Diffraction & Interference: Experimenting with Various Apertures

Advanced Lab II

Spring 2006

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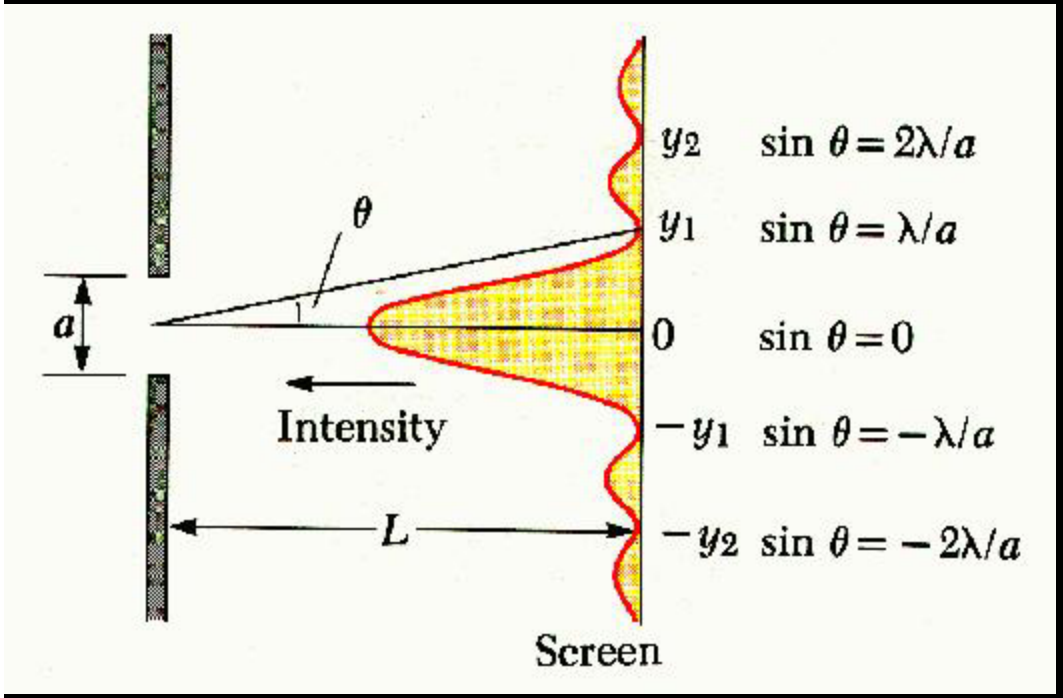
Rectangular Apertures

Single Slit Diffraction

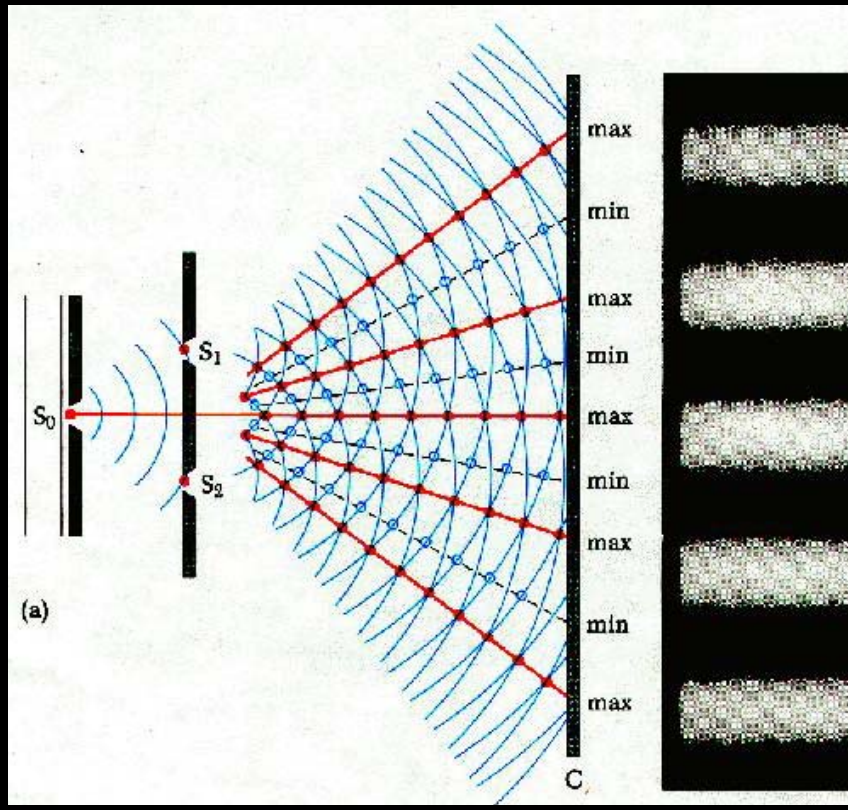
Light rays coming from different parts of the slit have different path lengths, causing the diffraction pattern.



http://www.physics.utoledo.edu/~ljc/interf03.jpg

Double Slit Interference

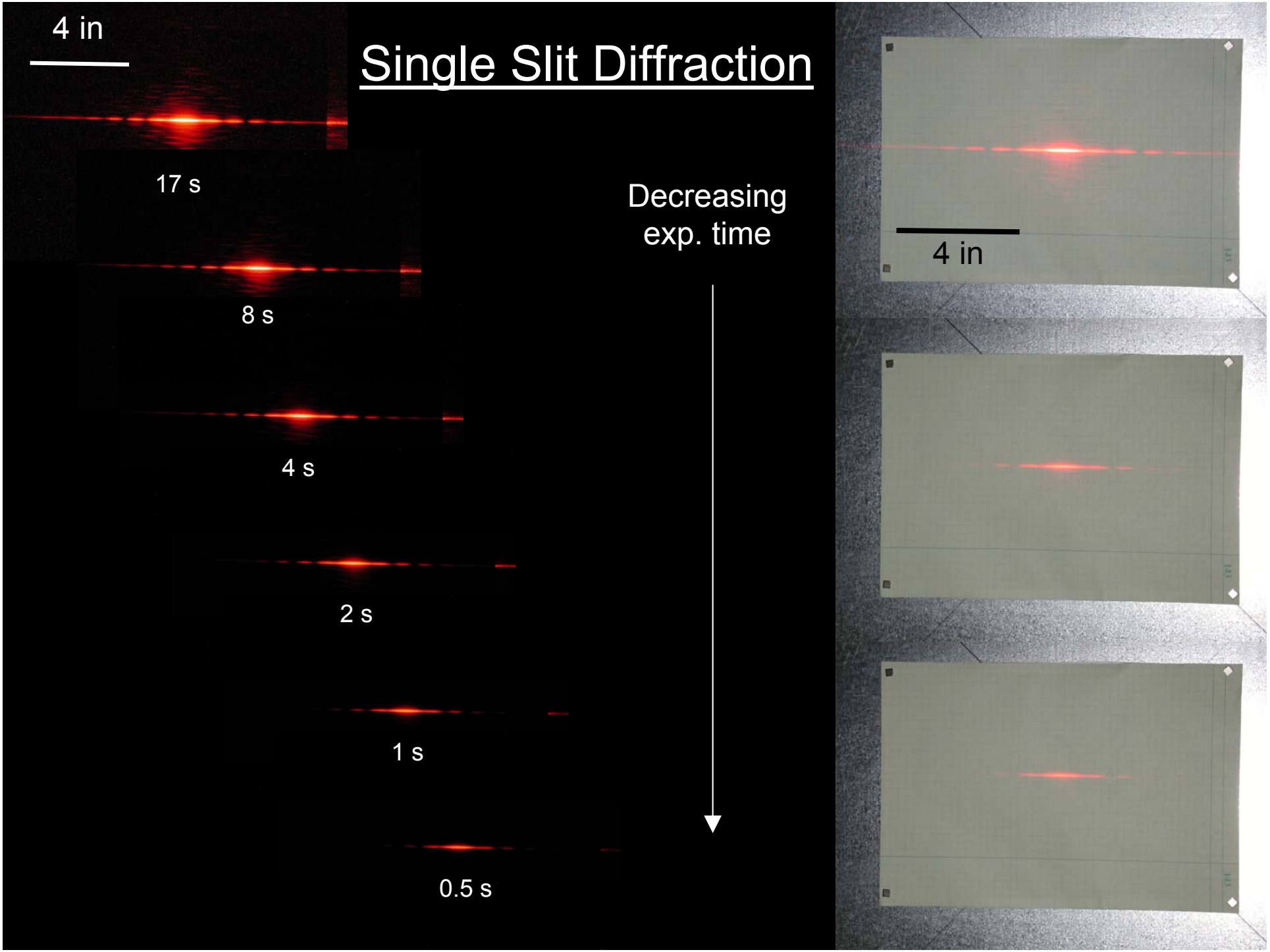
Light from the 2 slits spreads via Huygen's principle, and the spreading wavefronts interfere.



http://www.physics.utoledo.edu/~ljc/interf02.jpg

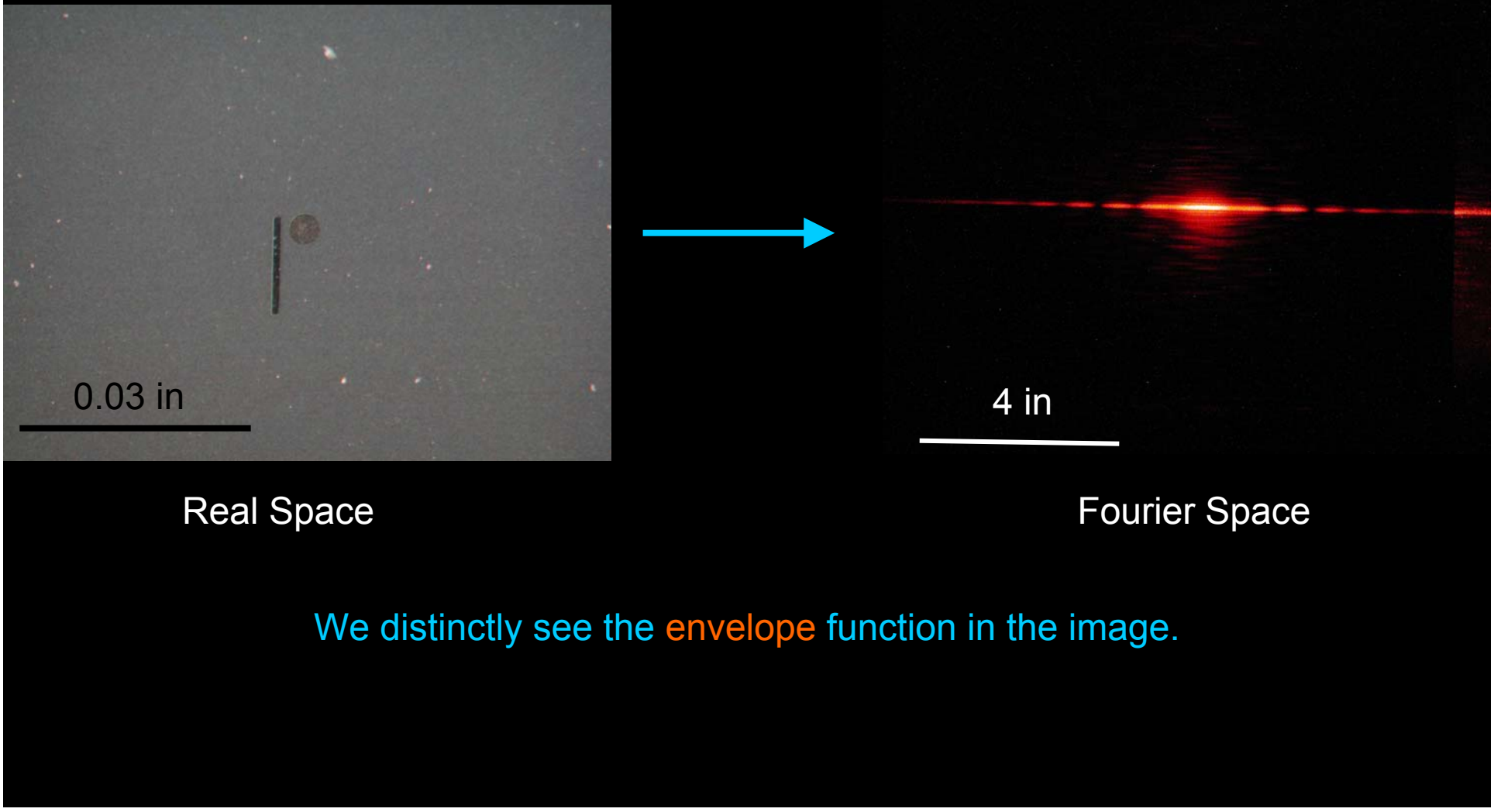
$$a \sin\theta = m\lambda$$

Single Slit Diffraction



Real Space vs. Fourier Space: Single Slit

Fourier Space = Image Space

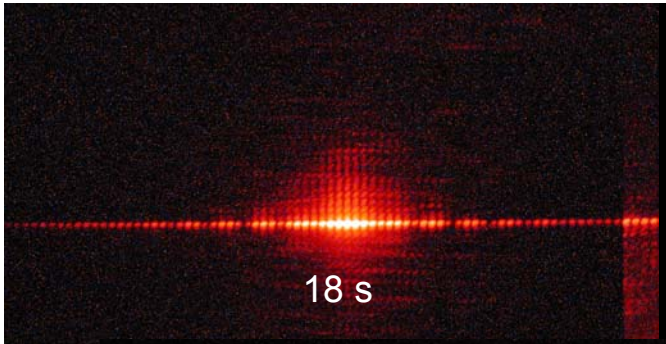


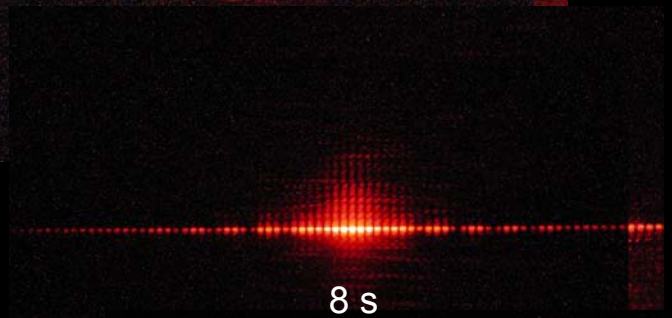
Real Space

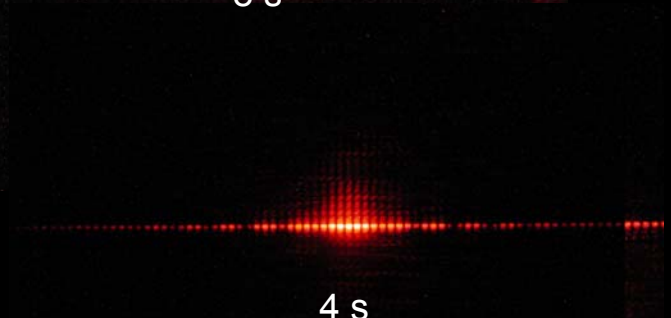
Fourier Space

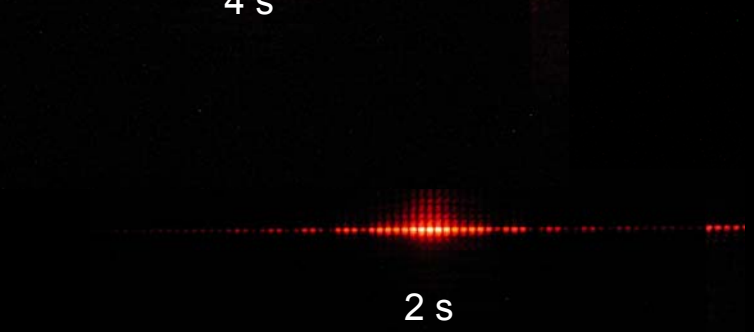
We distinctly see the envelope function in the image.

Double Slit Diffraction

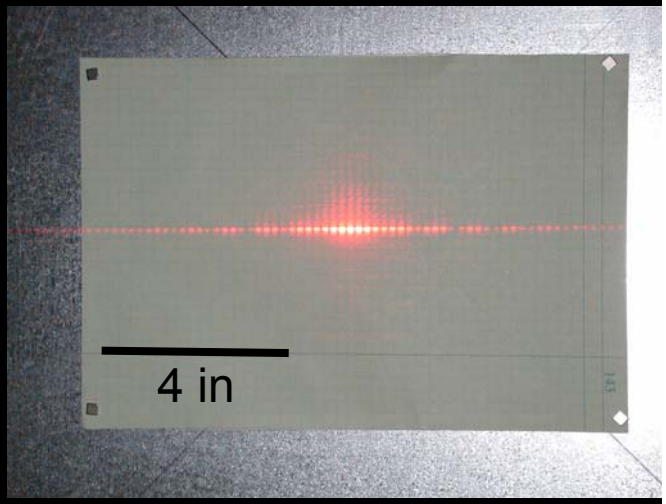




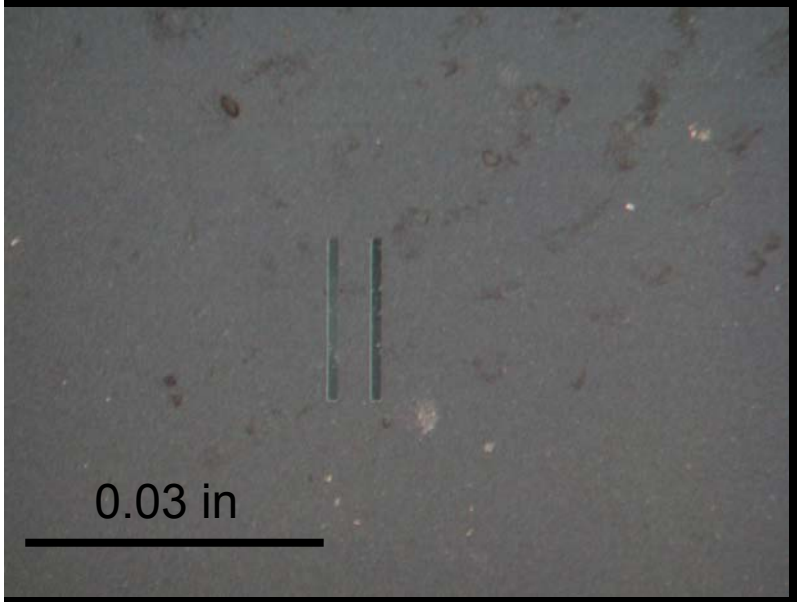




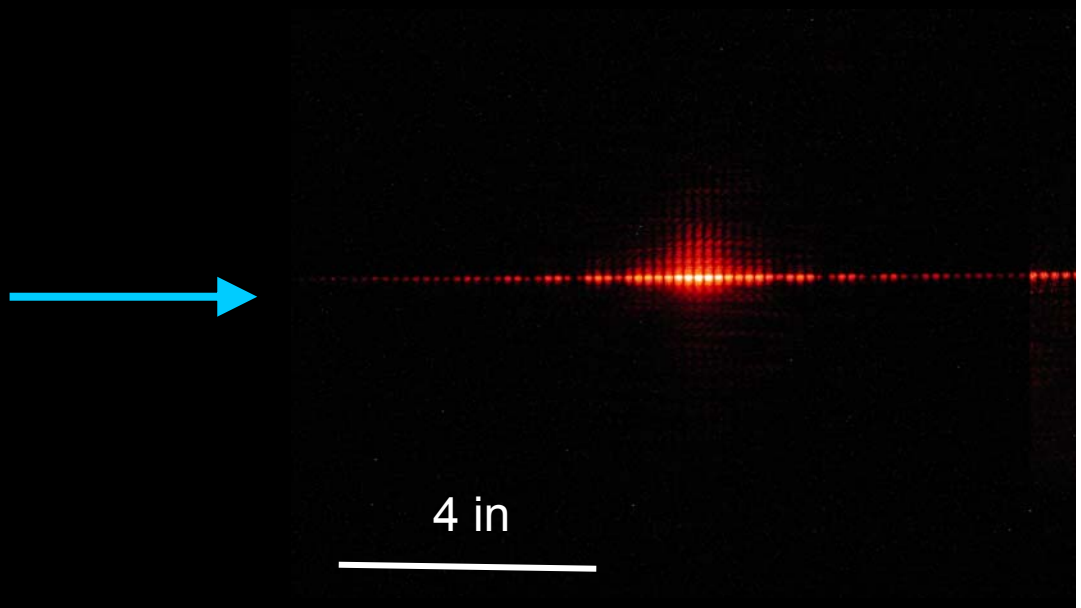
Decreasing
exp. time



Real Space vs. Fourier Space: Double Slit



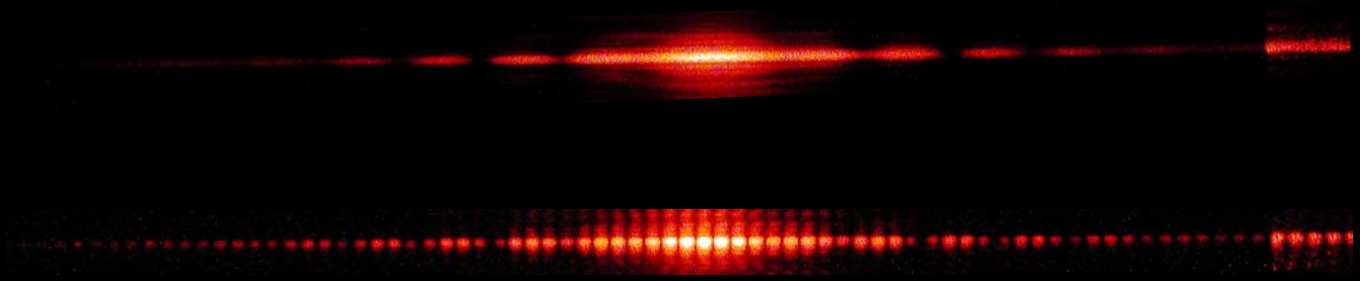
Real Space



Fourier Space

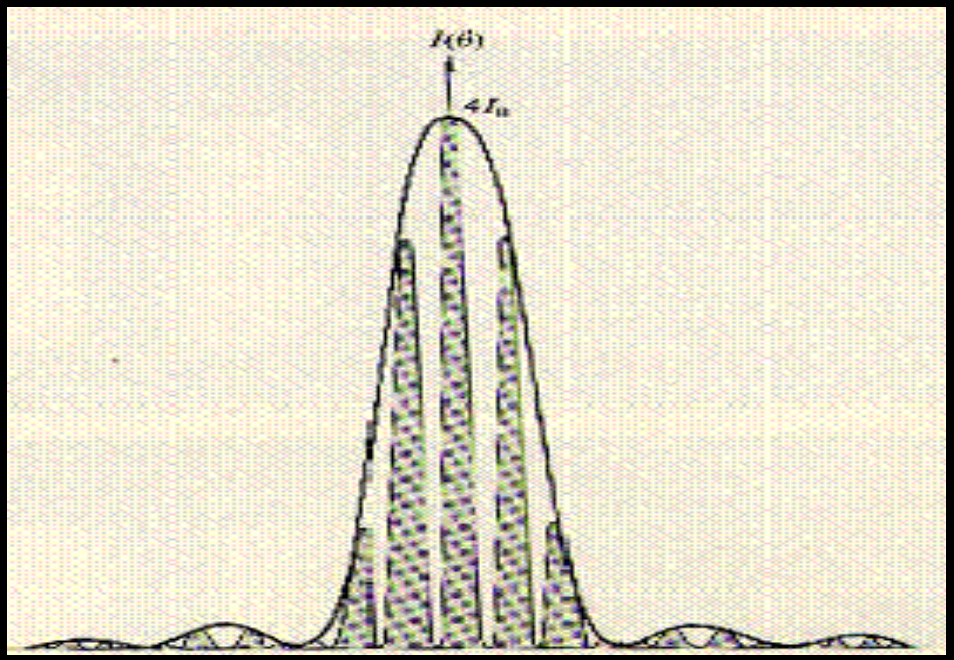
In the image, we can see both the envelope function and the interference pattern within each order.

Comparison: Rectangular Apertures



4 in

Plot of Intensity vs. sin(θ)



Hecht, *Optics*, 1998. Addison Wesley Longman, Inc.

Envelope function

- Single slit
- Diffraction phenomenon

Inner function

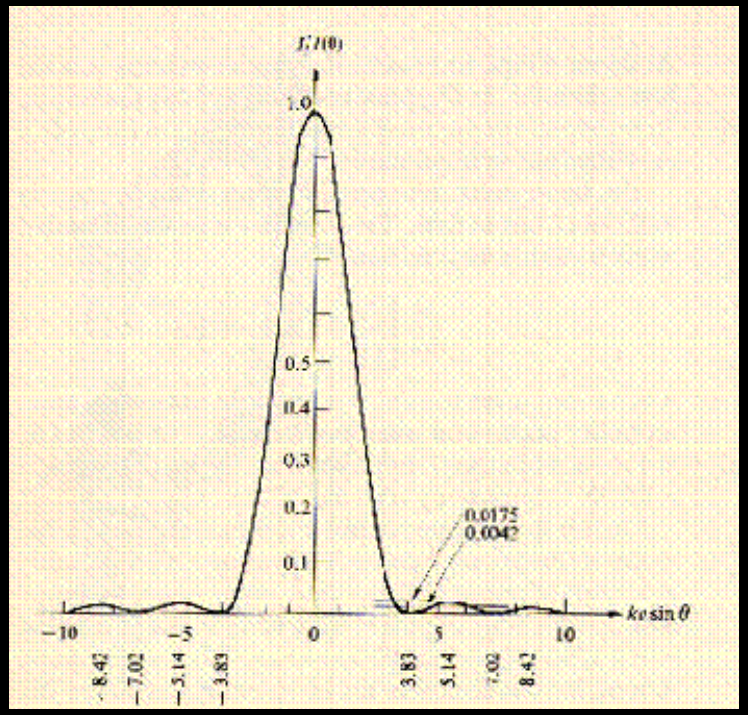
- Double slit
- Interference phenomenon

Circular Apertures

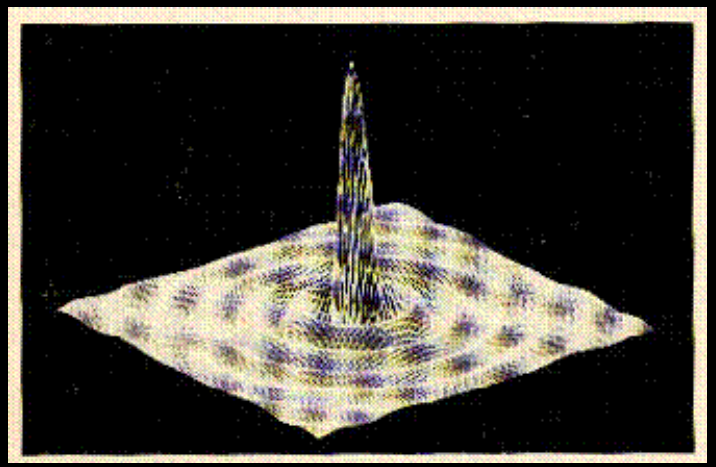
- E-field modeled by Bessel functions
- Square J(u) for intensity
- On principle, same diffraction phenomenon as single-slit

$$J_m(u) = \frac{i^{-m}}{2\pi} \int_0^{2\pi} e^{i(mv + u\cos v)} dv$$

Intensity vs. sin(θ)

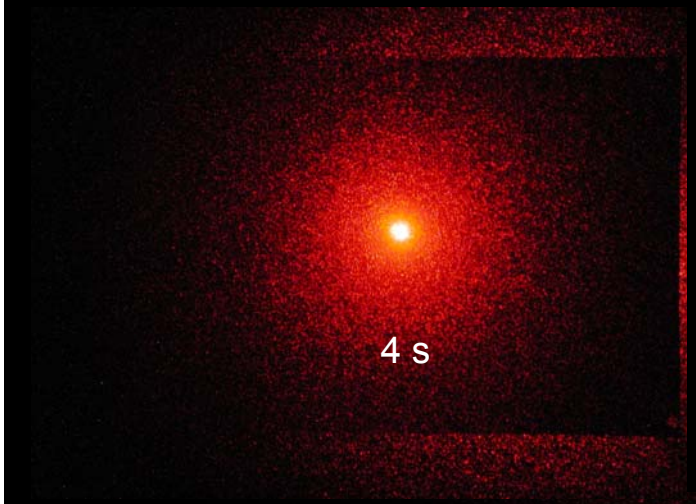


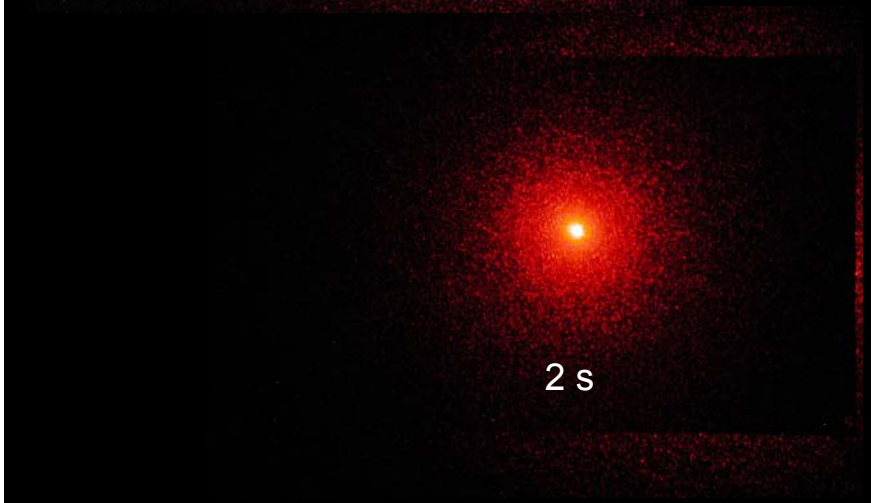
E-field plot



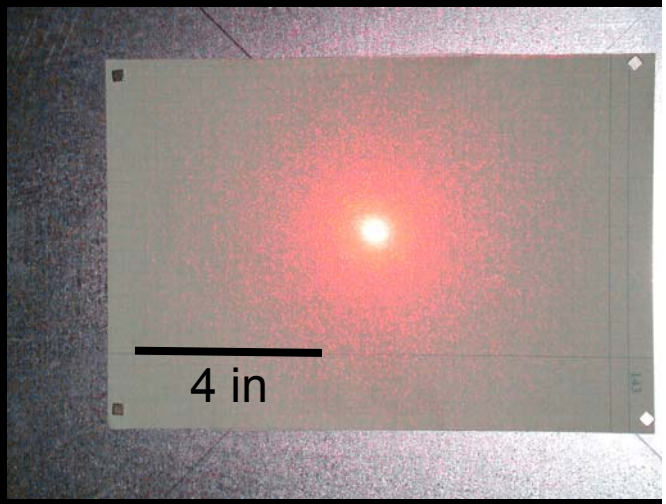
Hecht, *Optics*, 1998. Addison Wesley Longman, Inc.

Circular Aperture – 80mil





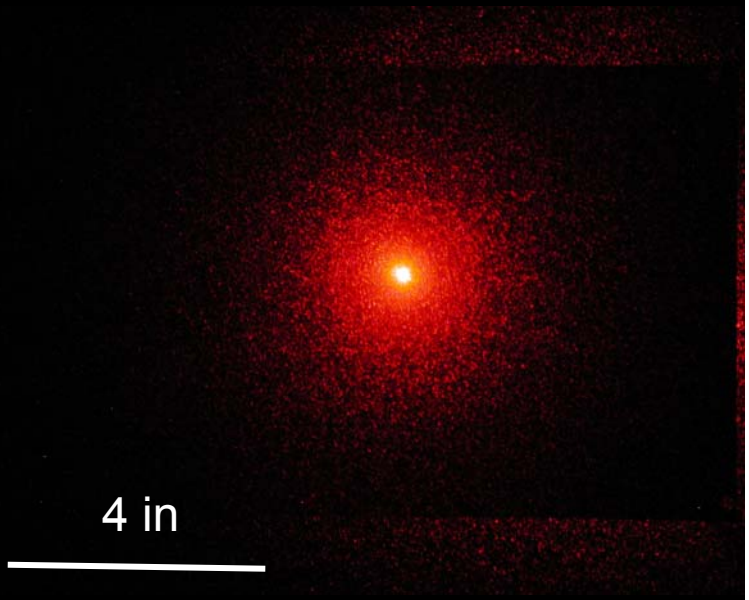
Decreasing
exp. time



No useful information gained from these photos,
since laser diameter is 1.27 mm << 80 mil

Real Space vs. Fourier Space: 80 mil Hole

Real Space



Fourier Space

Here we see only the plain laser beam since
the aperture size >> beam size.

Circular Aperture – 2mil
Bessel Functions

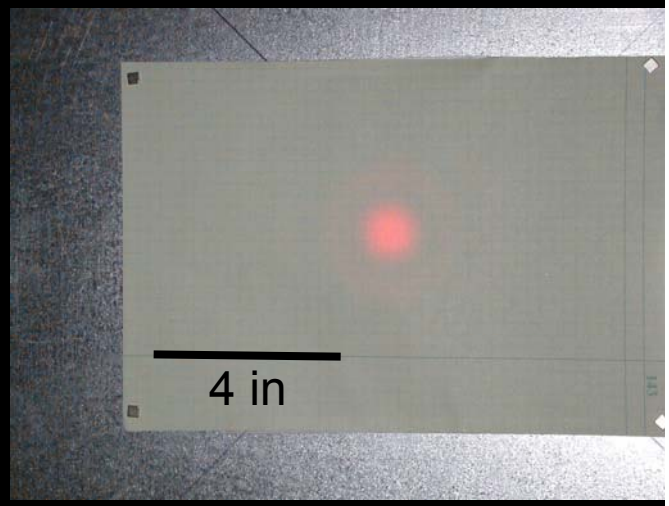
15 s

8 s

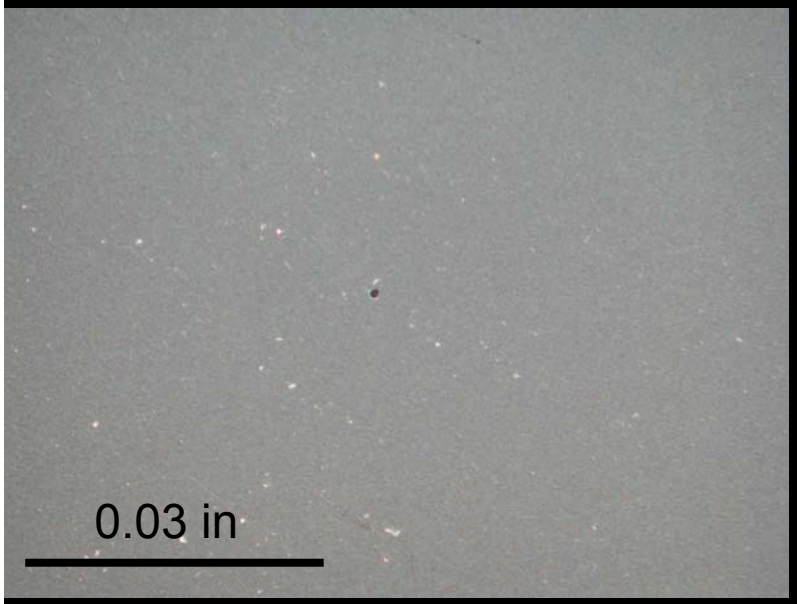
4 s

2 s

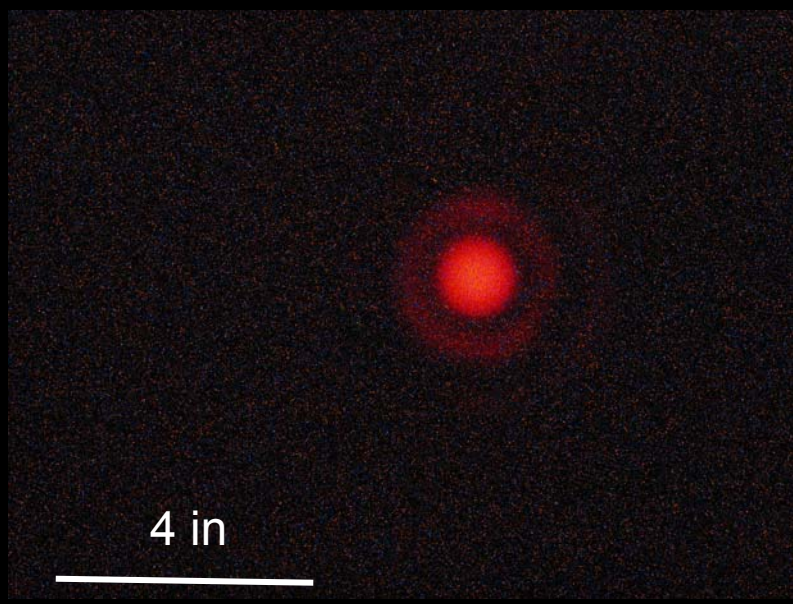
Decreasing
exp. time



Real Space vs. Fourier Space: 2 mil Hole



Real Space

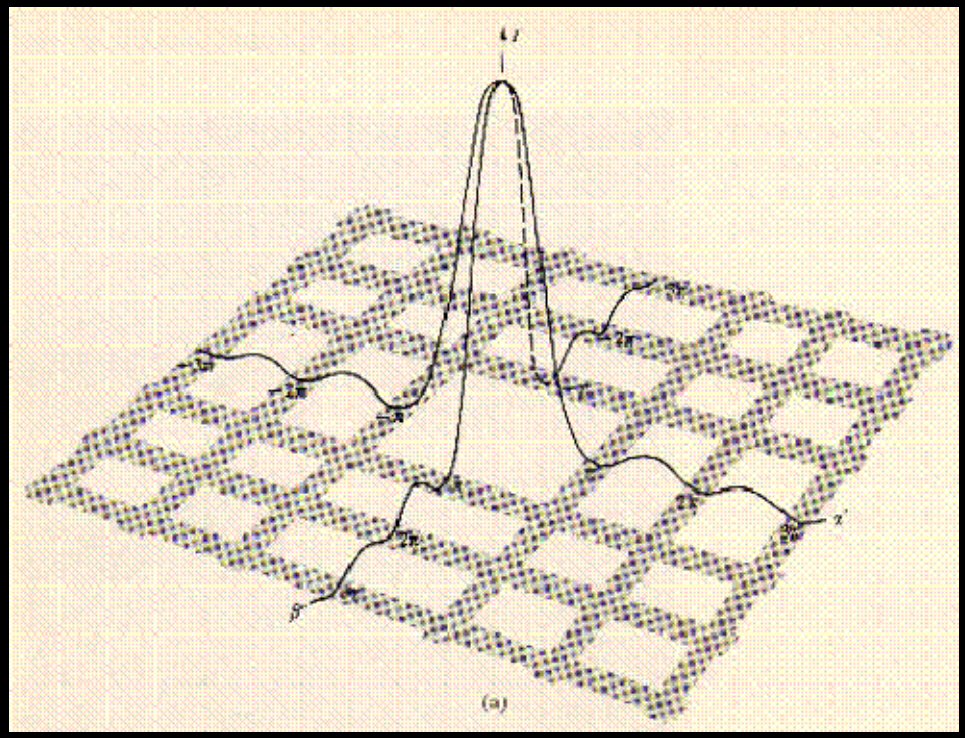


Fourier Space

We can just barely see 3 orders of the Bessel function pattern.

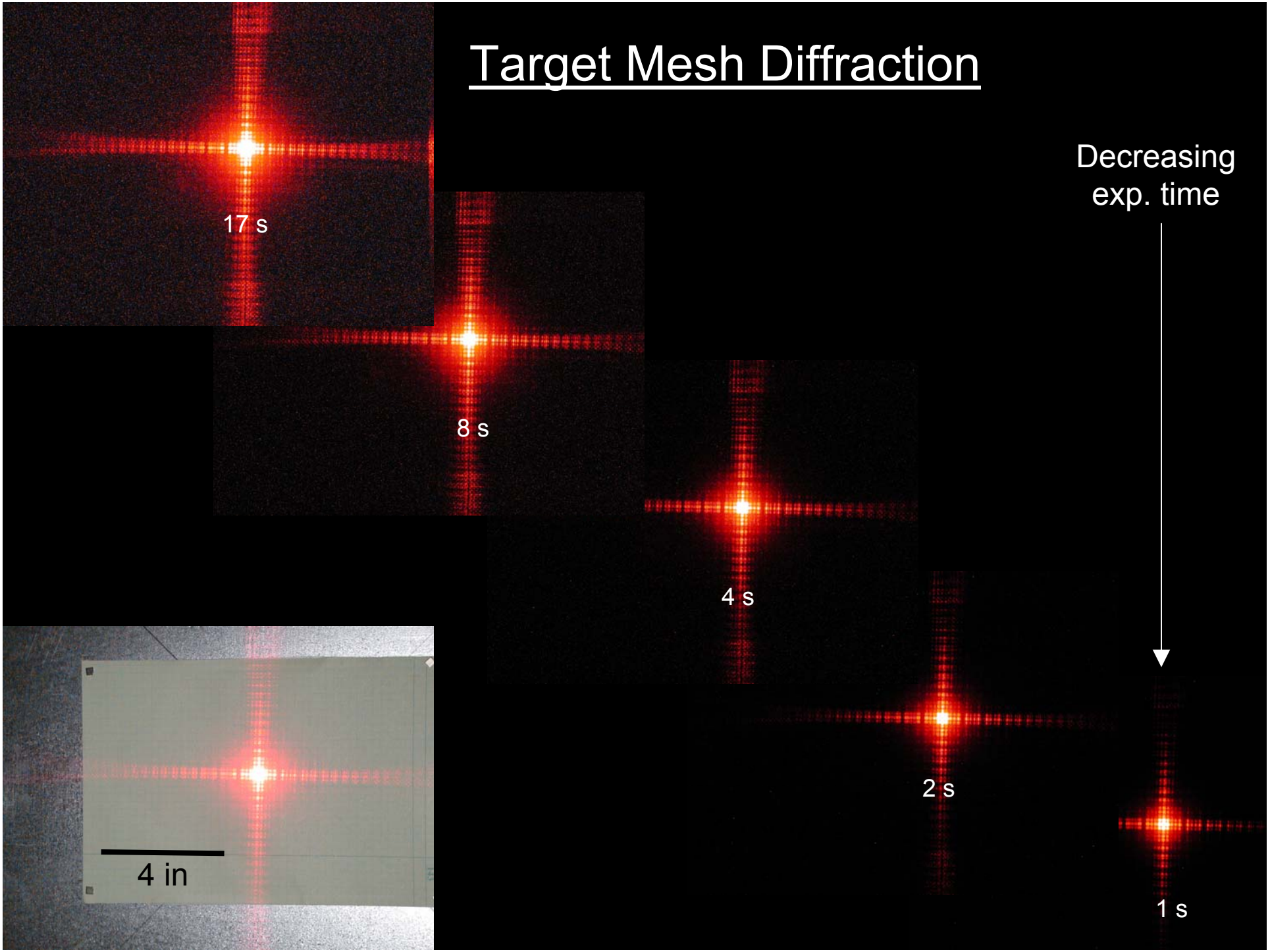
Target Mesh

- Dispersion direction is perpendicular to longest edge of slit
- Square aperture = dispersion in 2 directions!
- This is mesh, not single aperture – gives interference as well

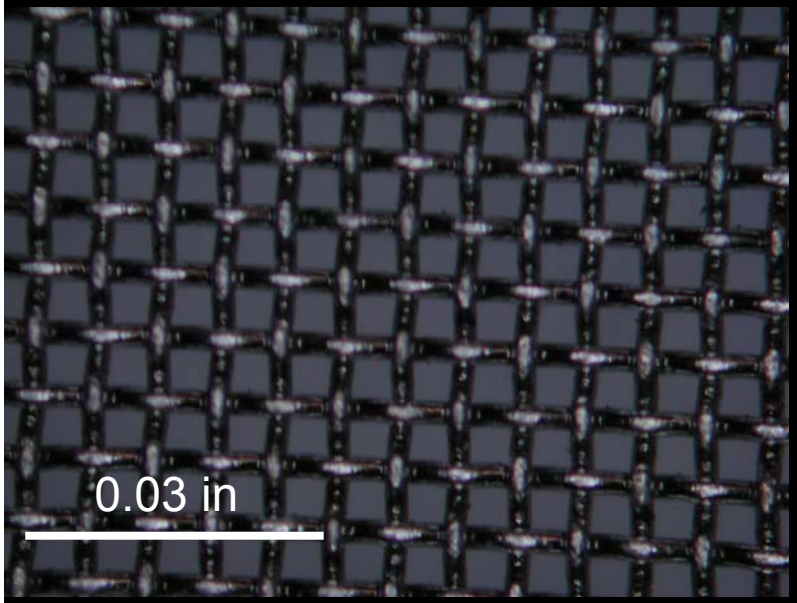


Hecht, *Optics*, 1998. Addison Wesley Longman, Inc.

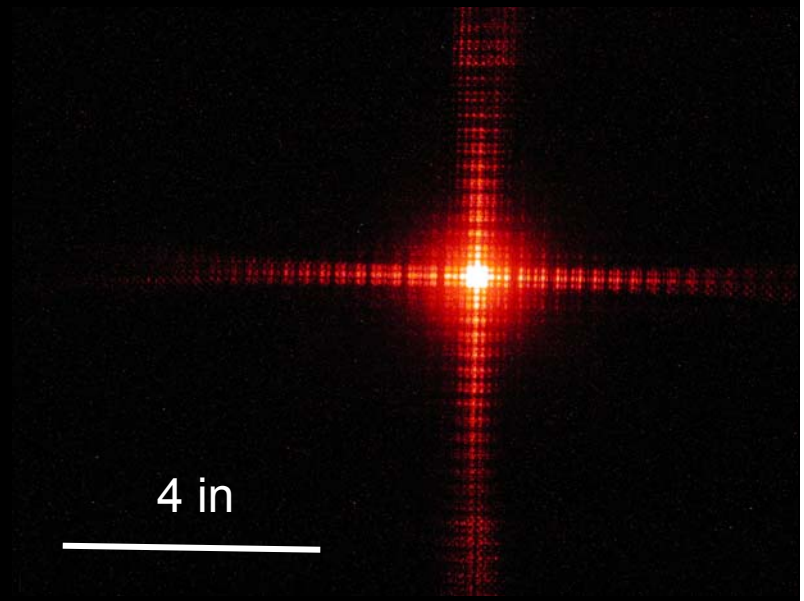
Target Mesh Diffraction



Real Space vs. Fourier Space: Target Mesh



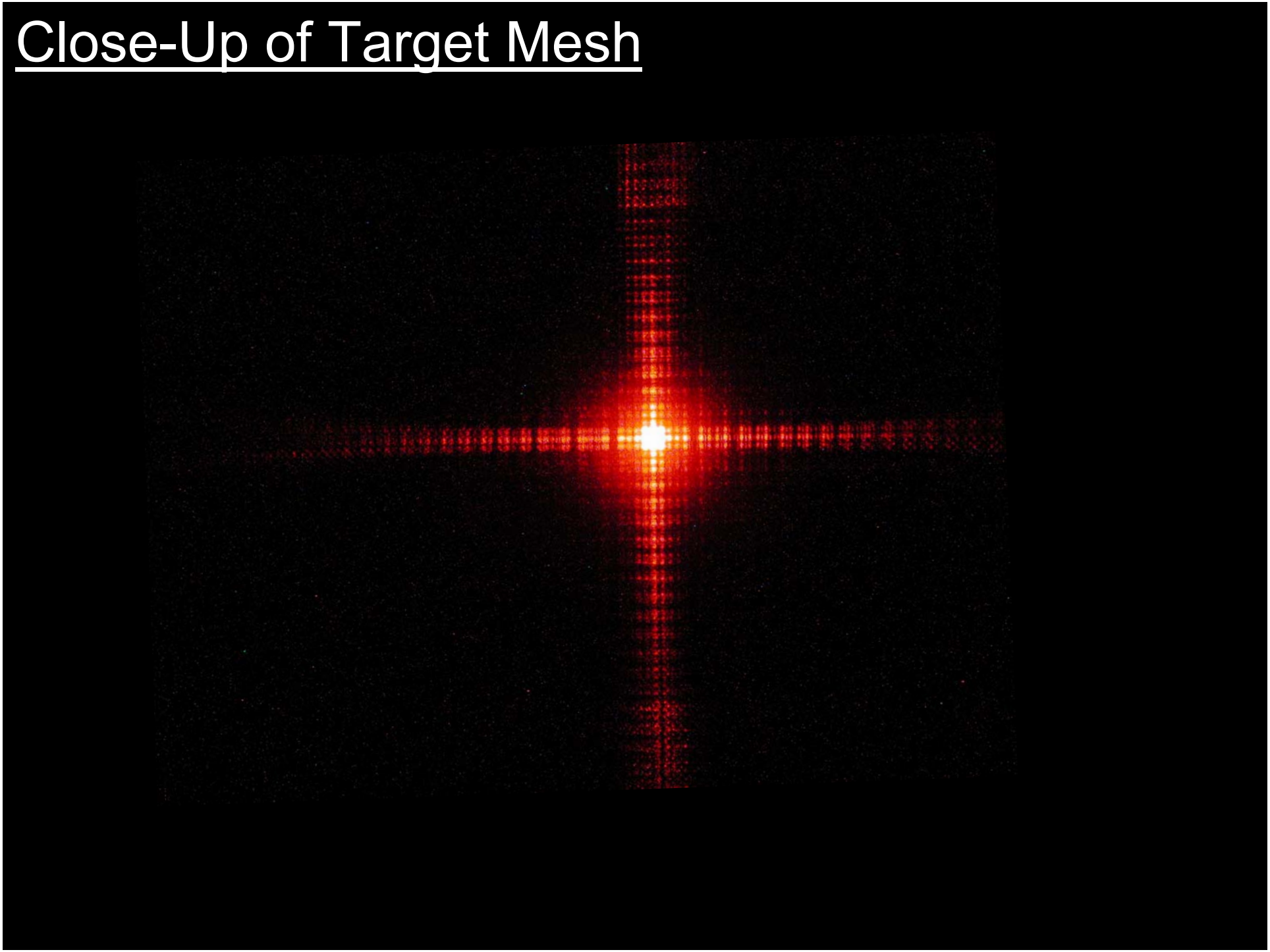
Real Space



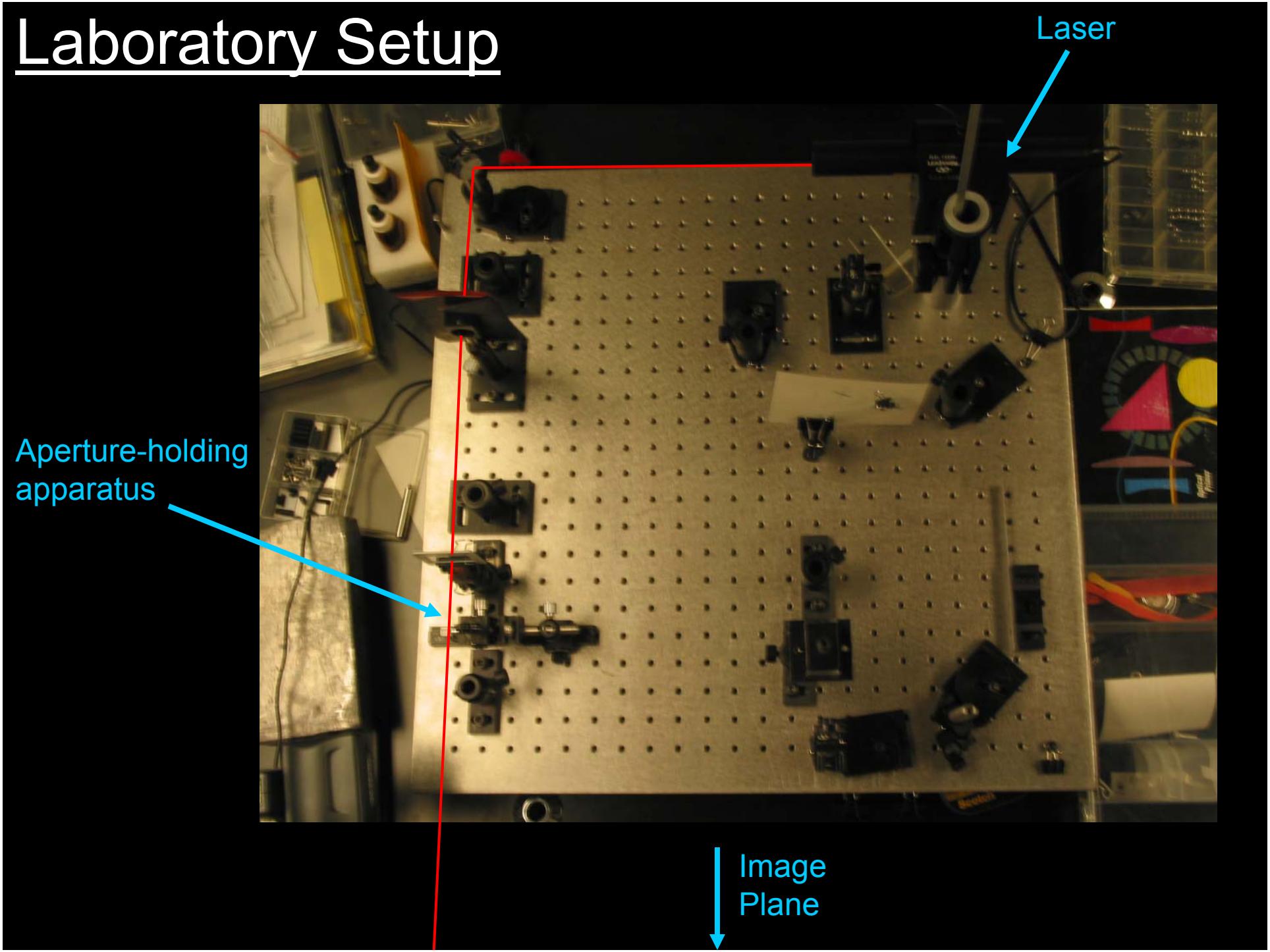
Fourier Space

In the image, we see orders of diffraction, but with interference resulting from the mesh.

Close-Up of Target Mesh



Laboratory Setup



For Scale