

A stone sphere with geometric patterns and a formula, resting on a pedestal with a plaque for Ernst Abbe. The sphere is inscribed with the formula  $d = \frac{\lambda}{2 \sin \alpha}$  and the name 'Abbe'. The pedestal has a plaque that reads 'ERNST ABBE 1840-1905 FRIEDRICH SCHILLER UNIVERSITÄT JENA'. The background shows a building with a staircase and a lawn.

# Super-resolution microscopy Humberto Cabrera

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## The Abbe diffraction experiment



Ernst Abbe  
(1840-1905)

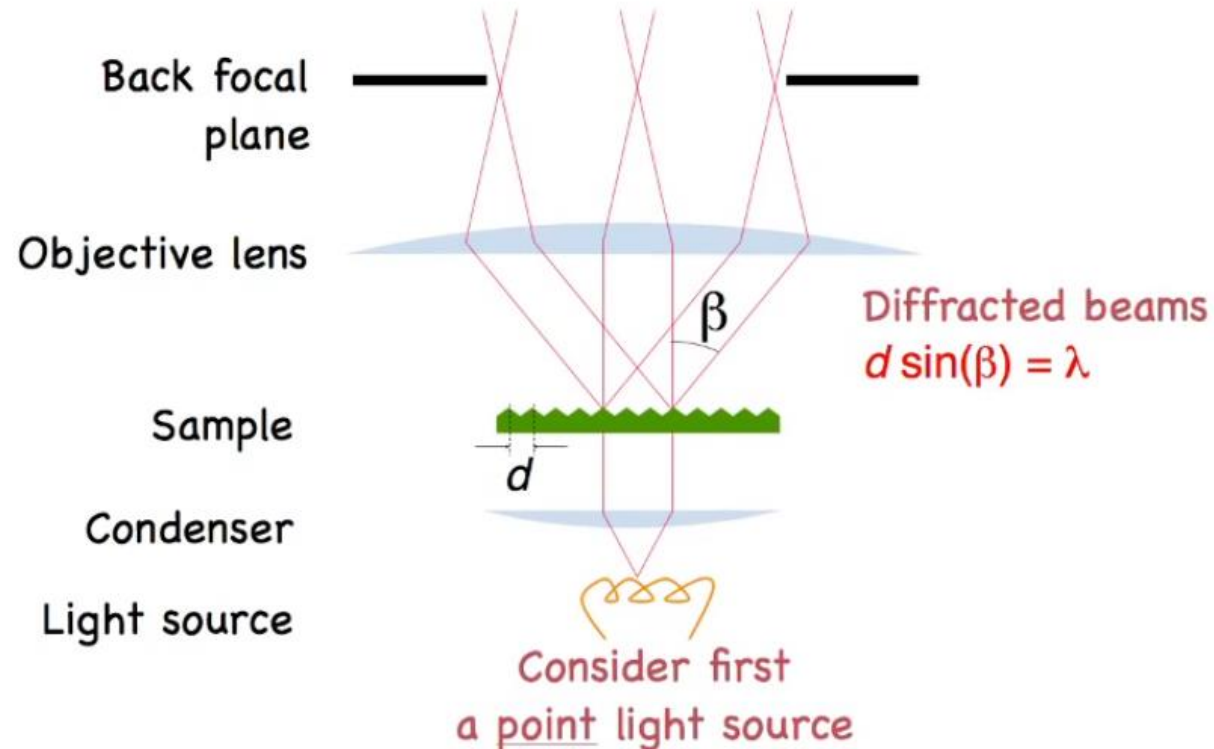


# The Abbe diffraction experiment

## Resolution

Ernst Abbe's argument (1873)

Consider a striped sample  $\approx$  a diffraction grating

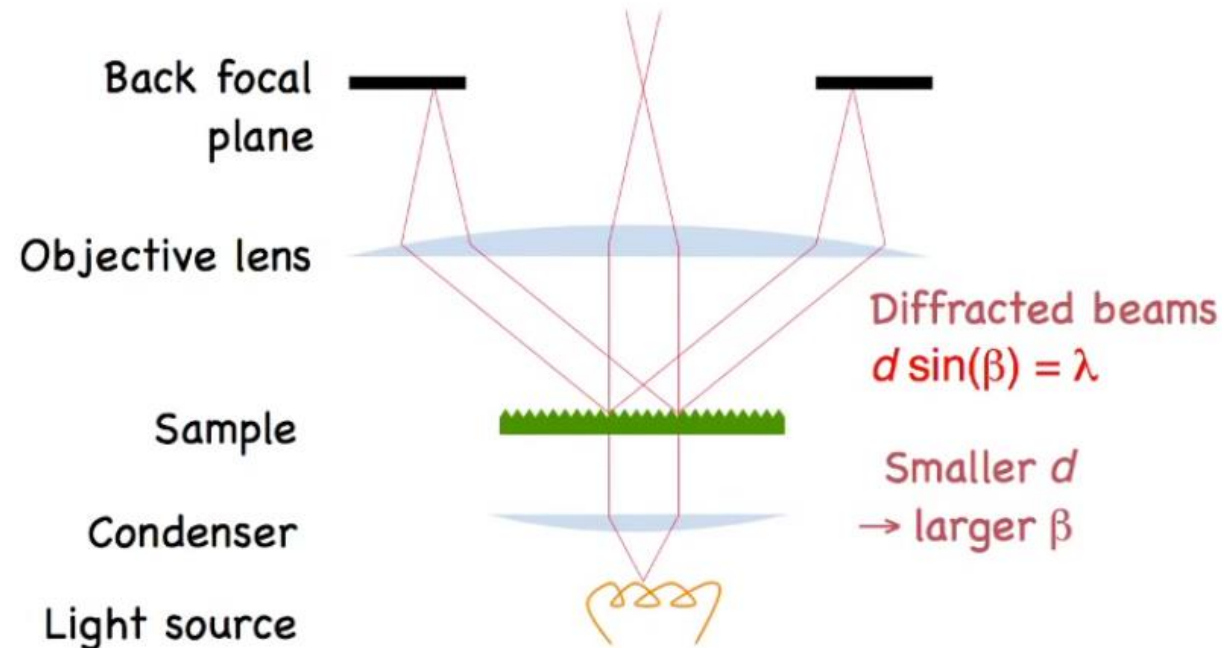


# The Abbe diffraction experiment

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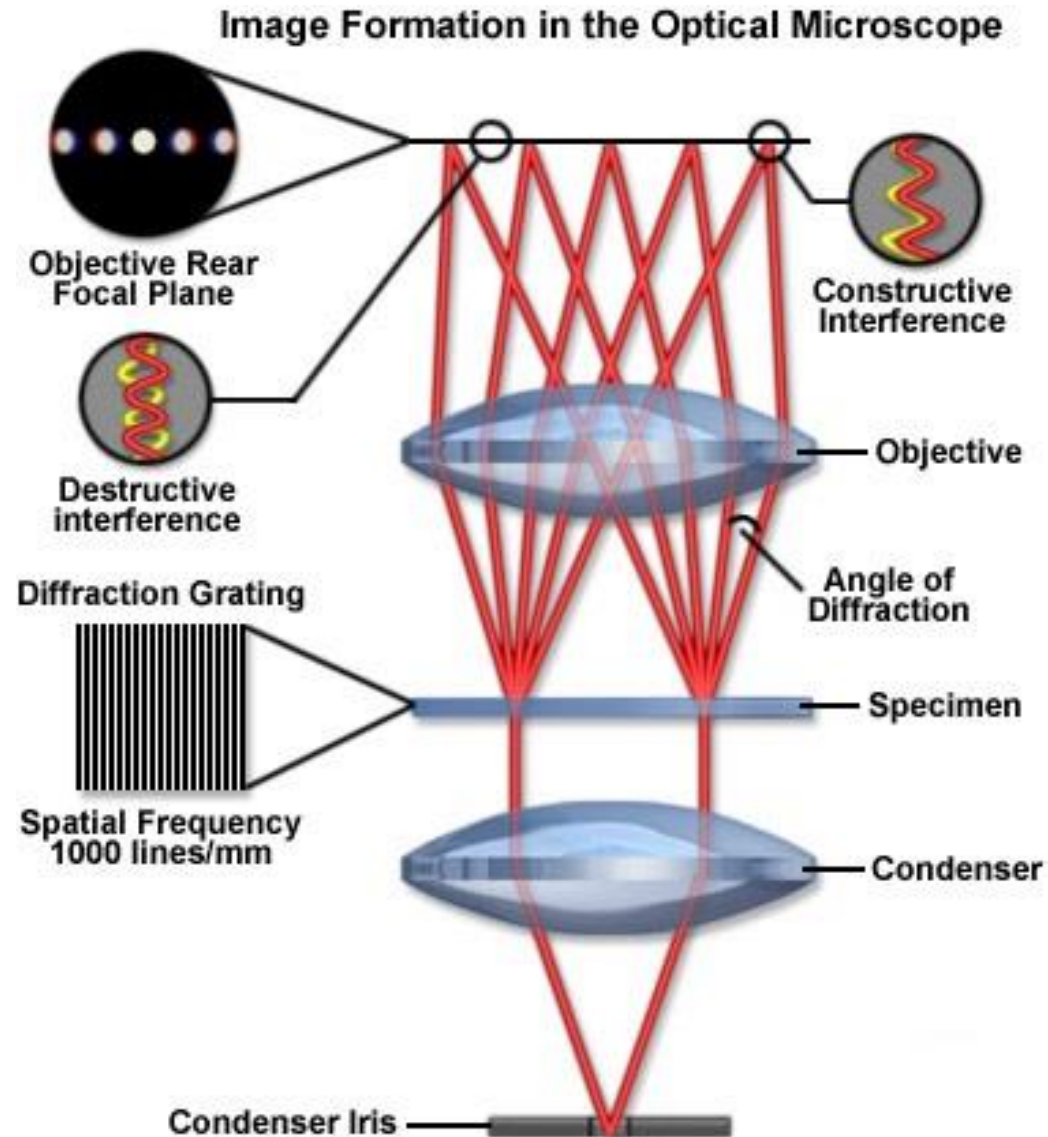
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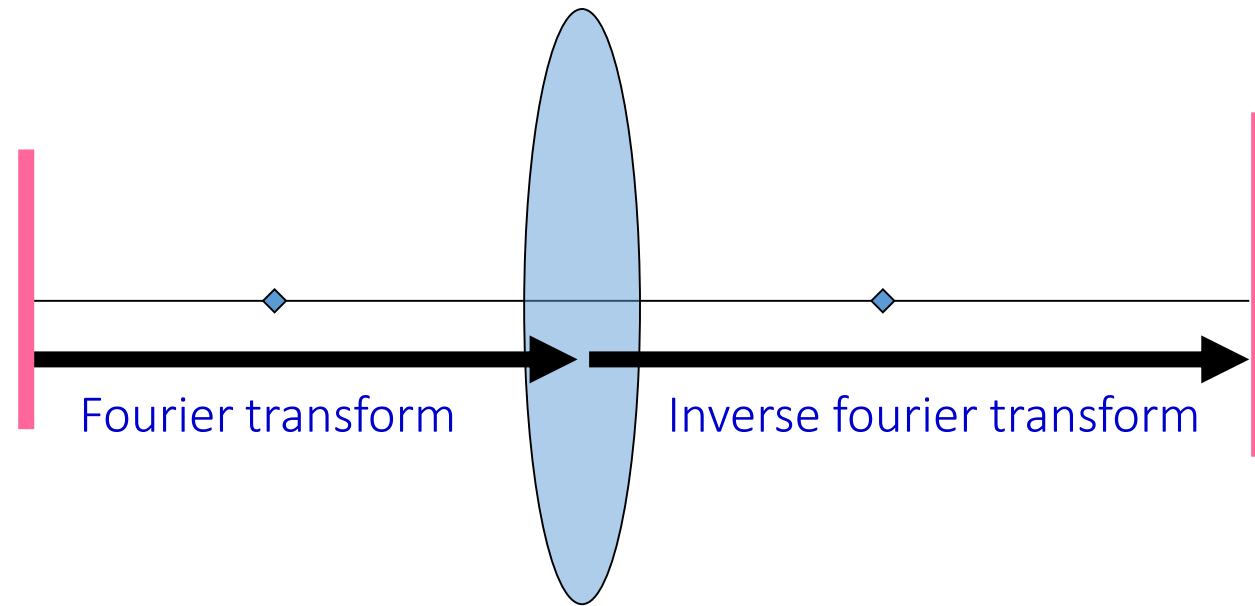


If  $\beta > \alpha$ , only one spot makes it through  
 $\Rightarrow$  no interference  $\Rightarrow$  no image formed

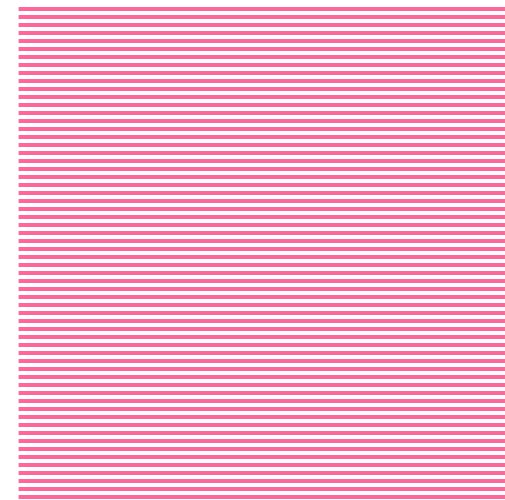
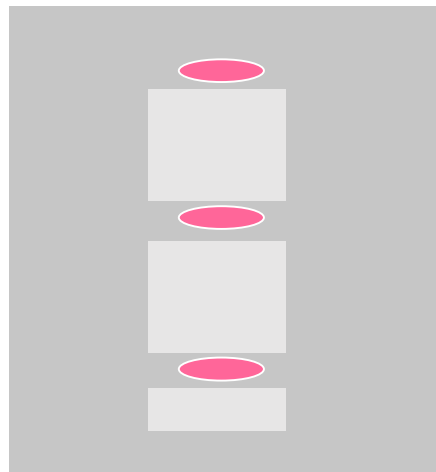
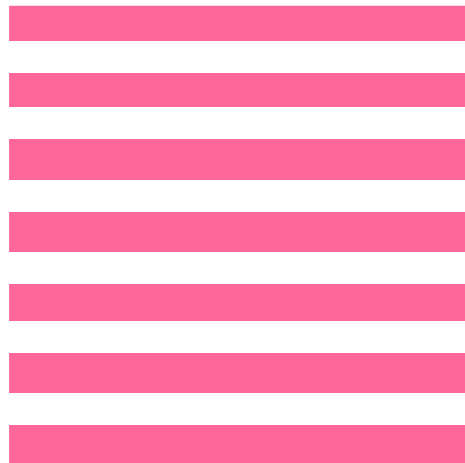
Resolution limit:  
 $\lambda/n \sin(\alpha) = \lambda/NA$

# 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?

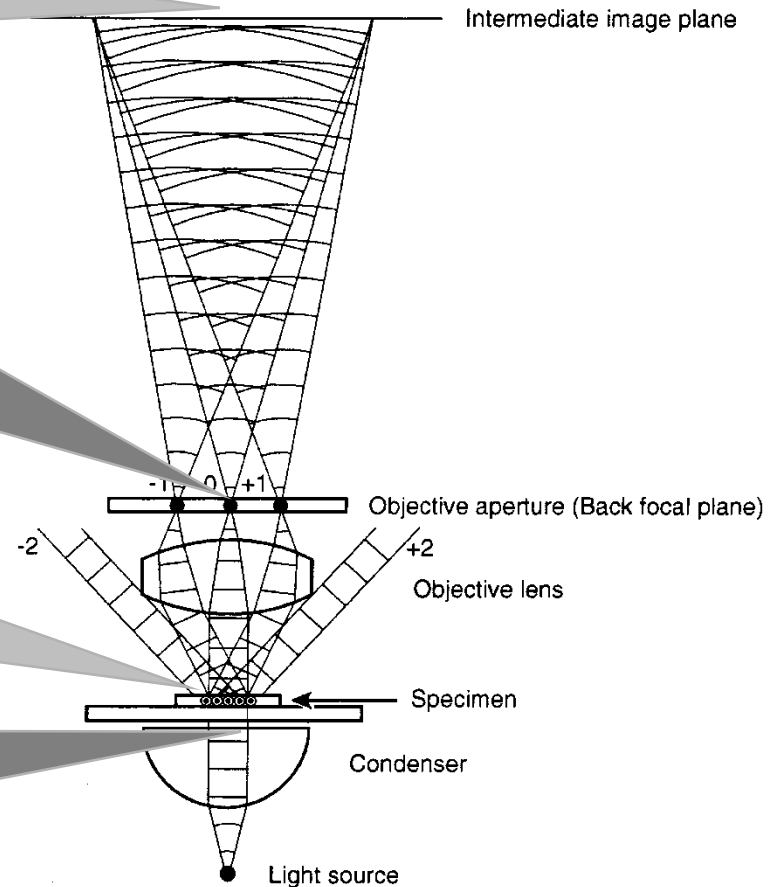
# Imaging a linear grating

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  $0^\circ$  (aperture is closed down to a pinhole).



“Illumination Path”

**Abbe:**

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



**Thanks**