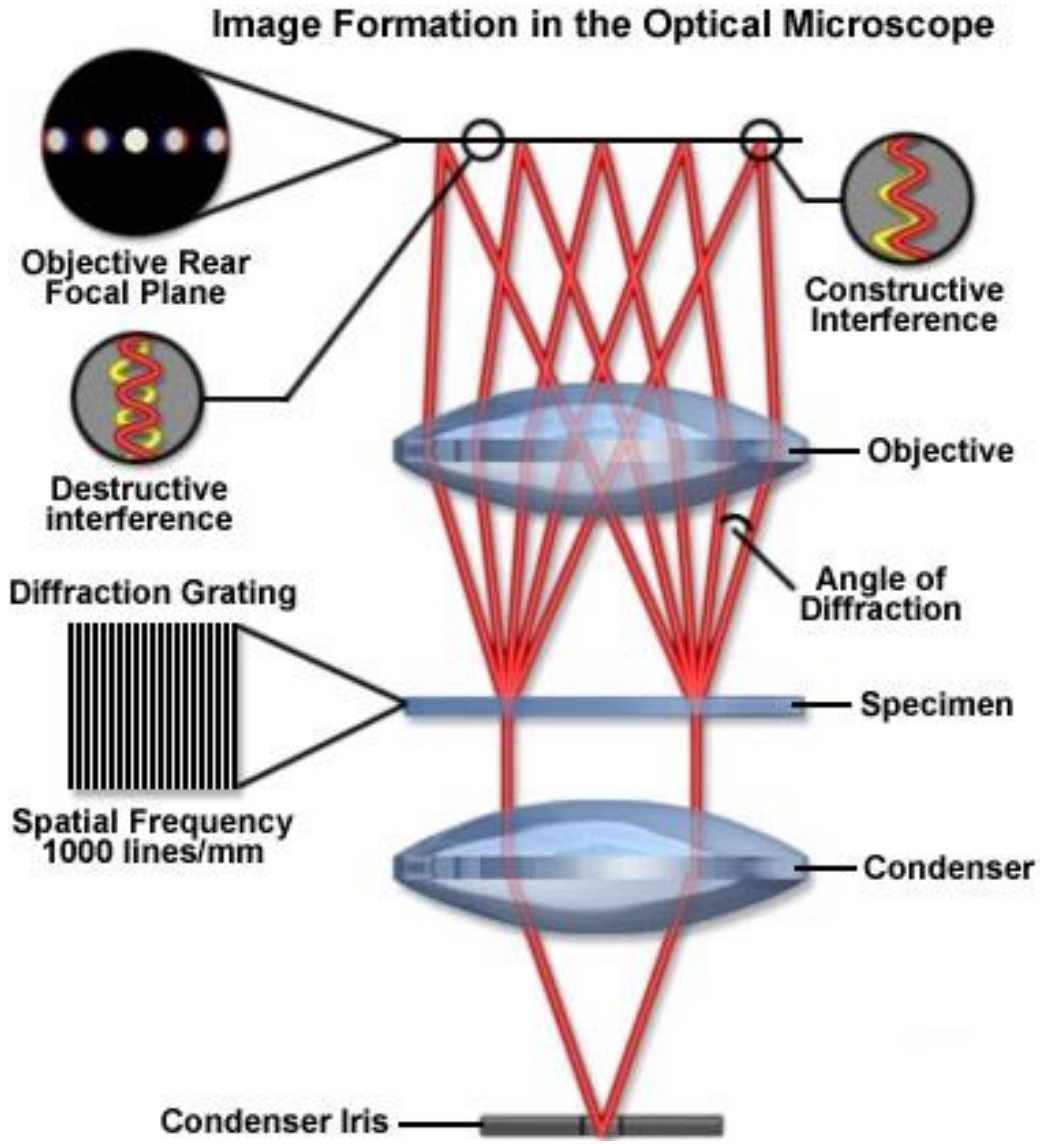
Consider a striped sample ≈ a diffraction grating

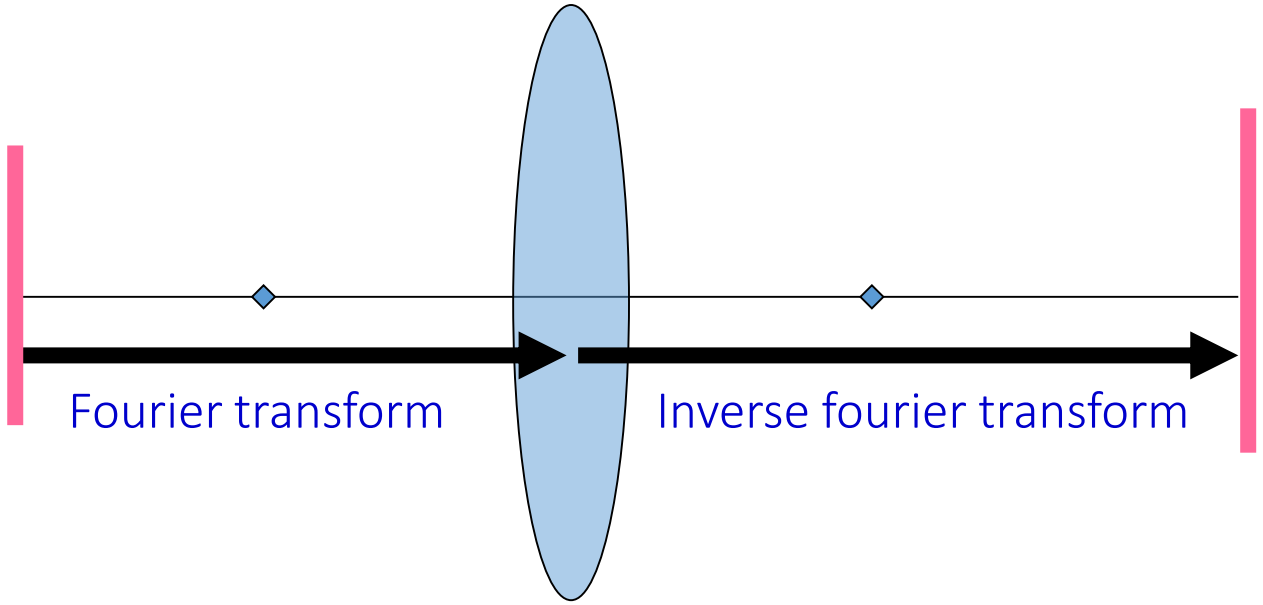


If $\beta > \alpha$, only one spot makes it through
⇒ no interference ⇒ no image formed

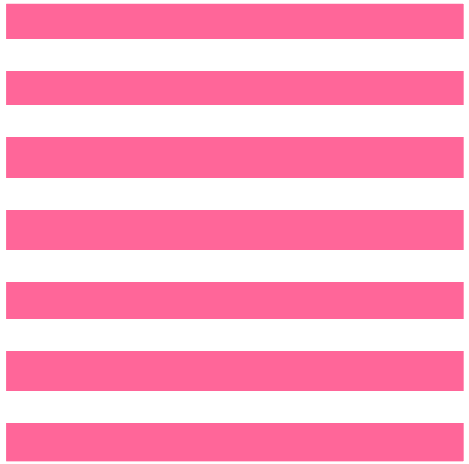
Resolution limit:
$\lambda/n \sin(\alpha) = \lambda/NA$

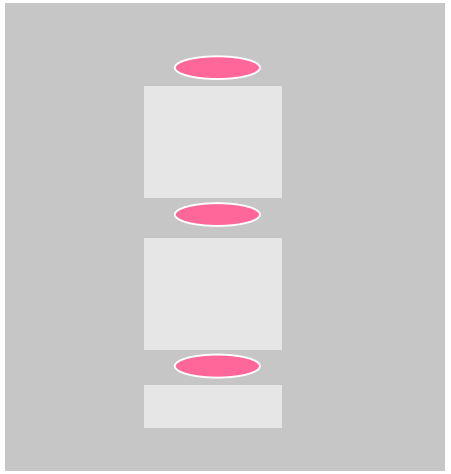
The Abbe diffraction experiment

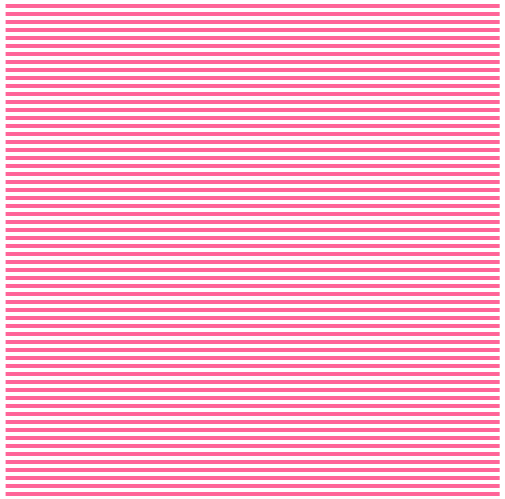




The image results from the number, position and orientation of the diffracted spots







What would happen if blocked some of the spots?

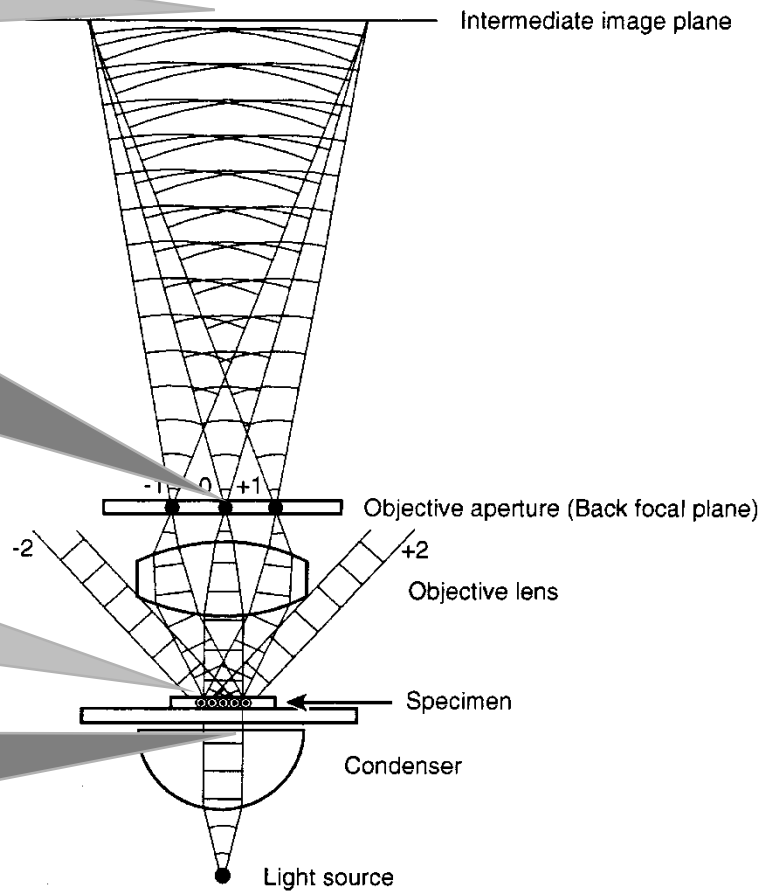
Imaging a linear grating

Intermediate Image: Formed by interfering waves from –1, 0, +1 orders

Back Focal Plane: Diffraction pattern, formed by objective (multiple images of the source as a result of line spacing)

Specimen: Slide with periodic lines. Spacing determines diffraction angles.

Condenser: Produces parallel wave front at 0° (aperture is closed down to a pinhole).



"Illumination Path"

Abbe:
“the microscope image is the interference effect of a diffraction phenomenon”

Thanks