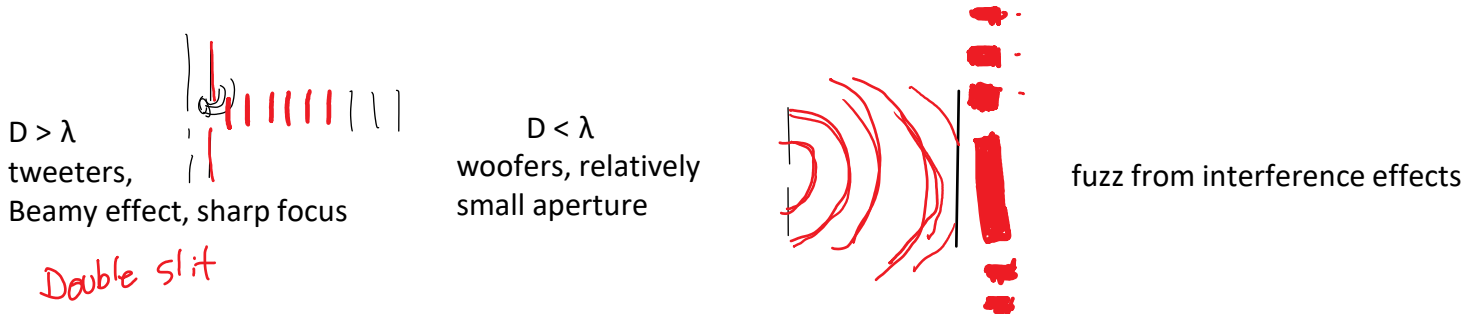Today:

Resolution - Spatial into temporal

Learning objectives: you will be able to analyze the spatial and temporal resolution of your images. You will be able to manipulate dynamic range of color channels in an editor.

- **Diffraction effects if lens aperture or pixel size < λ wavelength of light**

D > λ
tweeters,
Beamy effect, sharp focus

D < λ
woofers, relatively
small aperture

fuzz from interference effects

Double slit

Example: https://luminous-landscape.com/understanding-lens-diffraction/

Moral of the story: high f number has better depth of field, but sharpness can be defeated by diffraction effects.

Current sensor sizes range 35 - 3 mm. For 3k px wide, 1 pixel = 10 -1 μm.

Red λ = 0.7 μm. Pretty close!

Last year Homework results: F/ for best sharpness.

Best f/	Sensor size
10	DSLR
7.1	DSLR
6.3	DSLR
Around 8	Full frame
12	DSLR
3.5	Small camera
8	mirrorless

Our class: 12 said lower f/ was better. 2 said higher was better.

'Full Frame' DSLR: sensor size is ~35 mm
~ $1000
Often more MPx (35?), and larger sensor has less diffraction effects

For comparison:
Human eye resolution, 74 to >500 Mpx, depending on how you count.
http://www.clarkvision.com/articles/eye-resolution.html

How much resolution is needed?

Consider range of scales:

3000 px wide image, can see 1:1000 = 3 decades of scales

What is a decade? 10x; AKA order of magnitude O(x)

Largest scale = whole frame, takes 3000 px.

Smallest resolvable scale = feature that takes up 3 px or so.

3→30 One decade

30 → 300 2nd decade

300→3000 3rd decade.

We can resolve features that range across 3 decades of scales.

In flow, scales can be 3 minimum,

For turbulence need 4 or 5 decades minimum

Same scale considerations as for CFD (computational fluid dynamics, simulations of fluid flows):

If resolution is increased, is new information seen?

Is it important information?

In CFD, could have different physics; even large scale results could be wrong

In Flow Vis, missing small scales could lead to misinterpretation of physics

Short answer clicker: In your IV1 image, how many decades of length scale was in your **flow**? Breakout rooms; share your image and discuss scales in everybody's image.

1) Is there a sharp boundary in the flow that only takes up one or two pixels in the image.
2) Are all the scales of interest in the flow well-resolved in the **image**?In other words, was your flow spatially resolved?
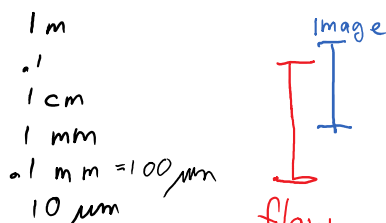3) What was the major effect that degraded the resolution?

How to tell motion blur from bad focus:

sides of streak will be in focus.

Just being out of focus will be an overall blur.

Main zoom room whiteboard: Please annotate

1 m

.1

1 cm

1 mm

.1 mm =100 μm

10 μm

Image

flow

1 mm
.1 mm = 100 μm
10 μm
1 μm

flow

Everybody do this
on the whiteboard

1 m —
1 cm —
1 mm —
.1 $\frac{mm}{100 \mu m}$
10 μm
1
.1

MM
F
I
OW
CF
SL
HM
JS
N
RP
AB
JC
OW
EP RR
HM
MB

Matthew McC...