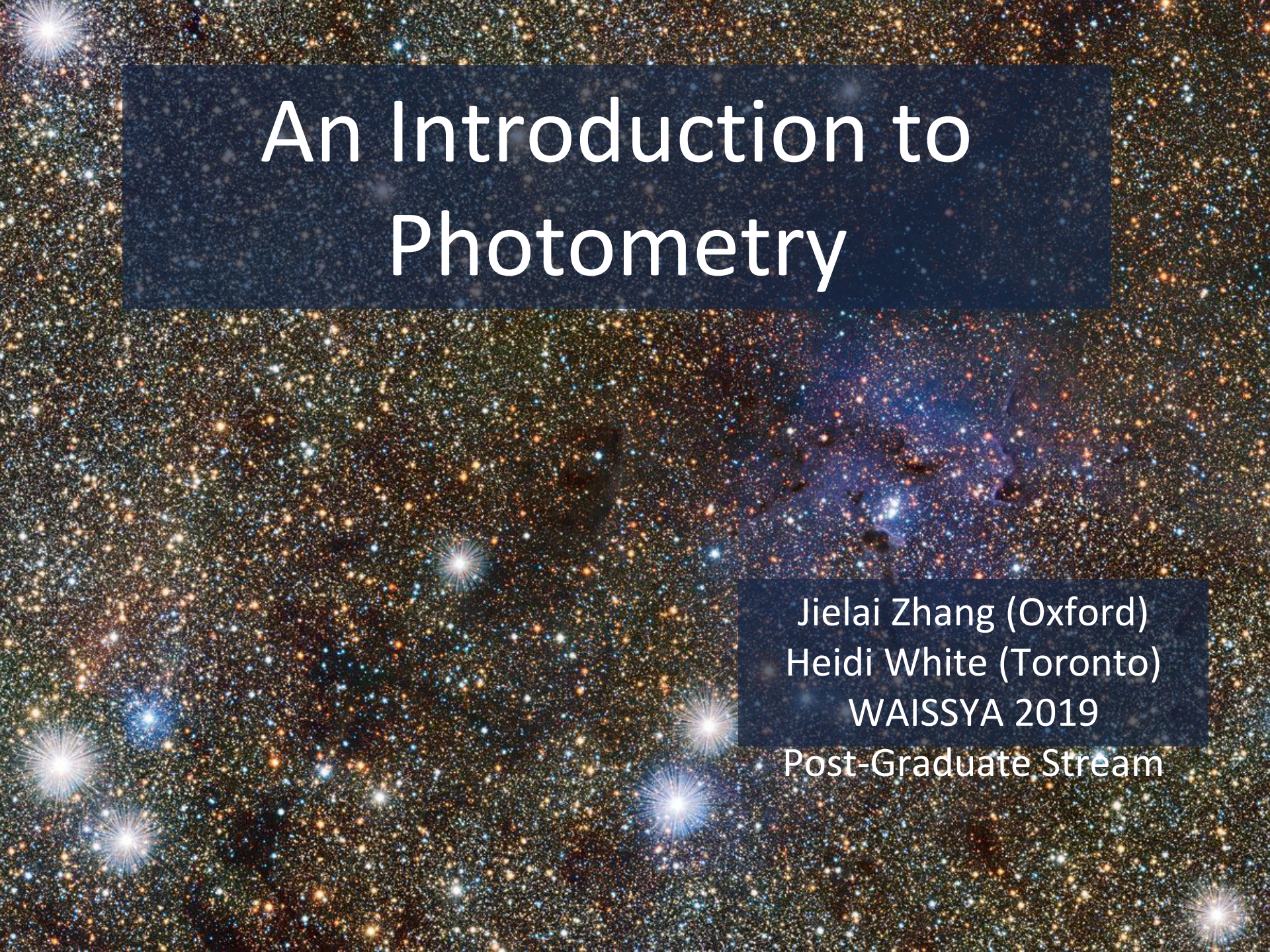
An Introduction to Photometry



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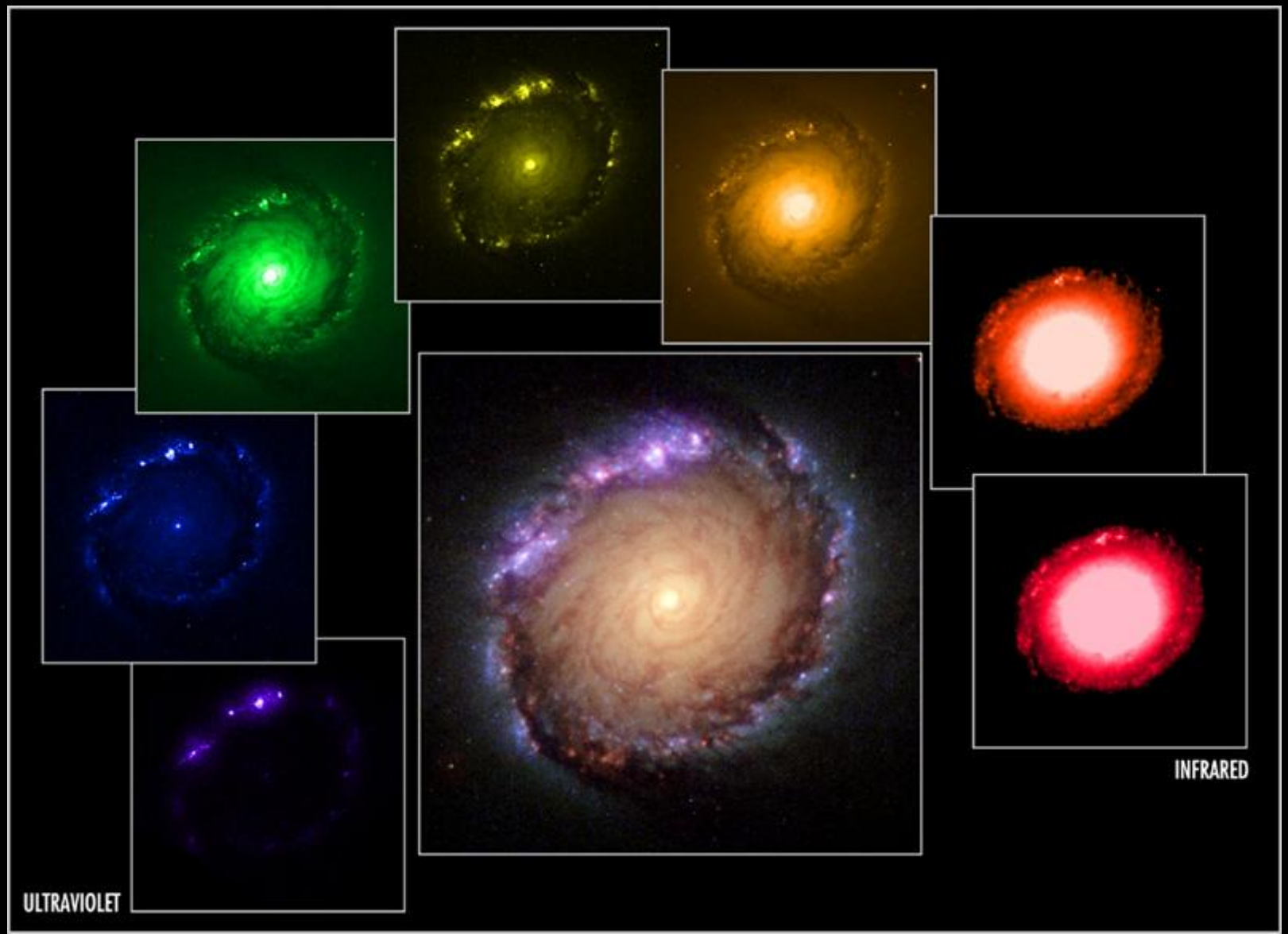
WAISSYA 2019
Post-Graduate Stream

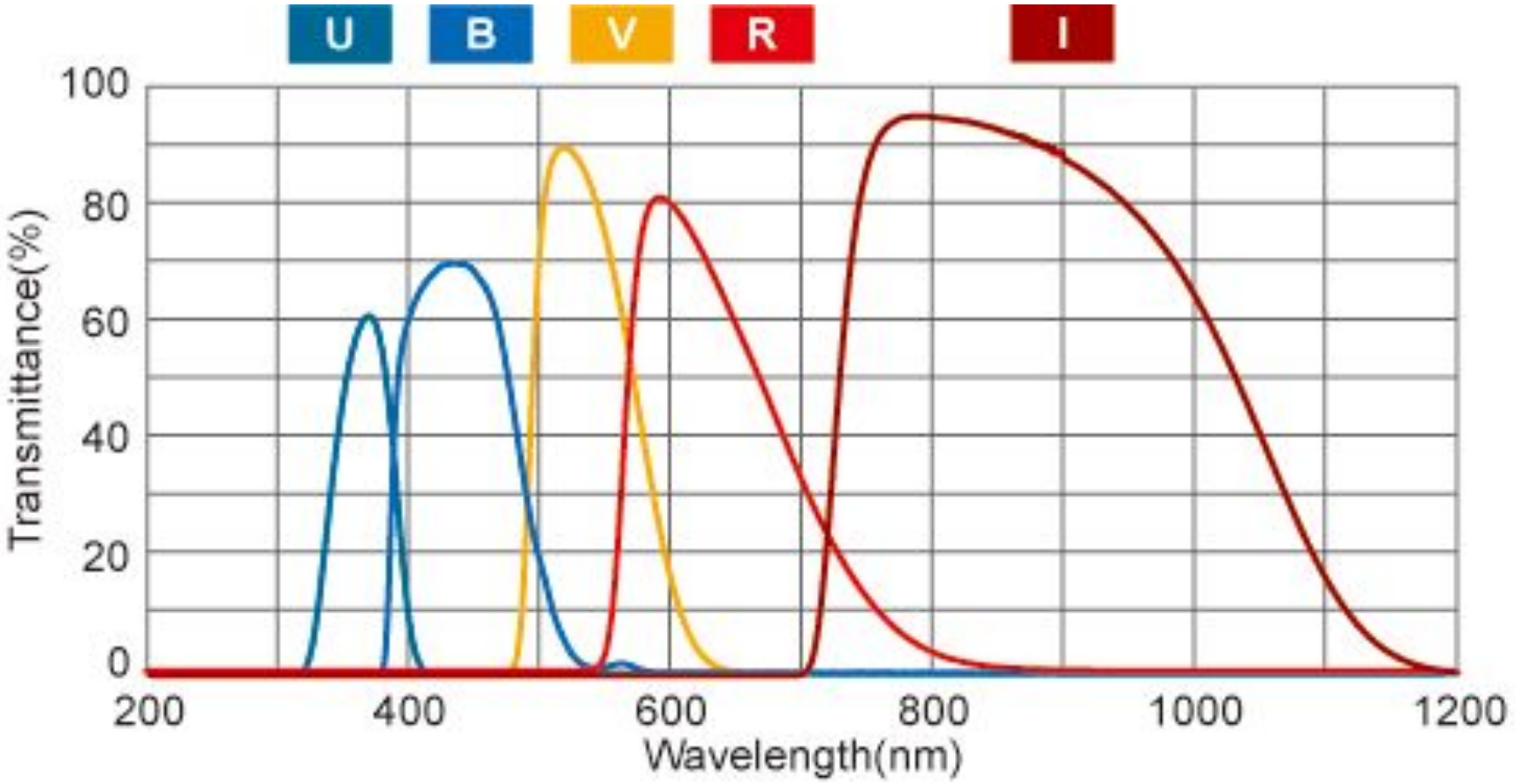
Photometry is a method for measuring how much light (photons/s) is received from an astronomical object.

The amount of light received from a source (per second) is the flux of the source

Astronomical objects emit light at a wide range of wavelengths.

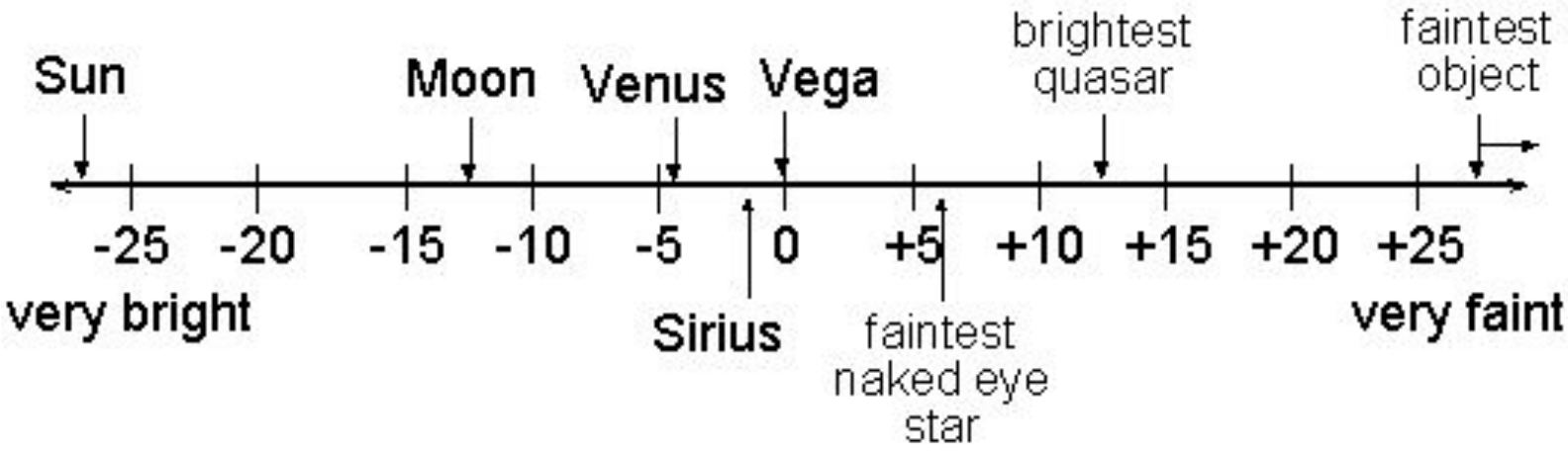


The “amount of light” measured in photometry is limited to a specific *filter*.



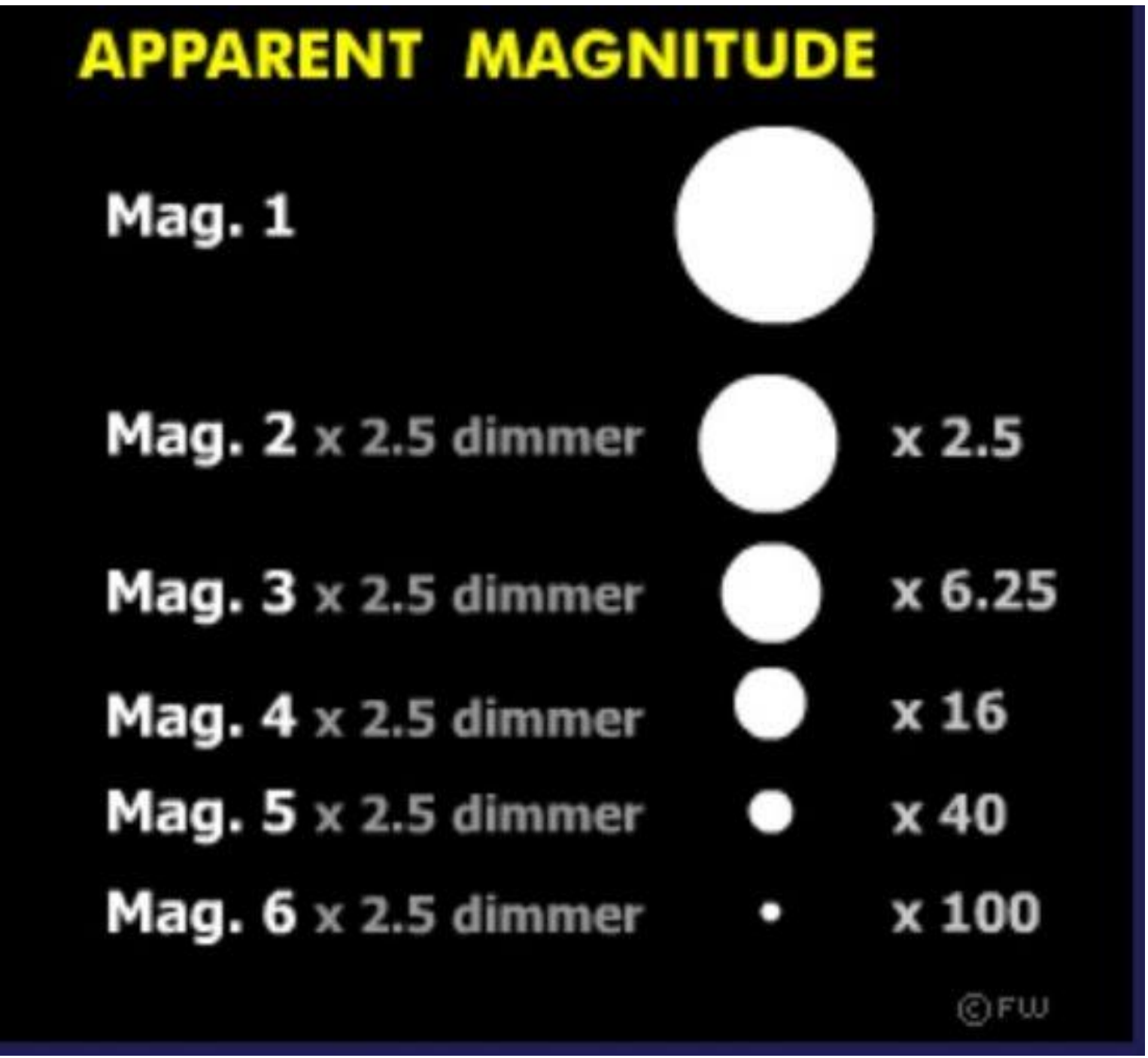
Filters can be either “broad” or “narrow”.
What do you think that means?

This flux can be converted to something called a magnitude. We then talk about the magnitude of an object in a given filter.



Apparent brightnesses of some objects in the magnitude system.

APPARENT MAGNITUDE

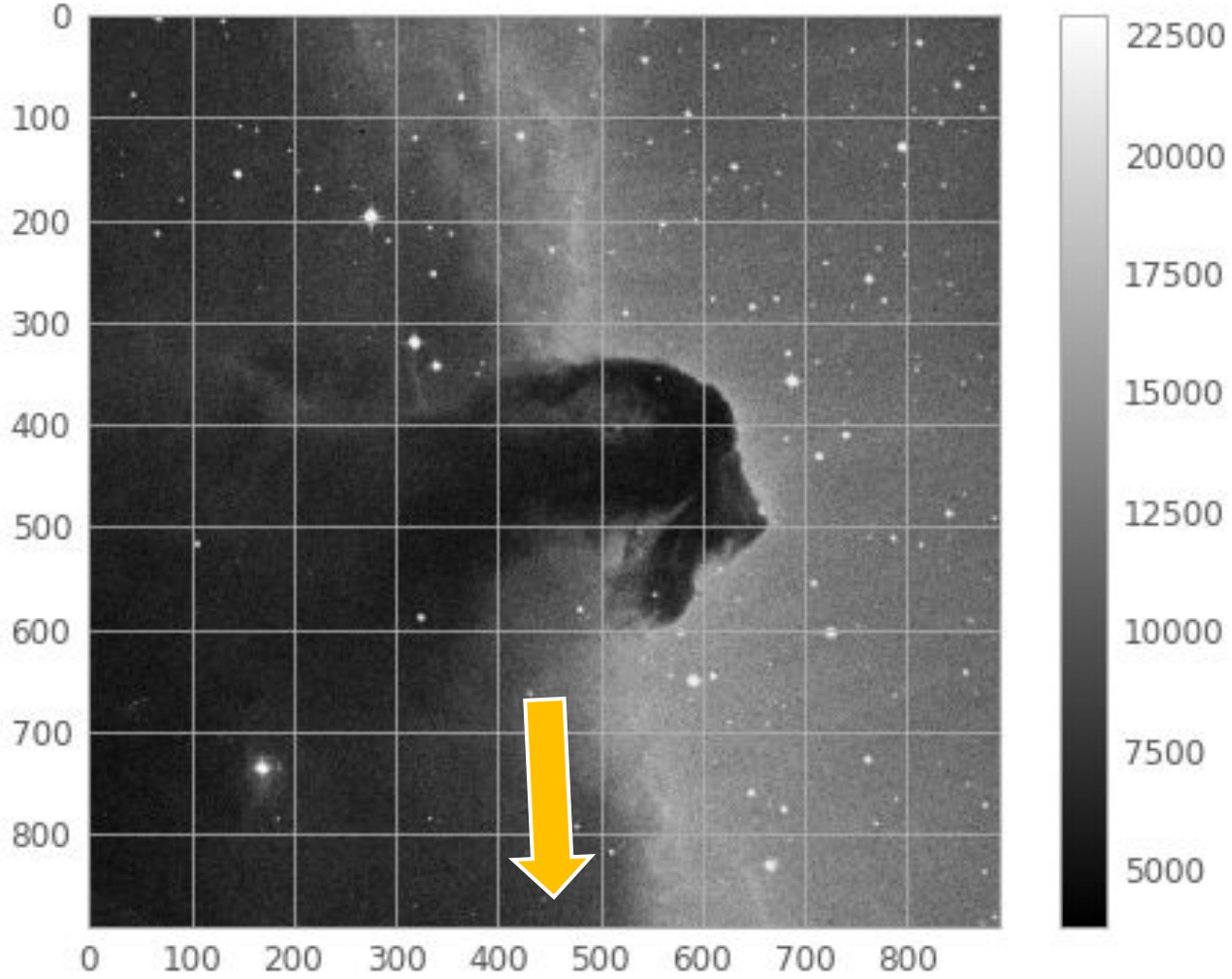


FITS files are astronomical images produced by telescopes.

Like everyday photos, these images are an *array of numbers* which relates the *amount of light recorded in each pixel* of the CCD.

FITS files are astronomical images!

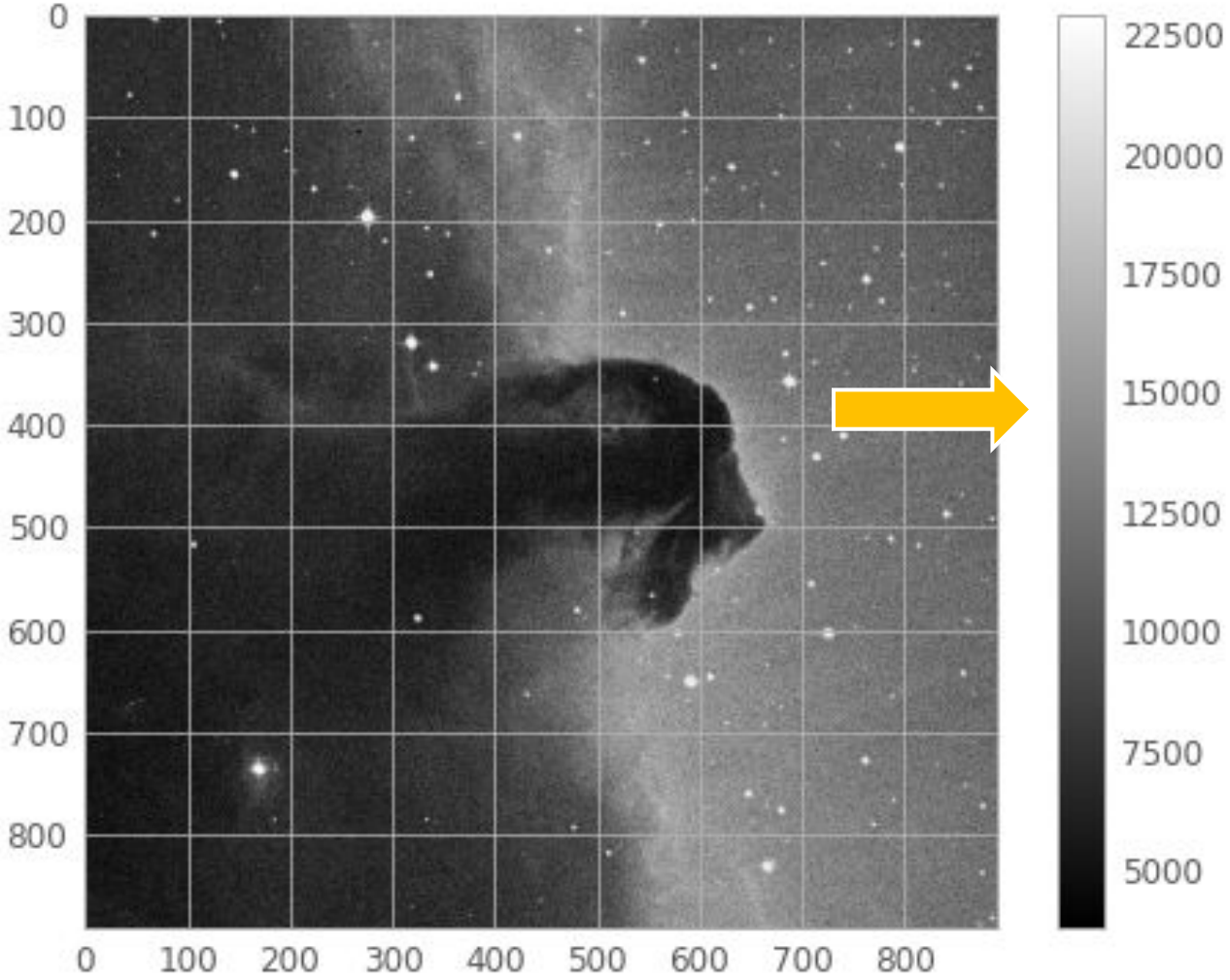
In this Hubble image of the Horsehead Nebula, the X & Y axes relate pixel position.



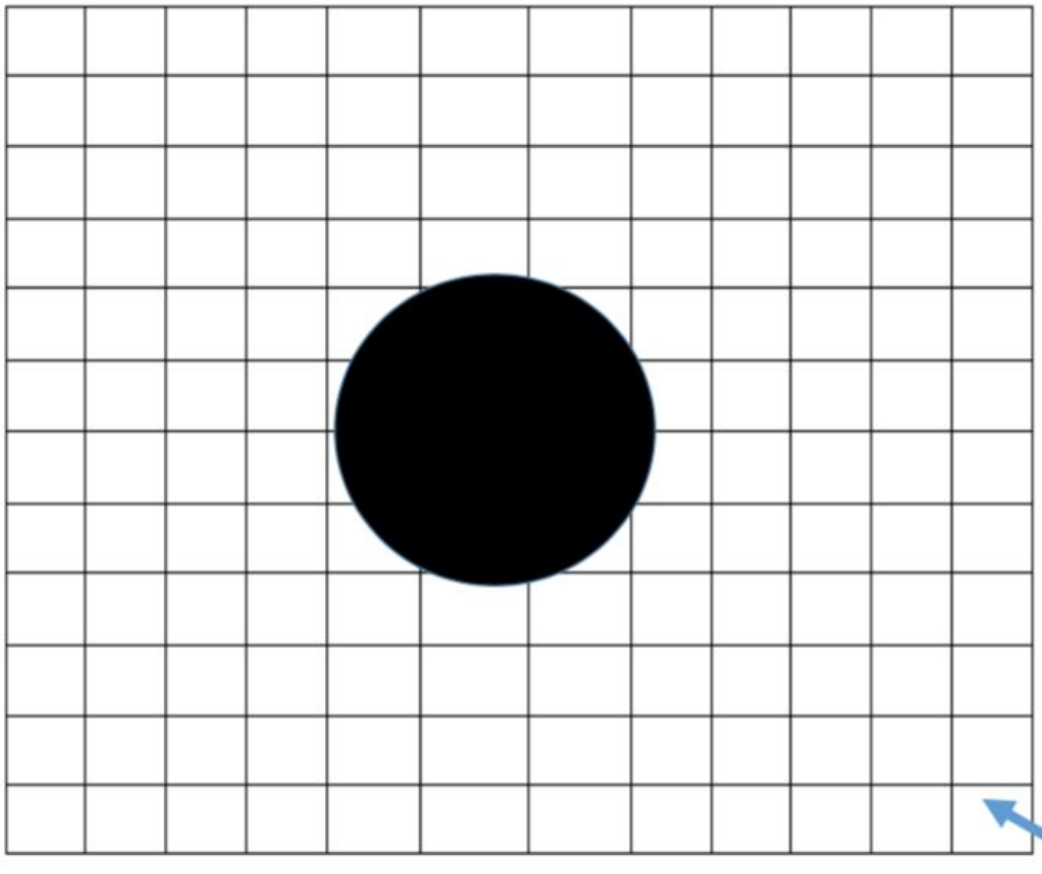
FITS files are astronomical images!

In this Hubble image of the Horsehead Nebula, the X & Y axes relate pixel position.

The bar at the right shows the relative amount of light in each pixel.



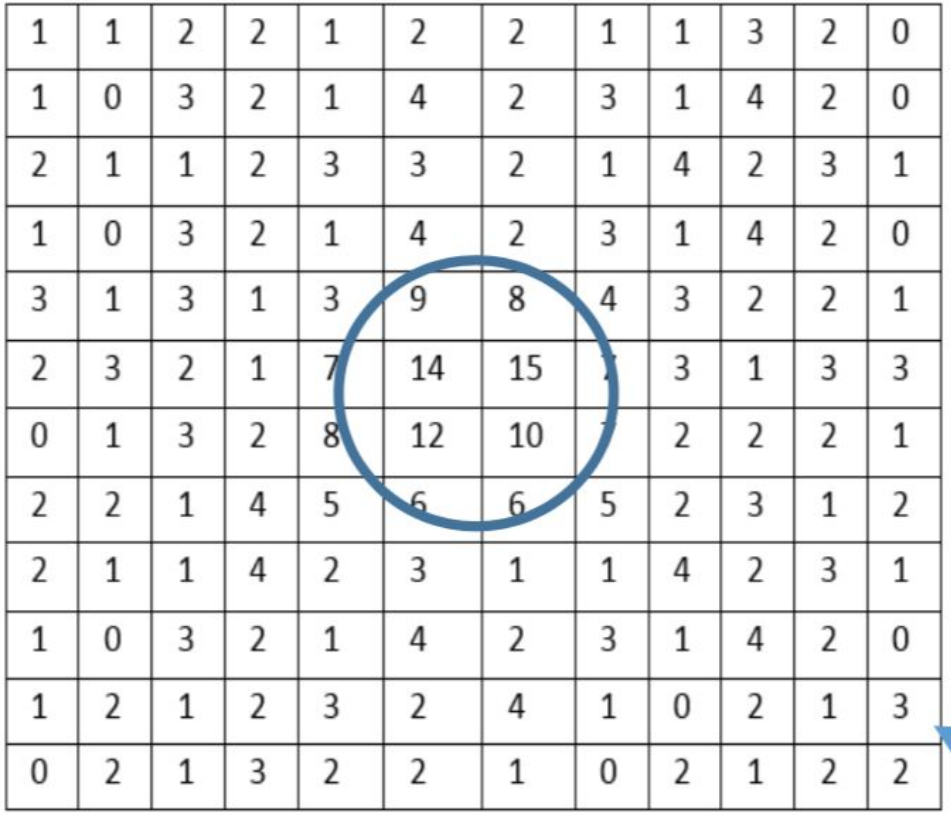
How do we measure the magnitude of astronomical sources?



How do we estimate the flux of the star on a CCD image?

CCD Pixels

Aperture Photometry



1	1	2	2	1	2	2	1	1	3	2	0
1	0	3	2	1	4	2	3	1	4	2	0
2	1	1	2	3	3	2	1	4	2	3	1
1	0	3	2	1	4	2	3	1	4	2	0
3	1	3	1	3	9	8	4	3	2	2	1
2	3	2	1	7	14	15	7	3	1	3	3
0	1	3	2	8	12	10	7	2	2	2	1
2	2	1	4	5	6	6	5	2	3	1	2
2	1	1	4	2	3	1	1	4	2	3	1
1	0	3	2	1	4	2	3	1	4	2	0
1	2	1	2	3	2	4	1	0	2	1	3
0	2	1	3	2	2	1	0	2	1	2	2

How do we estimate the flux of the star on a CCD image?

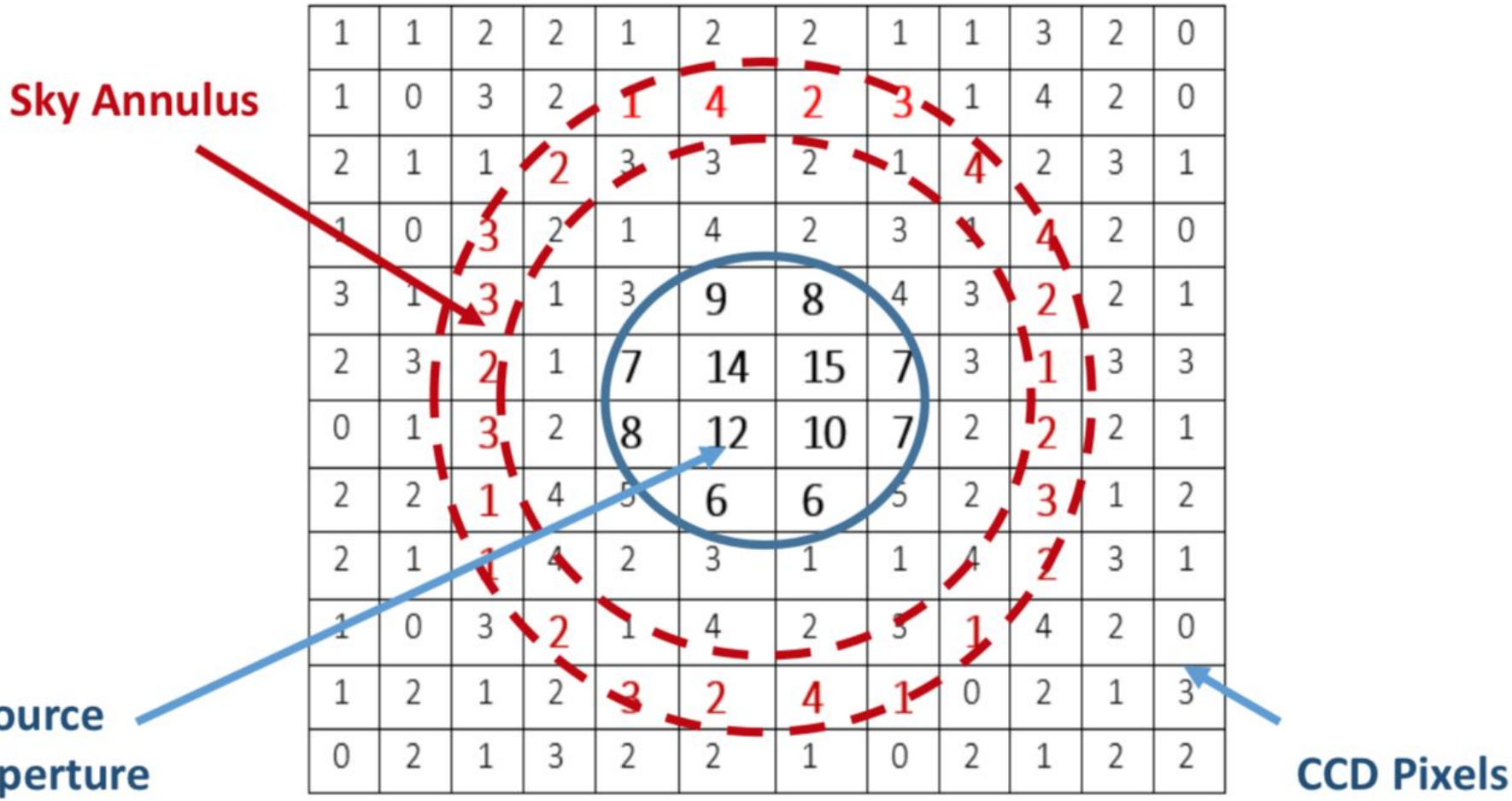
- **Non-zero background**
- **Increased data number at the location of the star**

CCD Pixels

We need to define regions to estimate light from the star and the sky background.

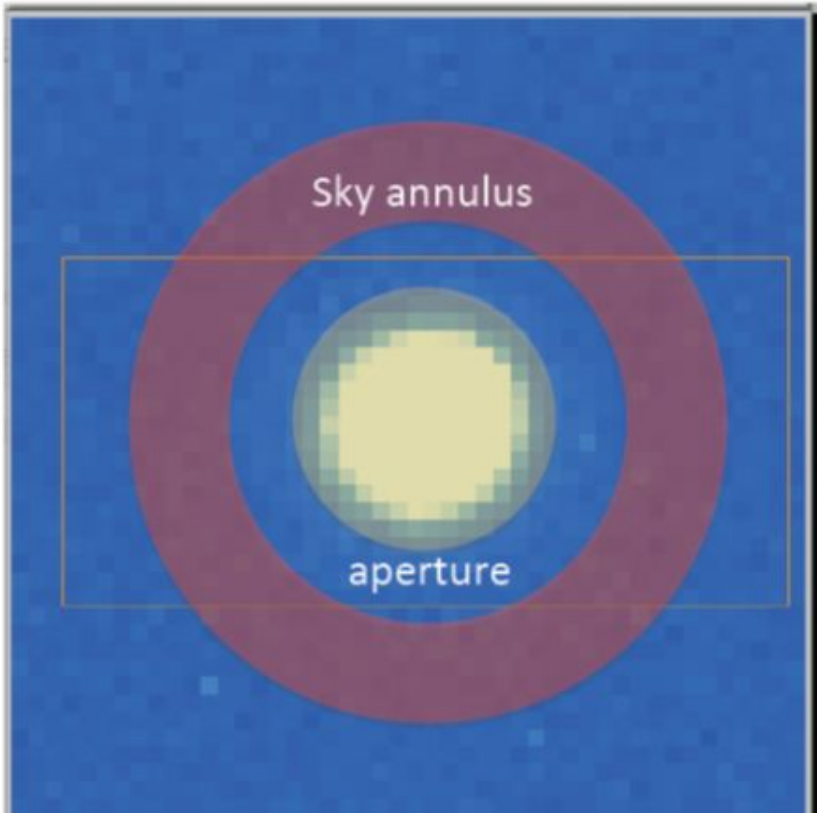
Aperture
Photometry

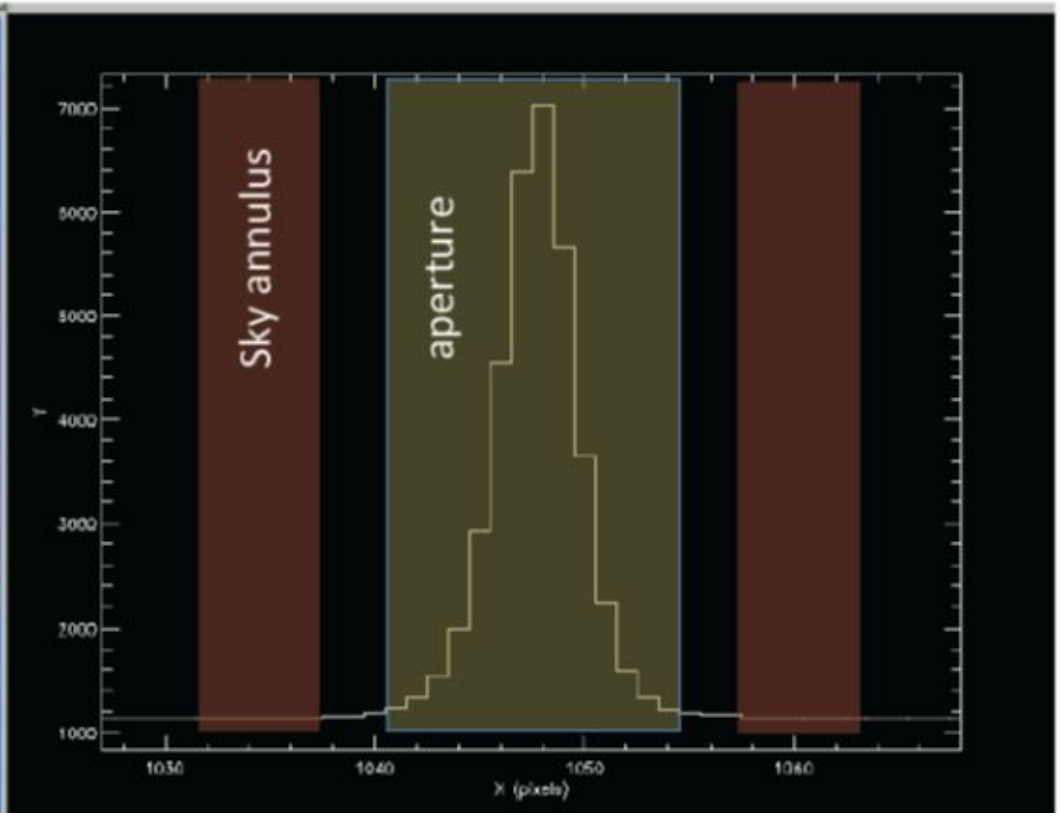
Aperture Photometry



Aperture photometry

- How would you define the aperture mask on the star?
  - What radius of an aperture?
  - Where would you define the sky region?





How do we isolate the light emitted by the star

Stellar and Sky Signal: N_* (star) and N_S

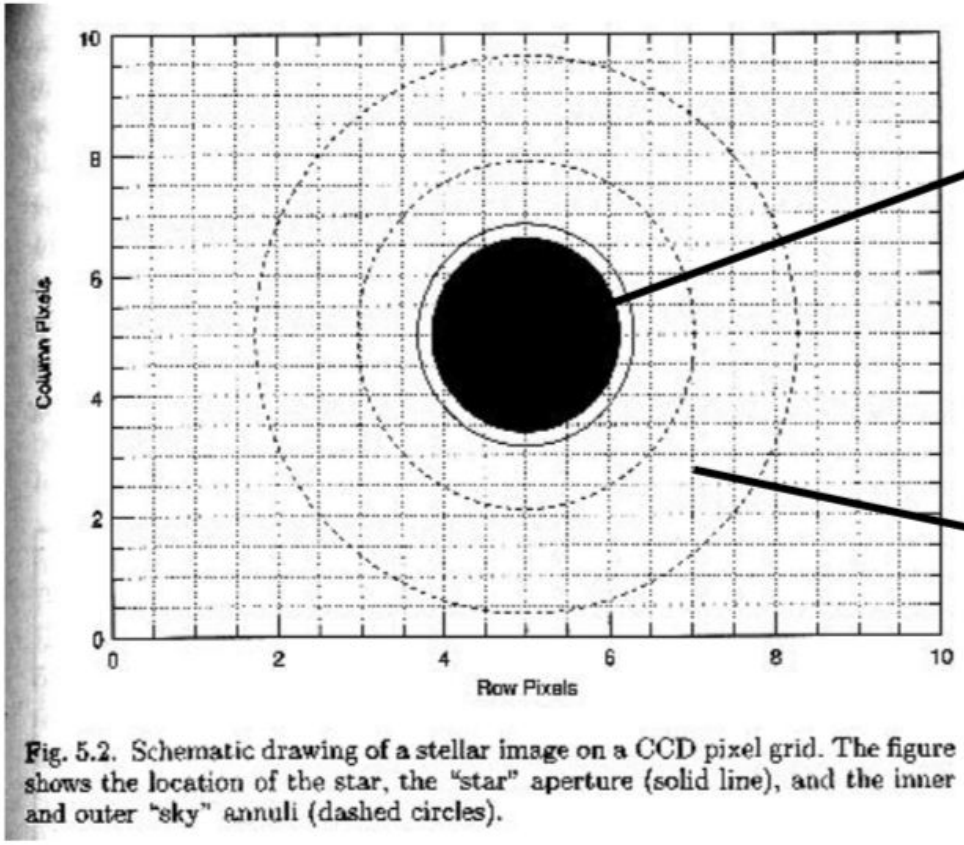


Fig. 5.2. Schematic drawing of a stellar image on a CCD pixel grid. The figure shows the location of the star, the "star" aperture (solid line), and the inner and outer "sky" annuli (dashed circles).

N_* is integrated within a proper aperture around the star. The background emission needs to be subtracted out.

N_S from a proper sky annulus around the star.

[Stellar Flux] = [Flux inside source aperture] – [Background]

You found

stellar flux = flux inside aperture - background
= 10

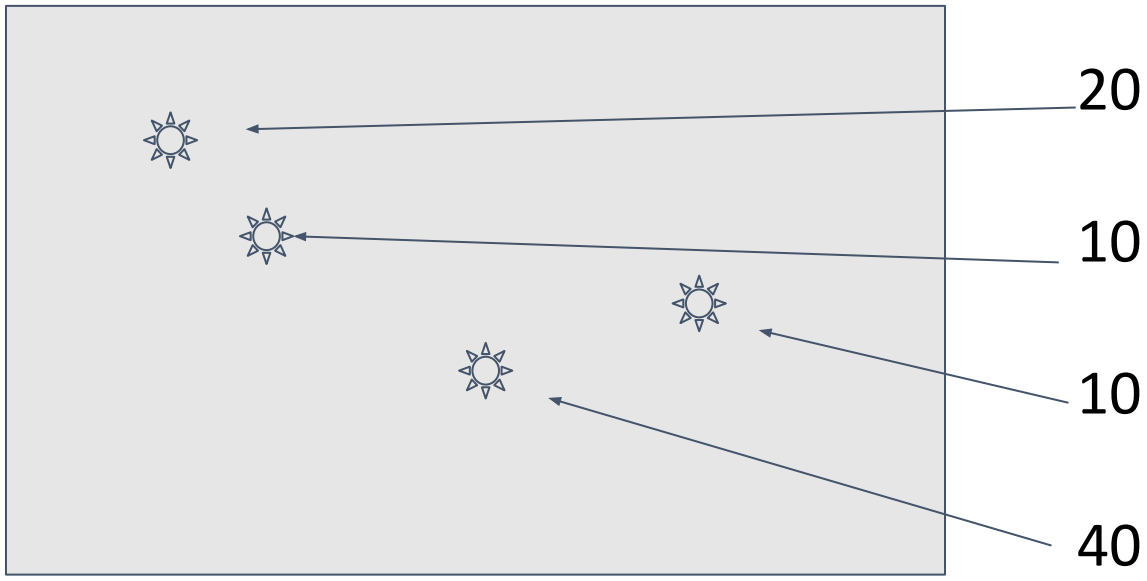
for “star A” when the exposure is 1 second.

What will you find for the stellar flux of “Star A” if the exposure is 2 seconds?

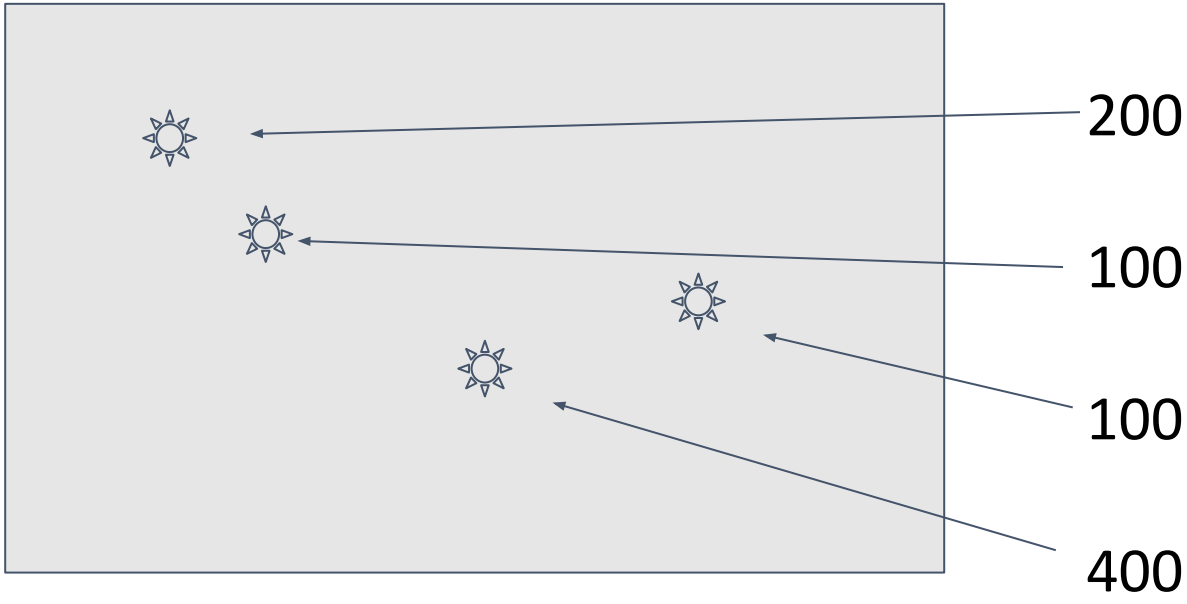
You found
stellar flux = flux inside aperture - background
= 10
for “star A” when the exposure is 1 second with clear skies.

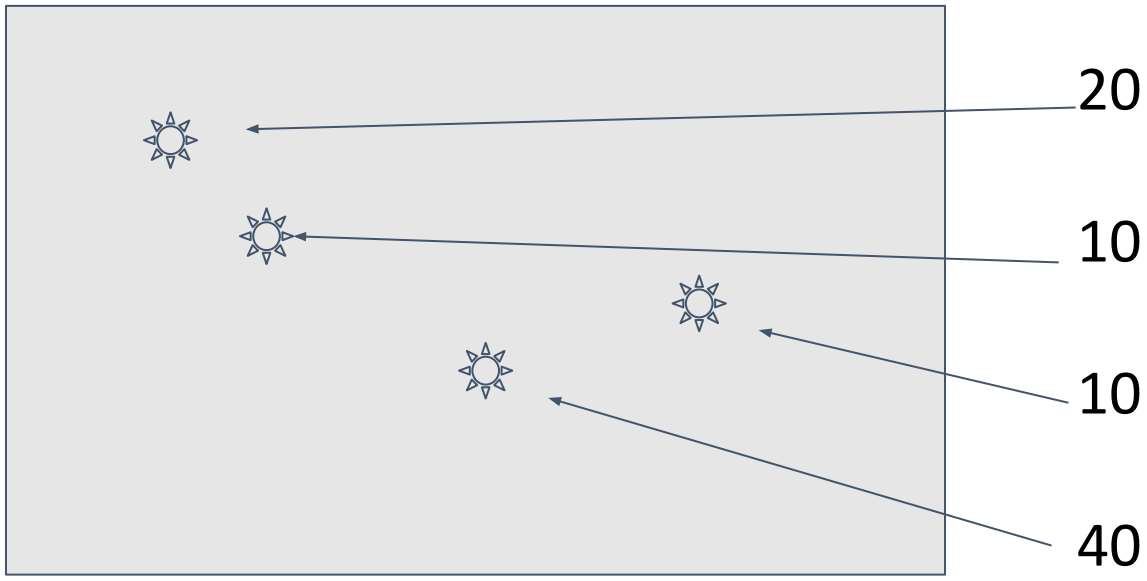
What will you find for the stellar flux of “Star A” if the exposure is 1 second but there is thin cloud cover (so some of the light from the star is blocked)?

How can you measure the actual variation in the brightness of a star if you can’t be sure the variation is due to thin cloud cover or not?



stellar fluxes measured





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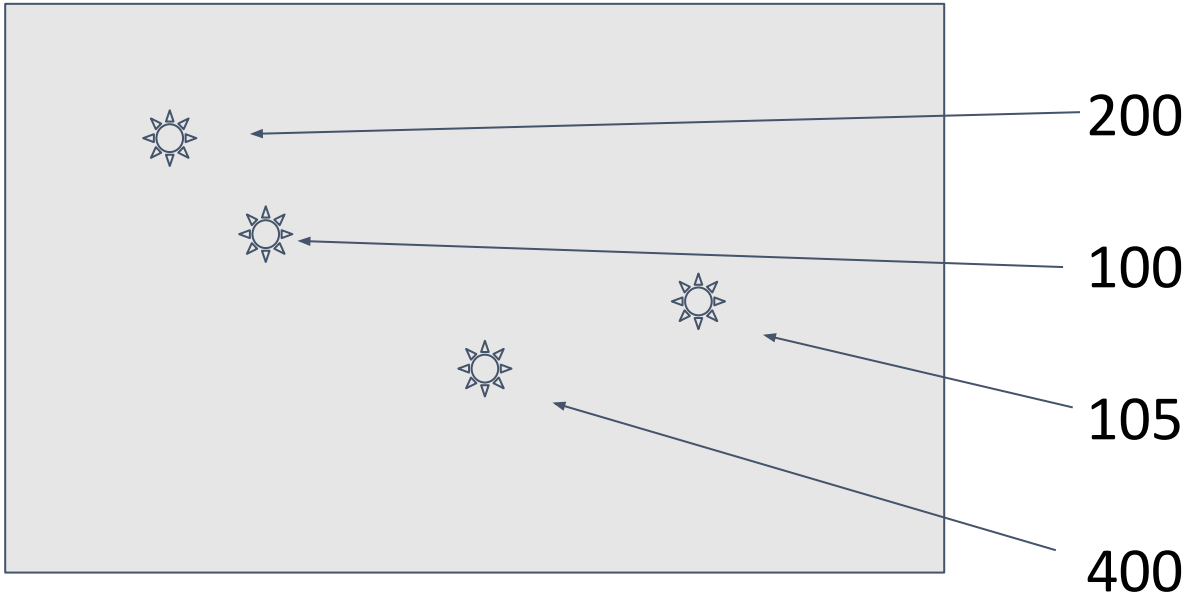

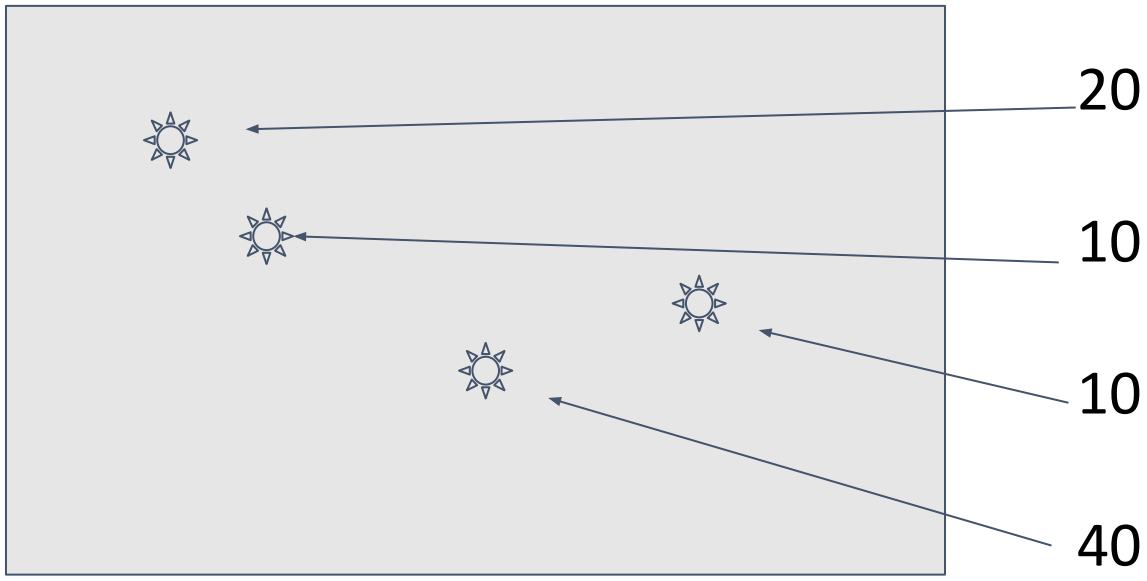

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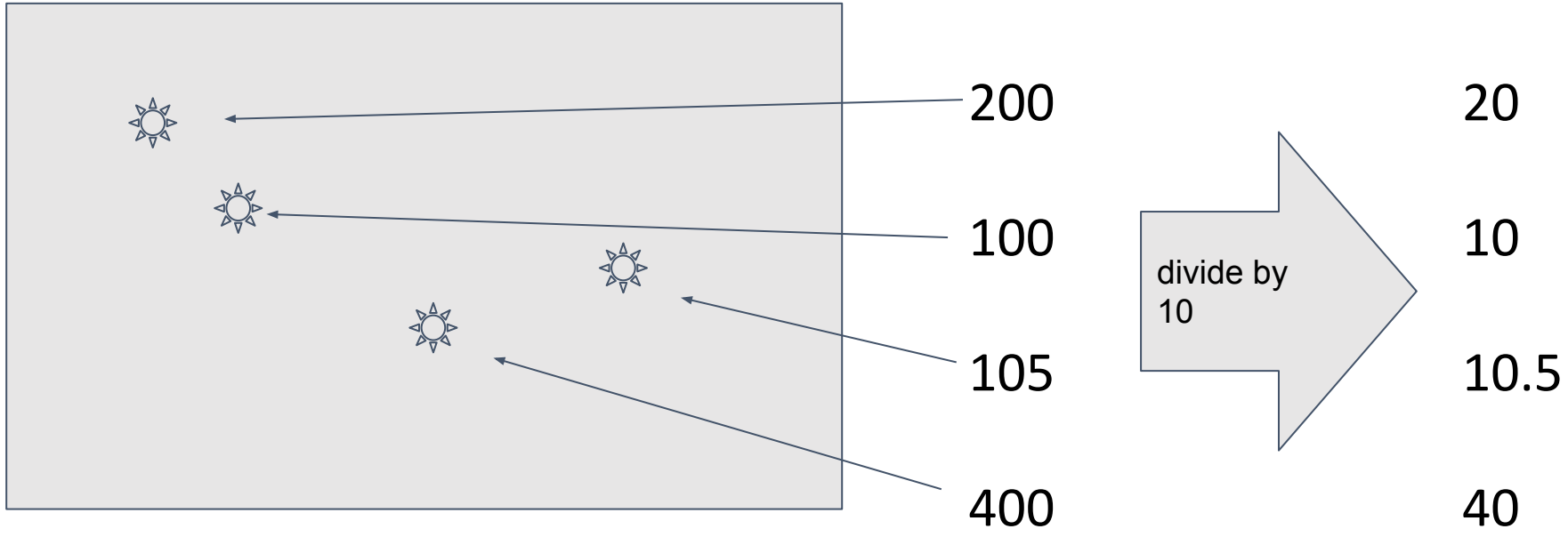
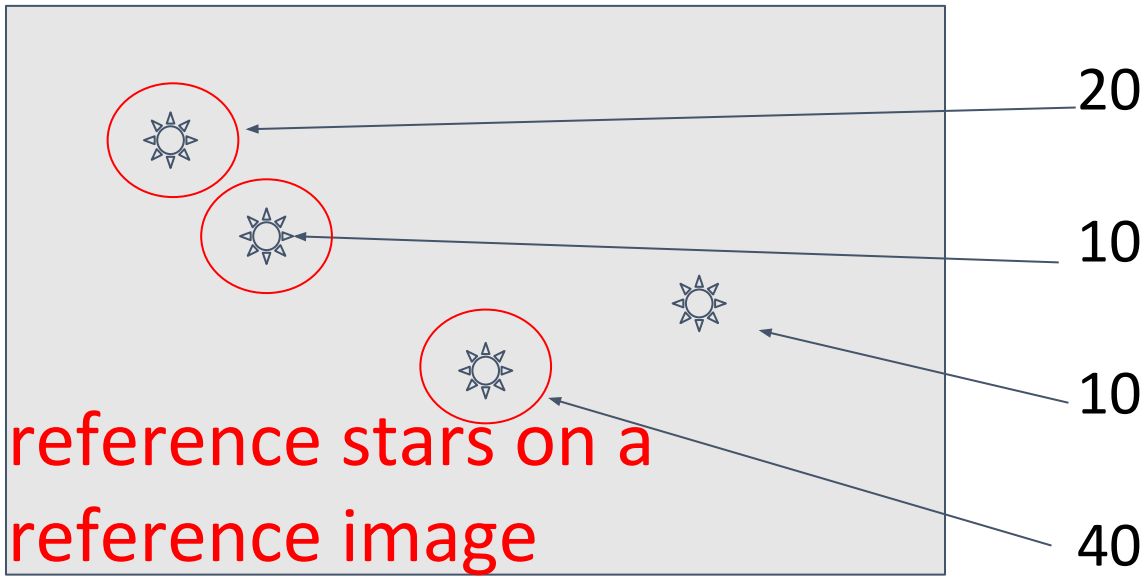
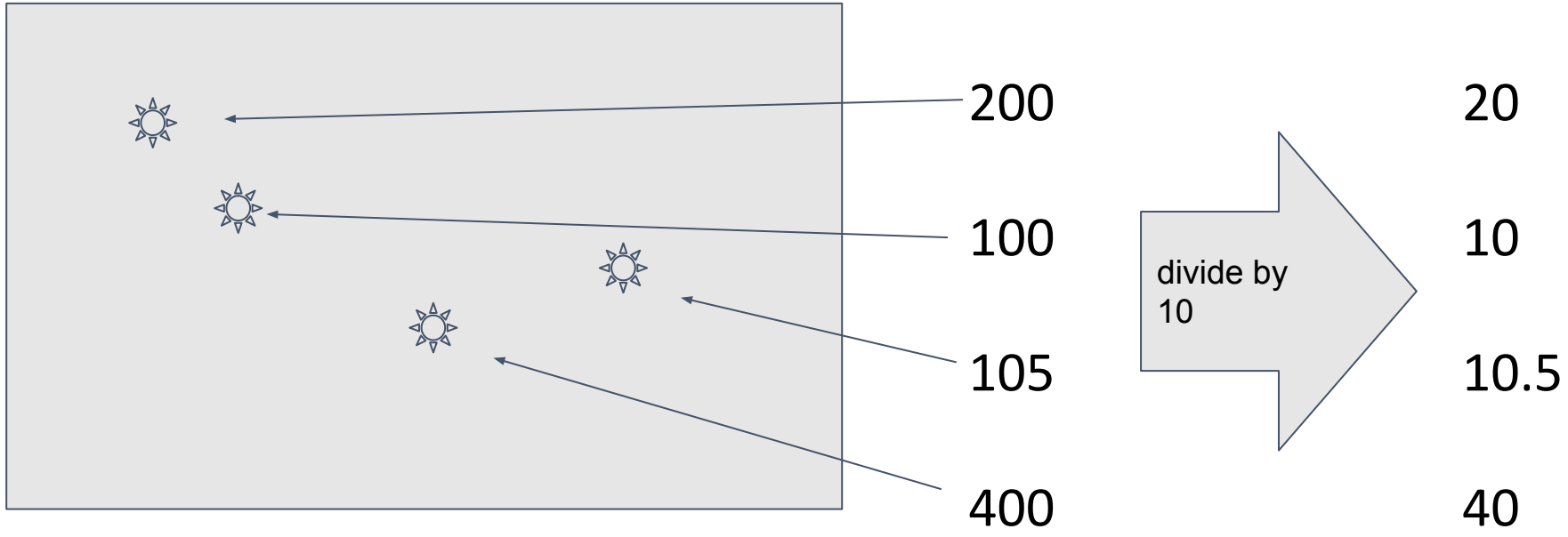
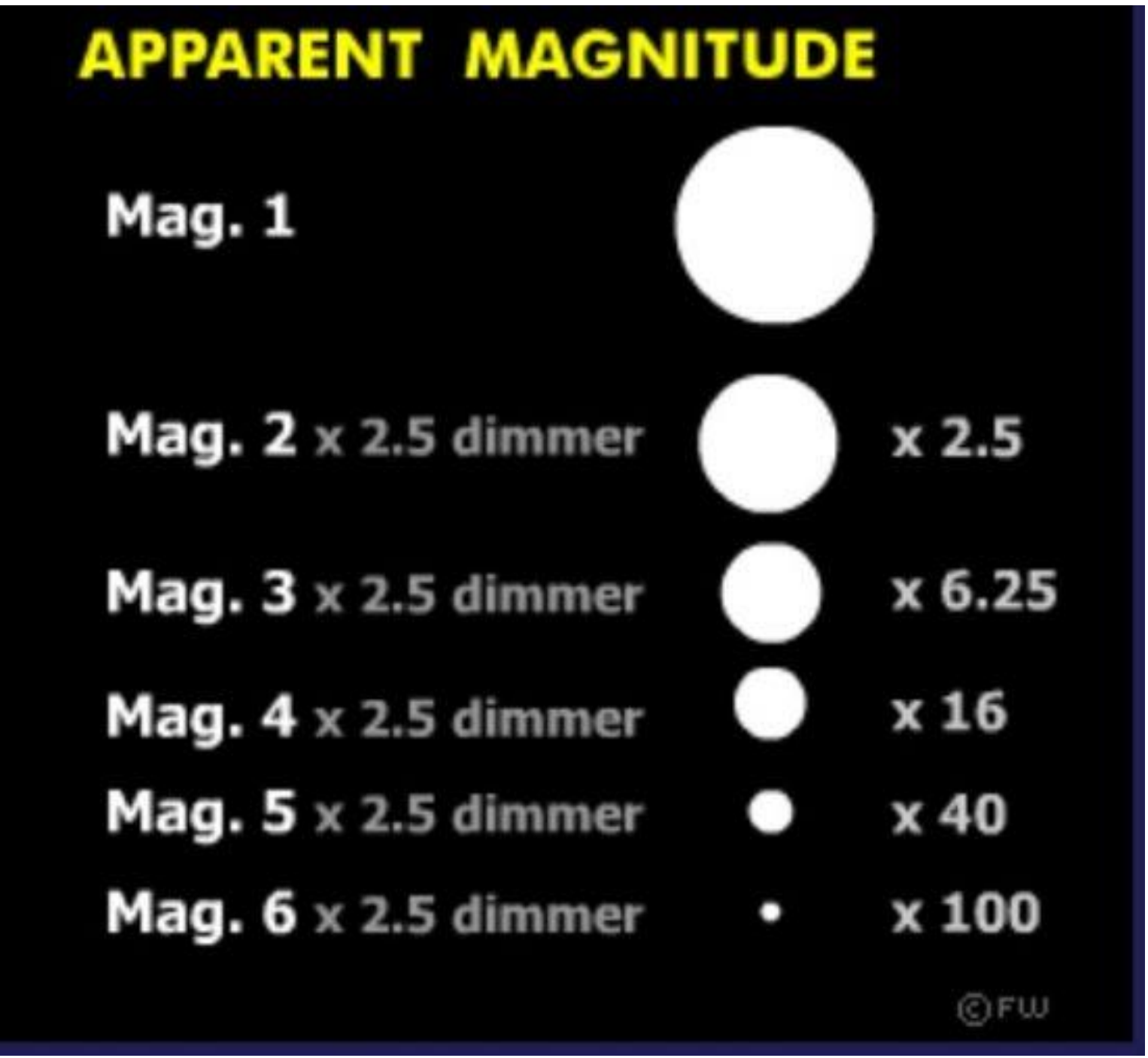


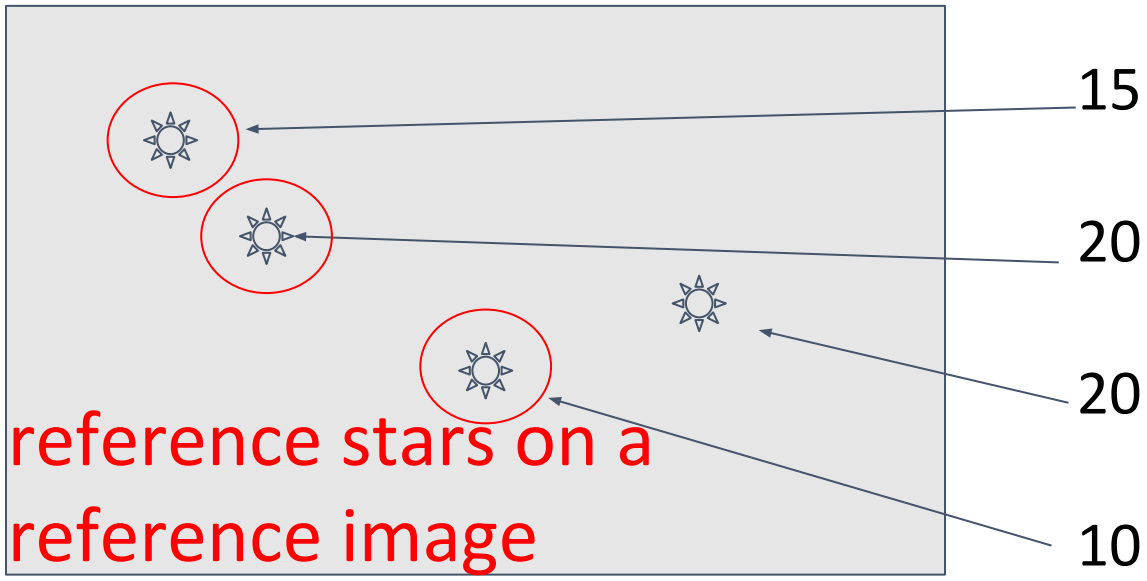


stellar
fluxes
measured

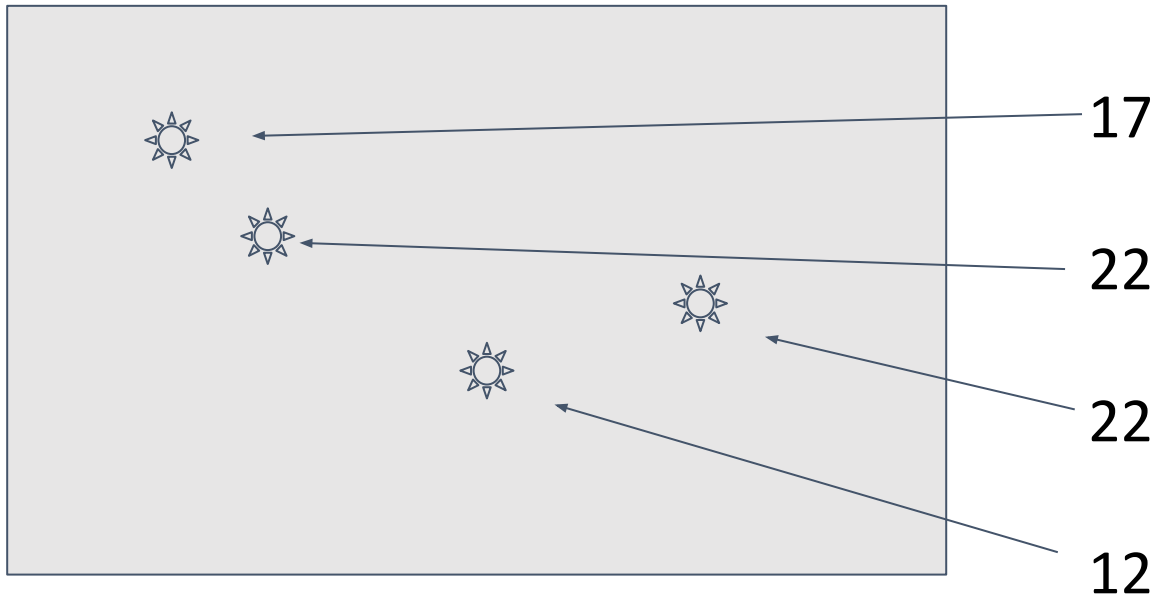


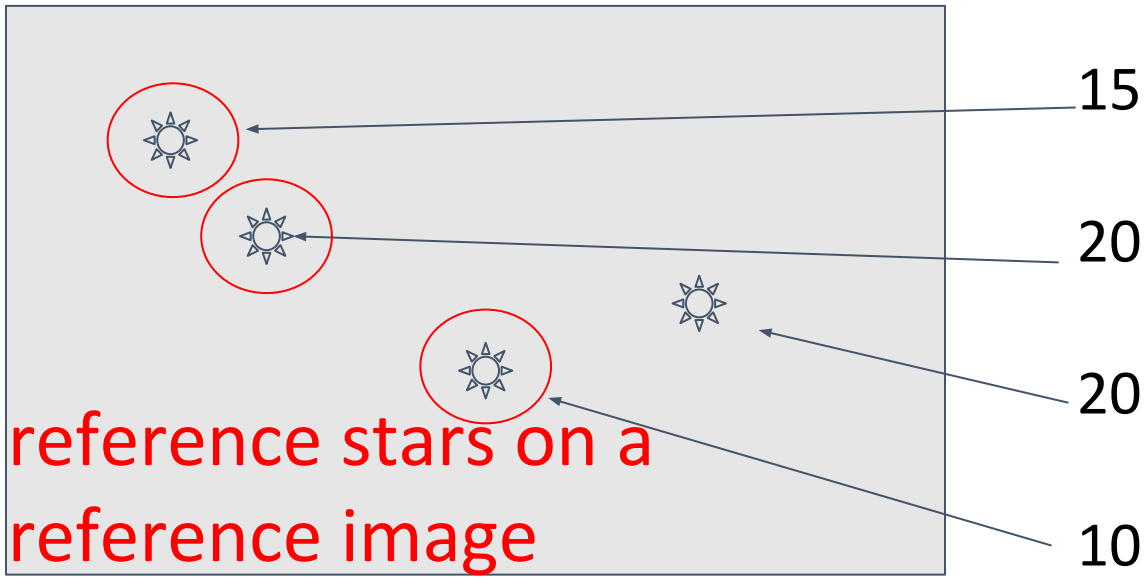
APPARENT MAGNITUDE





stellar
fluxes in
magnitude





stellar
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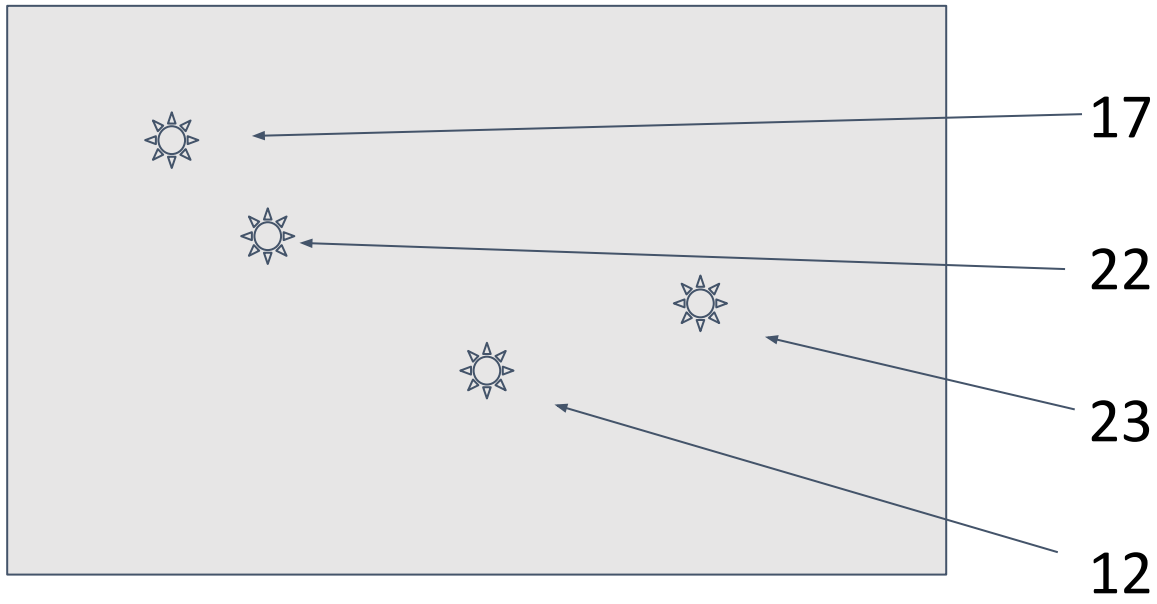
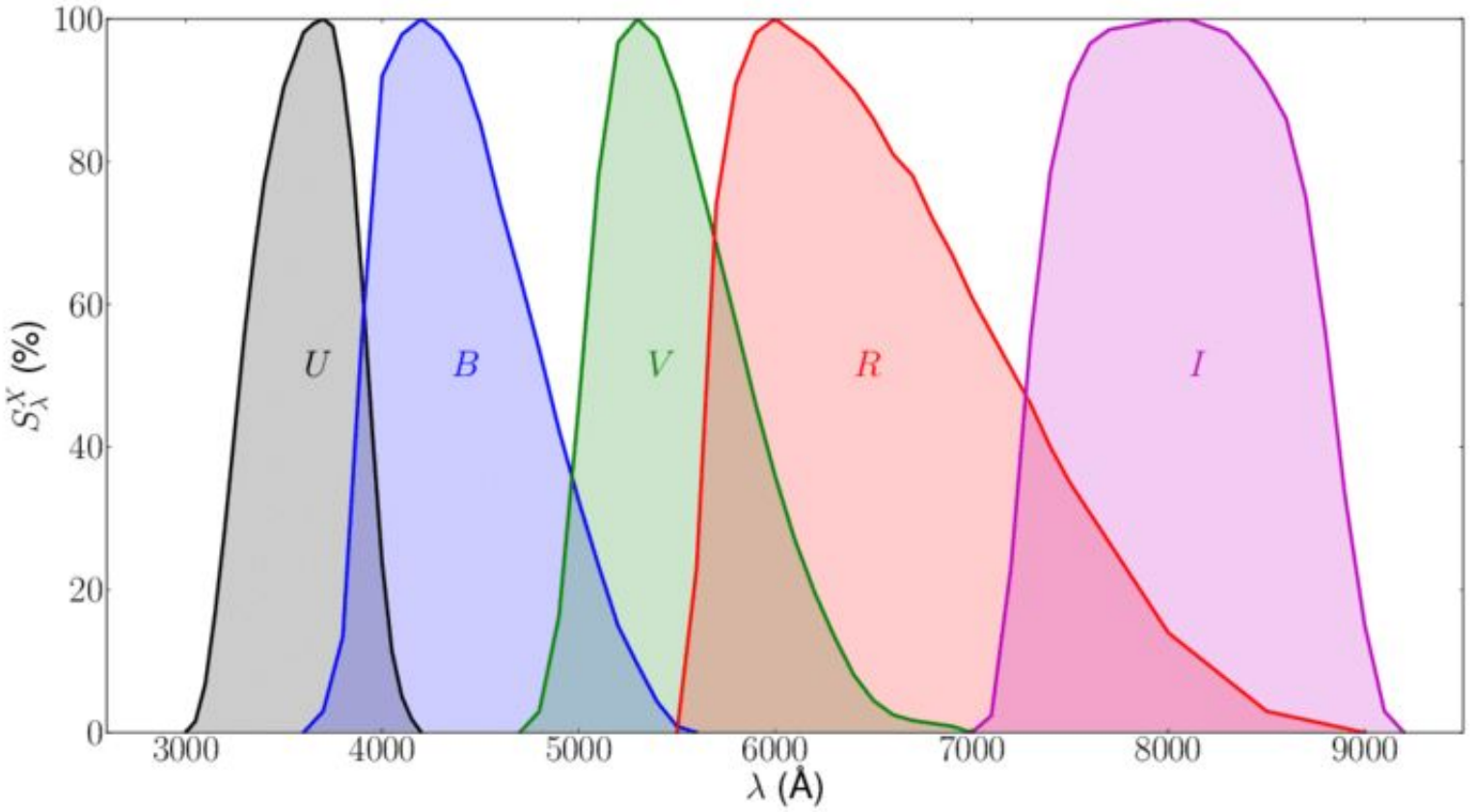


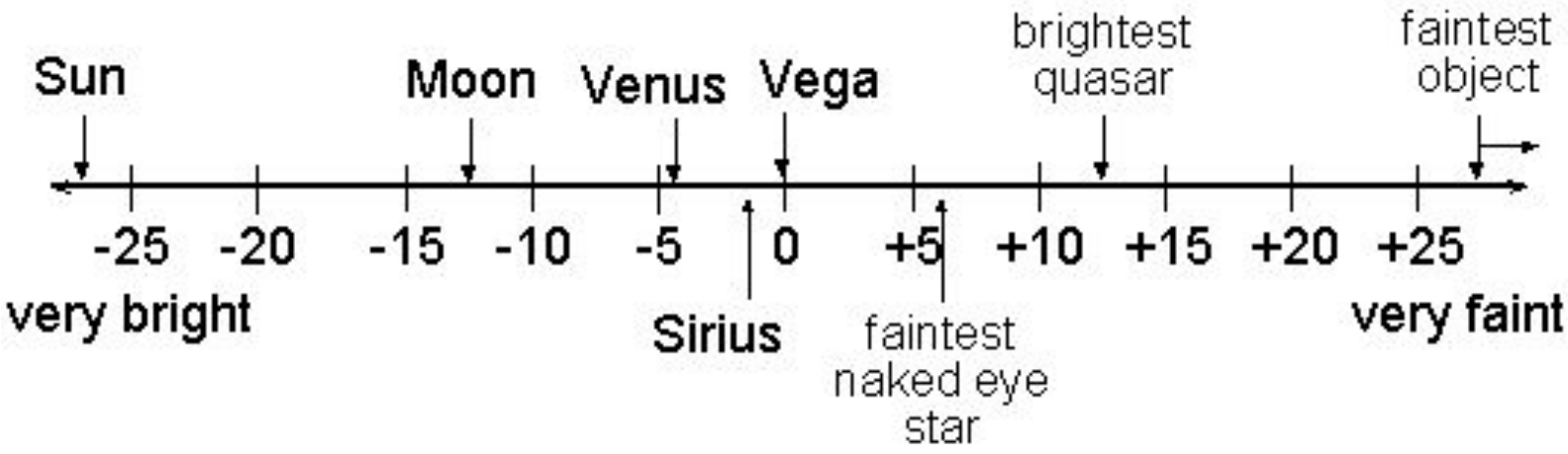
We can compare the brightness of the star in *two different filters* to estimate a color.

This slide needs to relate color as a mag. difference



A hot star has a B-V color index close to 0 or negative, while a cool star has a B-V color index close to 2.0.

This flux can be converted to something called a magnitude. We then talk about the magnitude of an object in a given filter.



Apparent brightnesses of some objects in the magnitude system.

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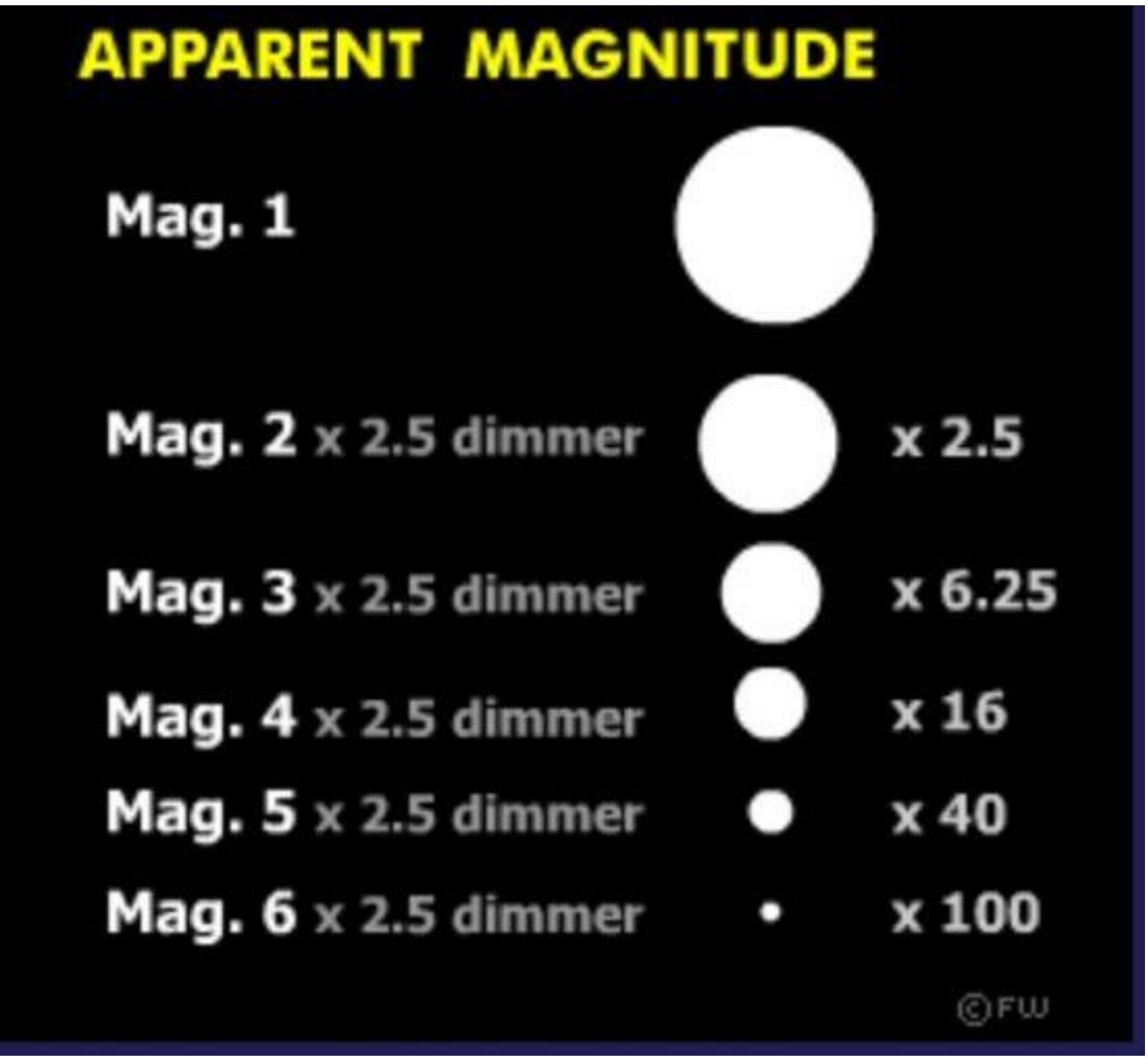

If a star has Vmag = 10, Bmag = 20
Is it more green (V) or more blue (B)?

Note: its V-B color will be -10

If a star has Vmag = 20, Bmag = 10
Is it more green (V) or more blue (B)?

Note: its V-B color will be 10

Summary

- The amount of light received from the source per second is the **flux** of the source.
- Flux can be measured in magnitudes.
- A **magnitude** 1 larger is ~2.5 times dimmer
- To measure the flux of a star, you add up all the pixel values associated with the star and subtract the **background**.
- **Reference** stars are used to find how the brightness of a target star varies with time.
- The difference between what the star looks like in two different filters tells you **color** information.

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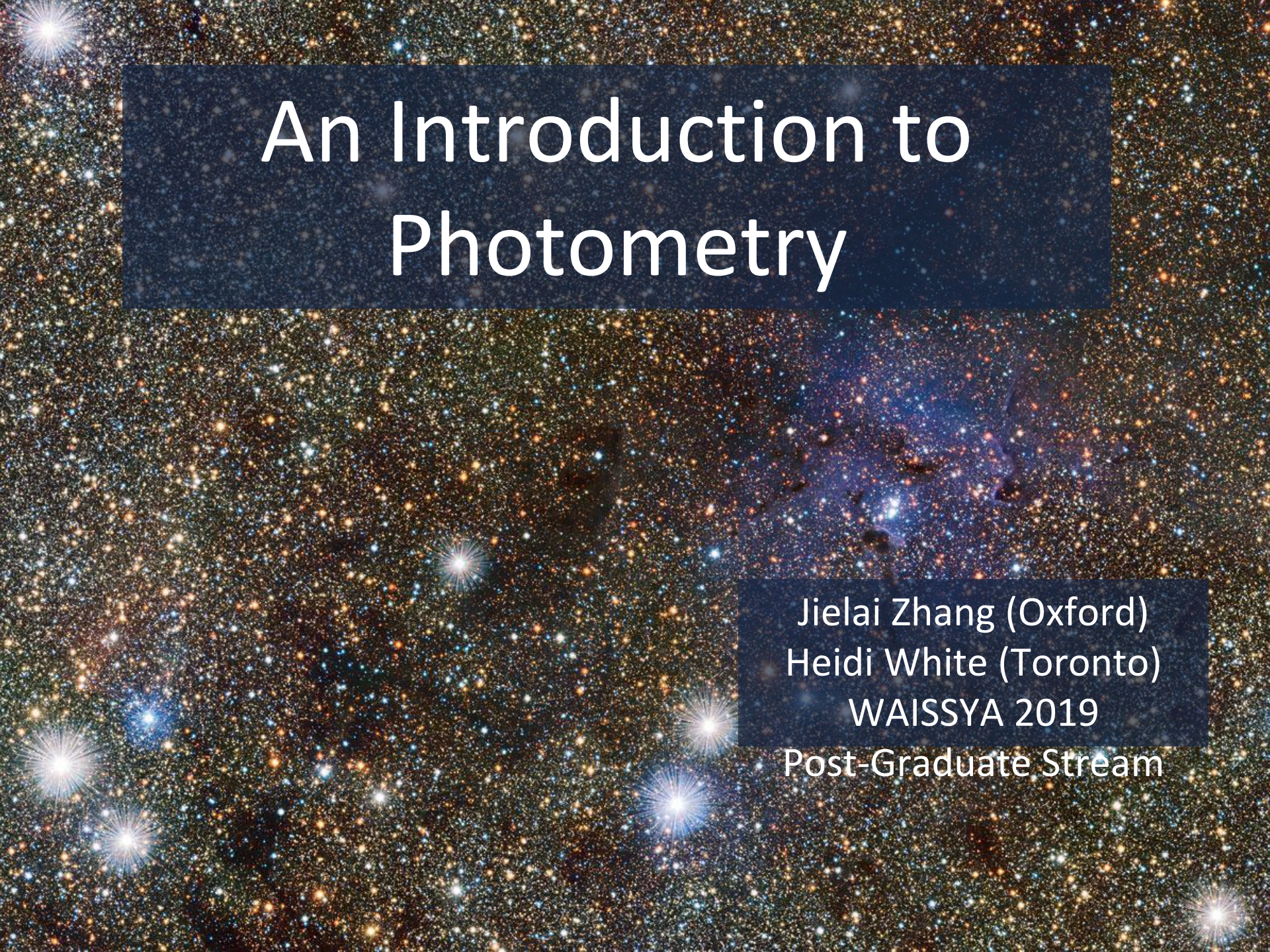

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