USING PHOTOMETRY TO DETERMINE IMF IN LOW-METALLICITY ENVIRONMENTS

EMILY APEL, RHONDA HOLTON, DR. PAUL SCOWEN

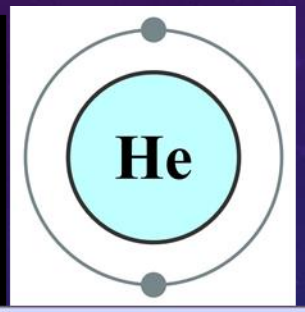
ARIZONA STATE UNIVERSITY

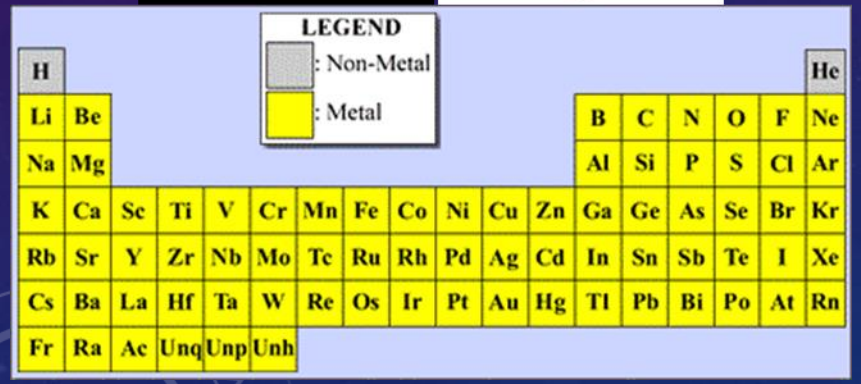
GOALS

1. Method: Develop a photometric method for finding the initial mass function (IMF)
2. Question: Does the IMF in metal-poor environments vary with cooling of star-forming gas
3. Analysis: Connect results to our understanding of early star formation

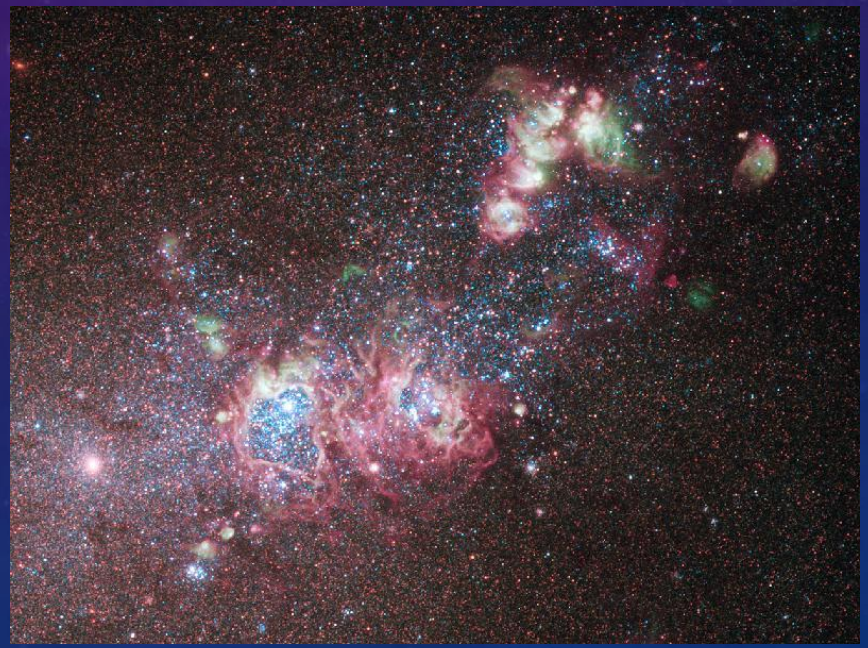
BACKGROUND

- Early universe → lack of heavier elements (metals)
- Theoretically, less metals → IMF skewed towards higher masses
- What is IMF?
- Local dwarf galaxies will help us determine this since looking to early universe is difficult.

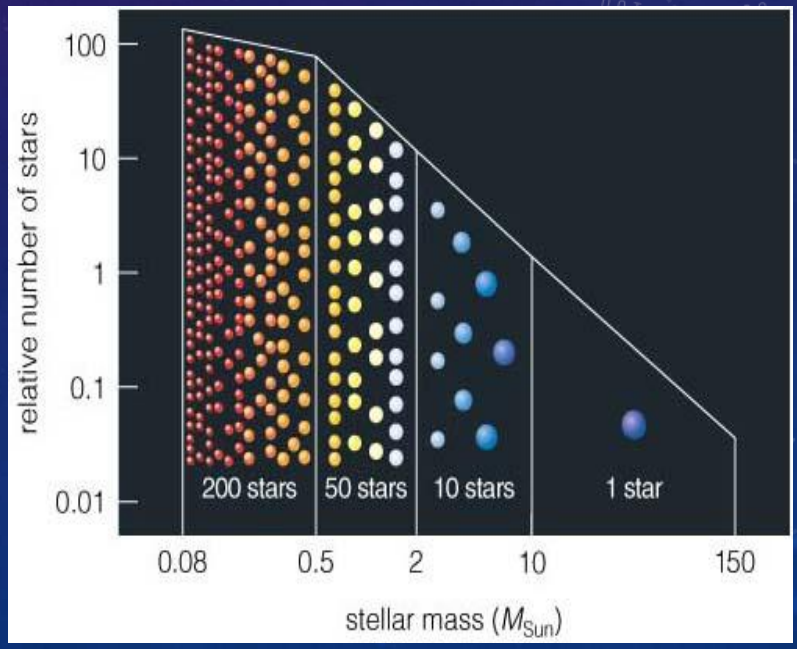




Credit: http://www.planetary.org/multimedia/space-images/charts/PeriodicTable-astro.html
https://commons.wikimedia.org/wiki/File:Electron_shell_002_Helium_-_no_label.svg
https://byjus.com/chemistry/uses-of-hydrogen/



Credit: NASA/ESA/Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration



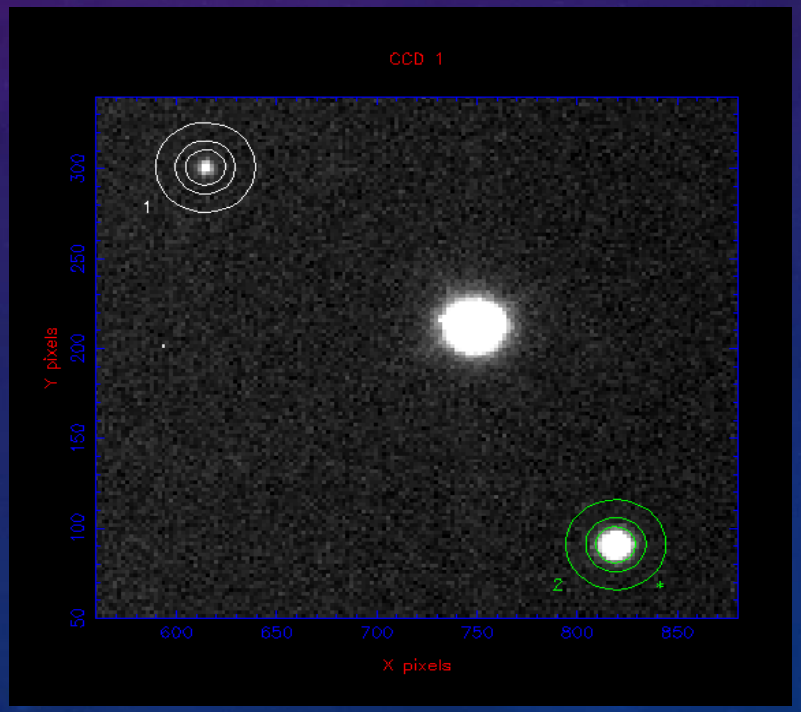
Credit: http://lasp.colorado.edu/education/outerplanets/images_solsys/big/star_demographic.jpg

METHODOLOGY

Photometric analysis method development based on:

- **Target selection** based on metallicity, distance, and available data
- **DAOPHOT** for initial estimates of stellar flux in cluster stars
- **Aperture photometry** of isolated stars is used to account for light scattered in the observing optics

Credit: S. D. Van Dyk (IPAC /Caltech) et al., KPNO 2.1-m Telescope, NOAO



Credit: Vik Dhillon

Credit: http://www2.lowell.edu/users/sholmes/wlm.html

TARGET SELECTION

- Requirements: Low enough metallicity, local target, and data available
- Data available from Hubble archive for F170W, F336W, and F555W filter

$$12 + [O/H] \leq 8.0$$

Metallicity

Target	12 + [O/H] [4]
Barnard's Galaxy	8.1 ± 0.2
WLM	7.8 ± 0.1
NGC 4214	8.2 ± 0.1
Sextans A	7.5 ± 0.1

Barnard's Galaxy
Credit: Local Group Galaxies Survey Team/NOAO/AURA/ NSF

Credit: http://www2.lowell.edu/users/sholmes/wlm.html

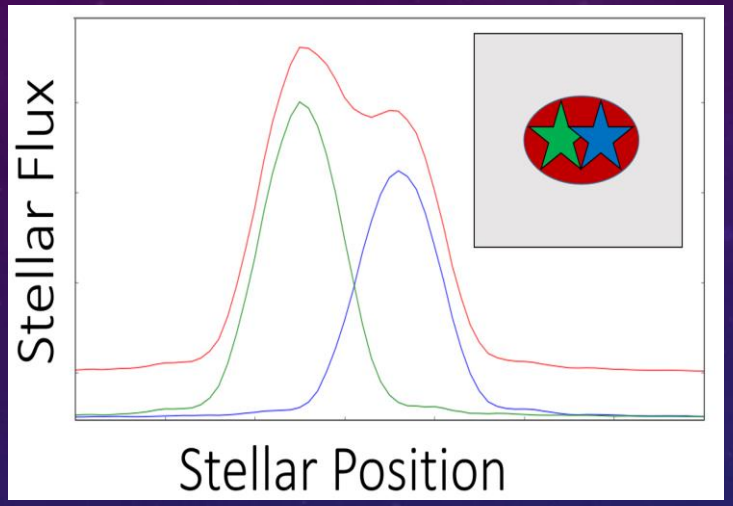
Credit: S. D. Van Dyk (IPAC /Caltech) et al., KPNO 2.1-m Telescope, NOAO

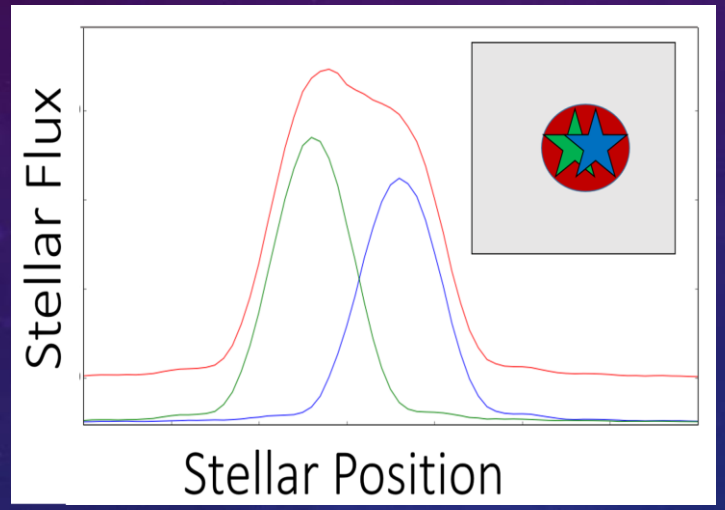
Credit: ESA/Hubble

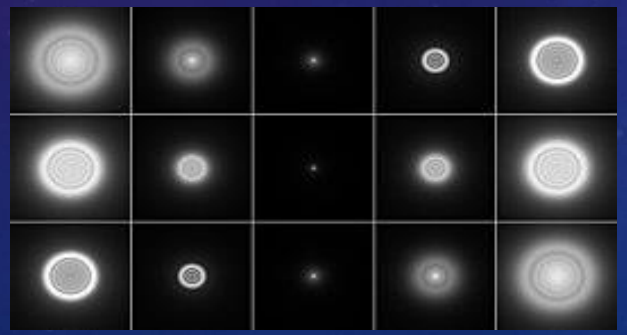
Credit: NASA/ESA/Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration

DAOPHOT

- Best tool for handling **spatial confusion**
- Used in conjunction with the **point spread function (PSF)** allows isolation of individual stars.
- DAOPHOT helps us discern **two** flux peaks, providing individual fluxes **AND** locations





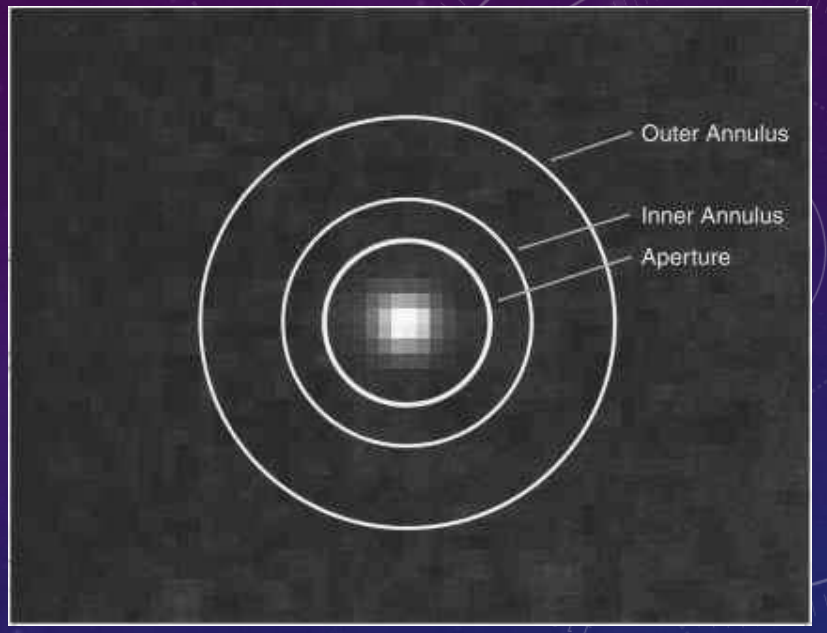


Credit: https://en.wikipedia.org/wiki/Point_spread_function

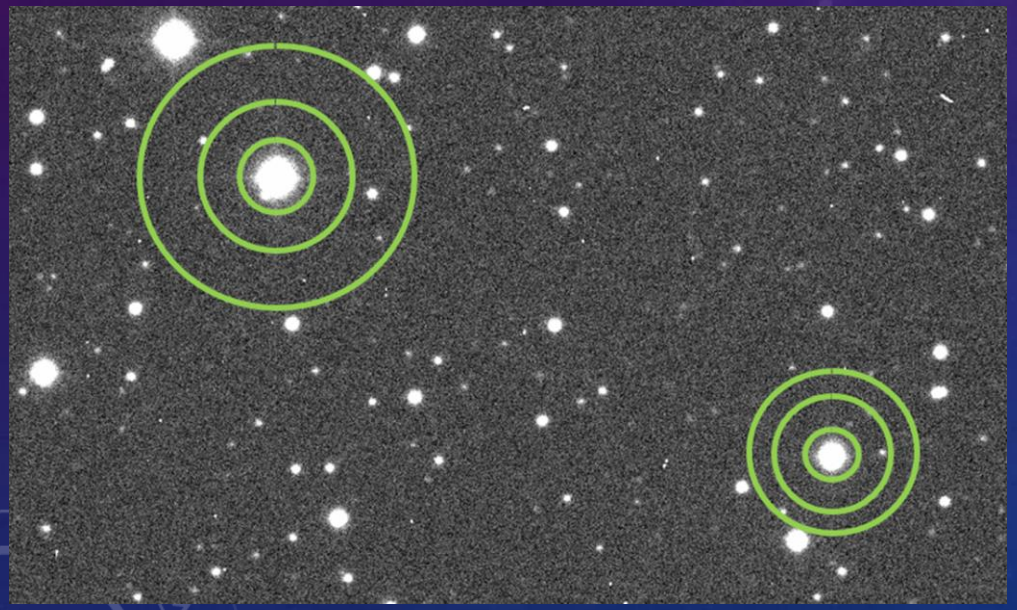
Barnard's Galaxy
Credit: Local Group Galaxies Survey Team/NOAO/AURA/ NSF

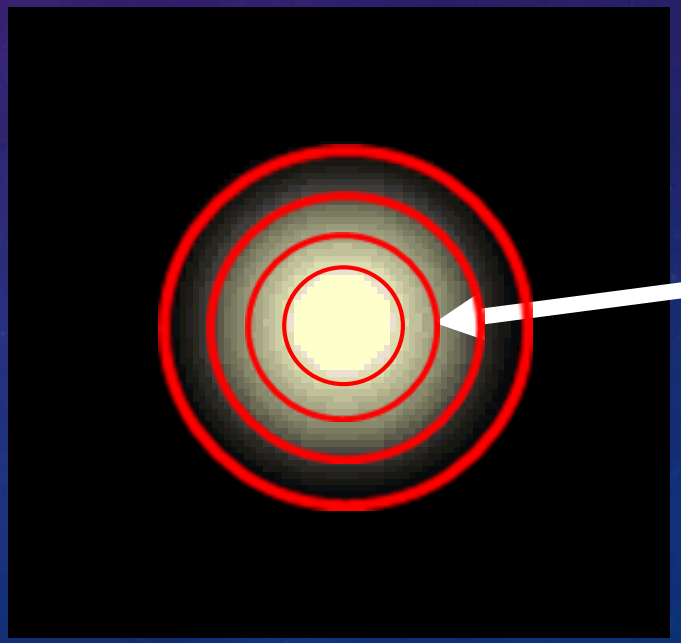
APERTURE PHOTOMETRY

- Helps determine flux in differently sized annuli around a few, easily separated stars.
- Ideally, center ring would capture all light, but some is scattered outwards.
- Thus, outer rings help us find percentage scattered
- Percentage scattered is then added to flux found using DAOPHOT



Credit: https://www.astronomyclub.xyz/image-processing/magnitudes-how-bright-is-this-star.html



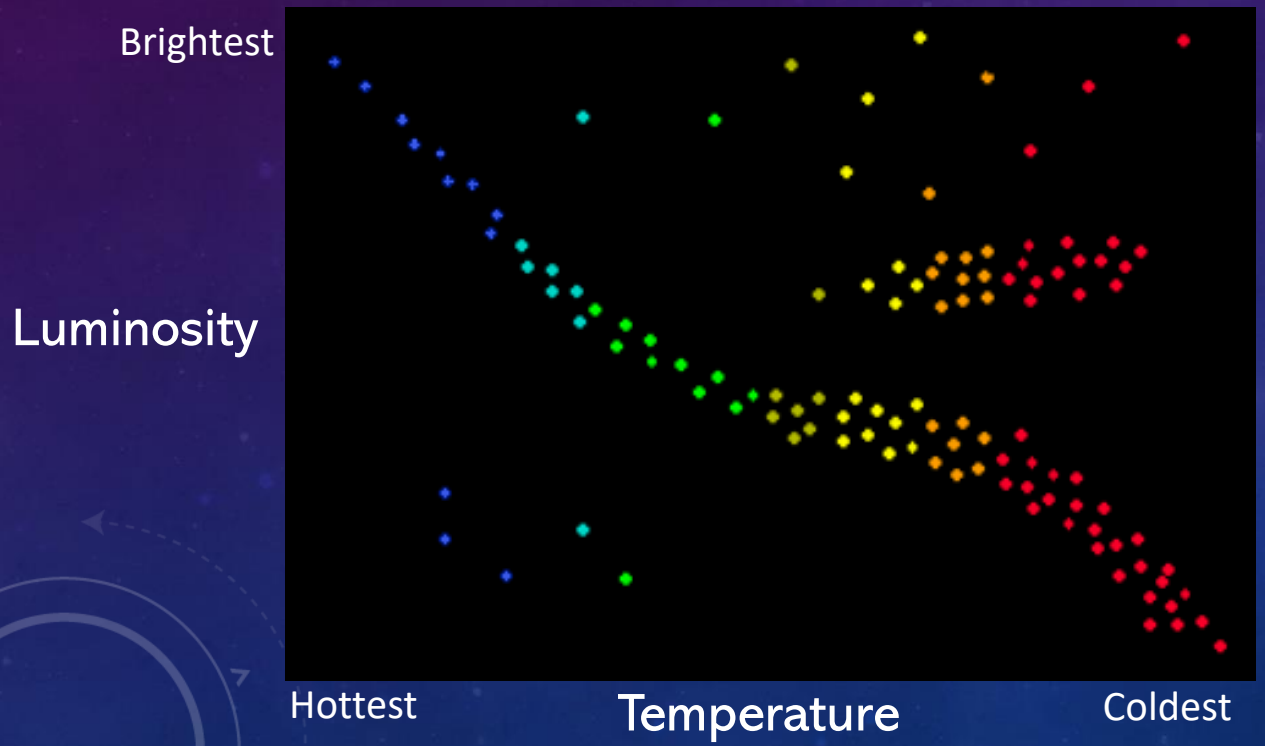


Credit: https://amazing-space.stsci.edu/resources/explorations/groundup/lesson/basics/g18a/

CALCULATION OF MASS FROM COLOR AND MAGNITUDE USING MASSEY'S METHOD

$U - B = 0.72*(B - V)$ → $Q = U - B + 0.72*(B - V)$ → **STELLAR COLOR**

Tells us the star's magnitude



Credit: http://www.astro.cornell.edu/academics/courses/astro201/hr_diagram.htm

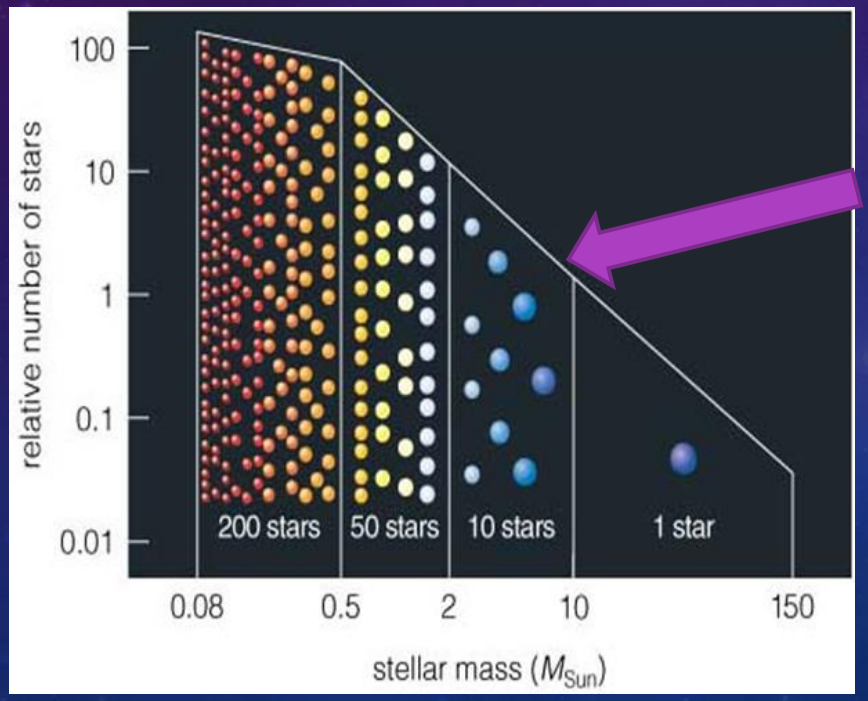
TEMPERATURE

MASS

And once we have the mass, we can find…

IMF

- IMFs in galaxies of average metallicity values have a slope value close to the Salpeter value of -2.0
- We expect low metallicity galaxies to skew towards higher masses, so we expect an IMF of slope GREATER THAN -2.0



More higher mass stars means slope will become **less negative**

Credit: http://lasp.colorado.edu/education/outerplanets/images_solsys/big/star_demographic.jpg

ACKNOWLEDGEMENTS

- NASA Space Grant Program
- Arizona State University
- Dr. Paul Scowen
- Rhonda Holton

QUESTIONS?