# Main Sequence Fitting

## *Another Rung on the Distance Ladder*

Ellie Lincoln
Dr. Mike Crenshaw
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# MS Fitting Methods


NASA, APOD

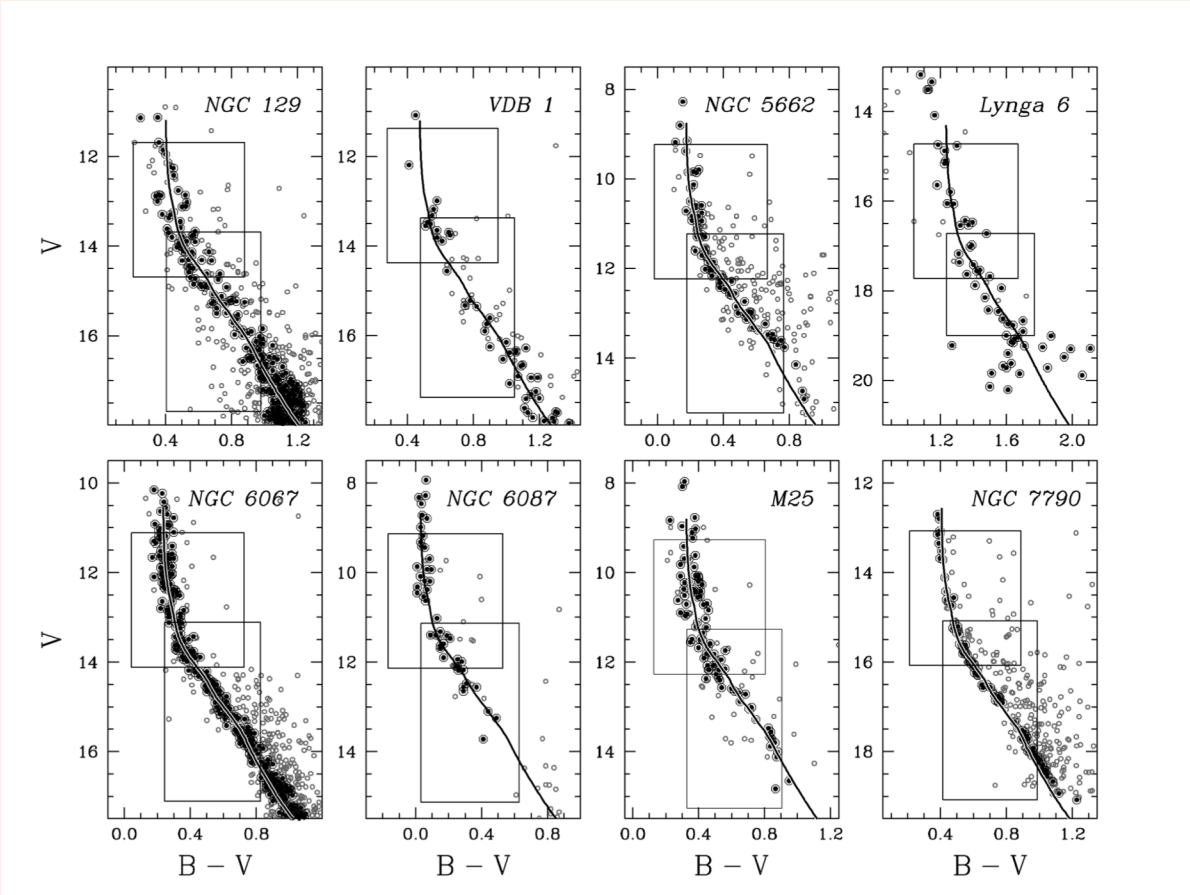
- Clusters too far for moving method

  1. Using Hyades
     - 0.02 mag or better if reddening of cluster is known
     - Limitations

  2. Using isochrone models
     - errors as small as 0.04 mag
     - Still tricky

# Photometry

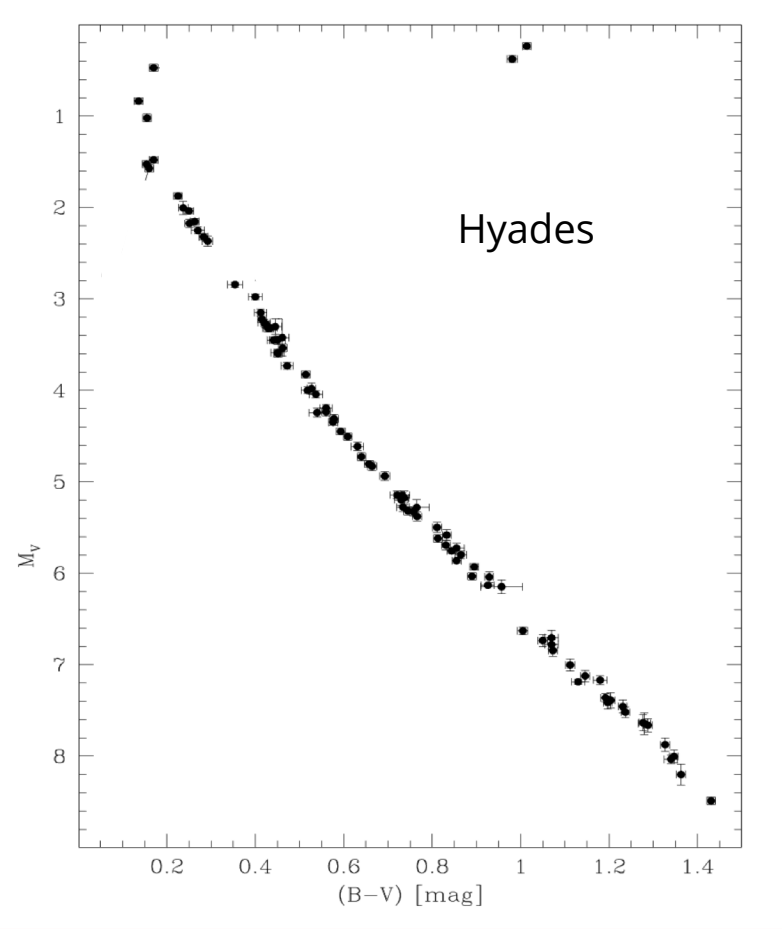
- Every star with suspected membership




An (2015)

# Hyades

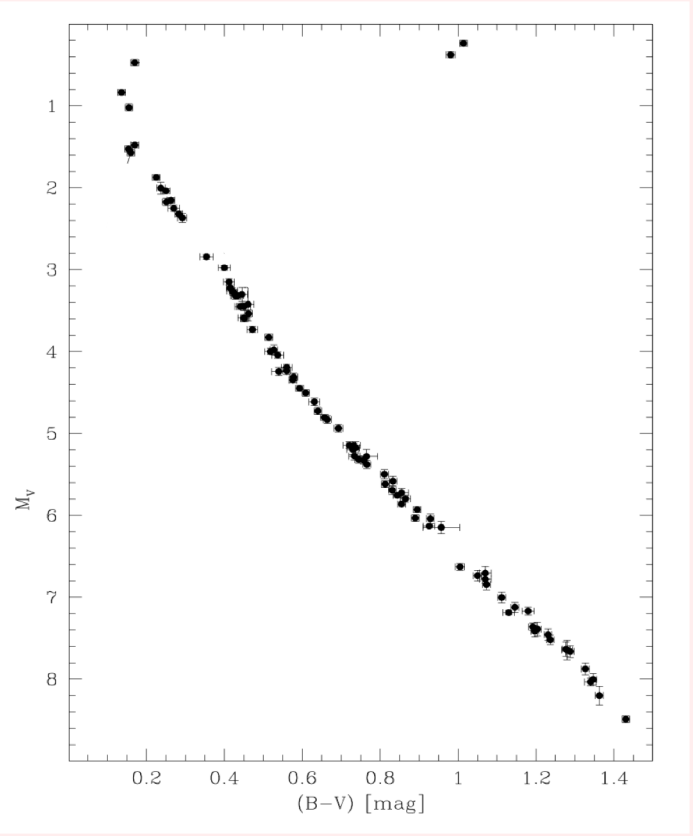
- Early standard for MS fitting
- Relatively nearby
  - Mean  distance of ~45pc
- Less interstellar reddening
- Less extinction




de Bruijne 2000

# Hyades Problems

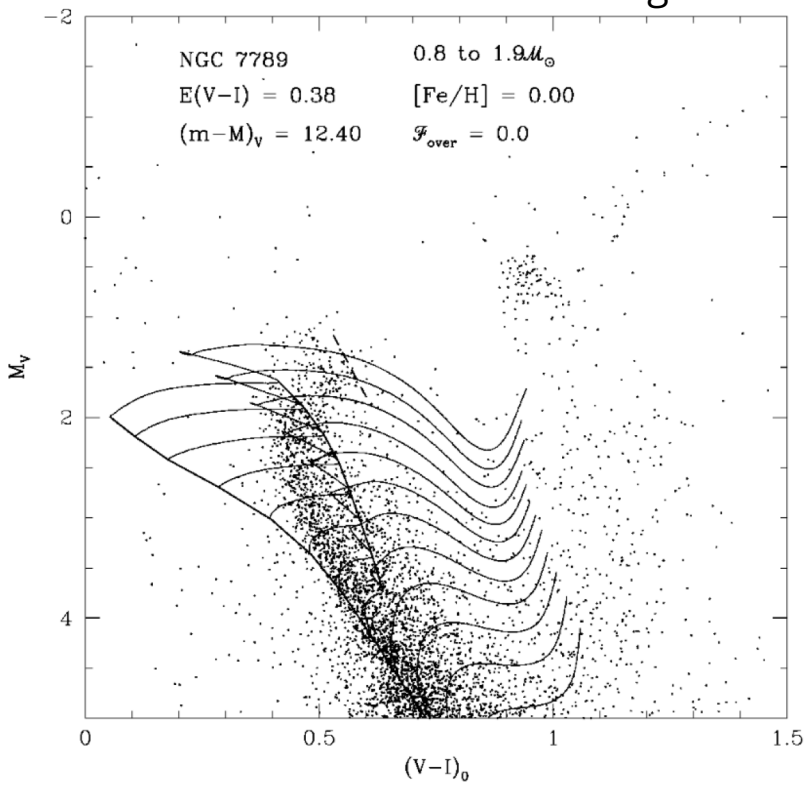
- Relatively old
  - ~550 Myr
  - Small number of upper MS stars to compare with younger clusters
  - More reliable at dimmer magnitudes
- Limited metallicity application



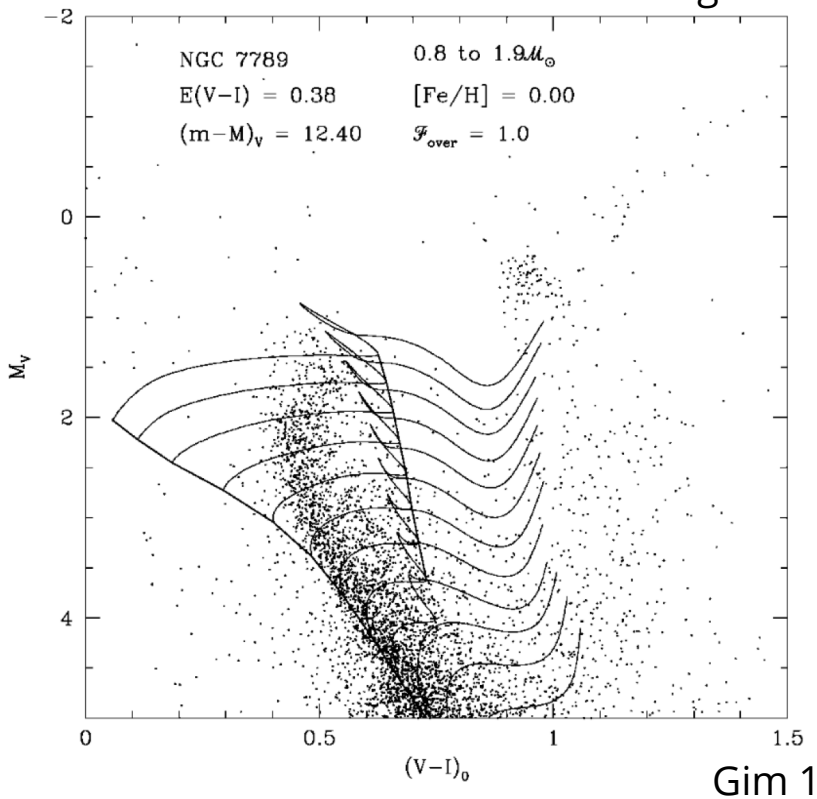

de Bruijne 2000

# Get Apparent Magnitudes

No convective overshooting

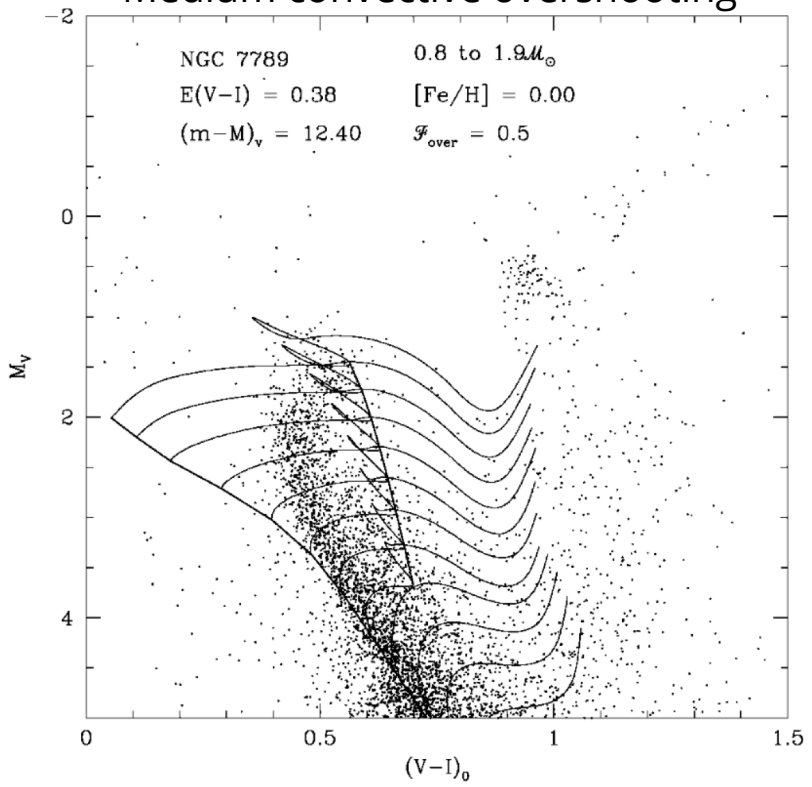


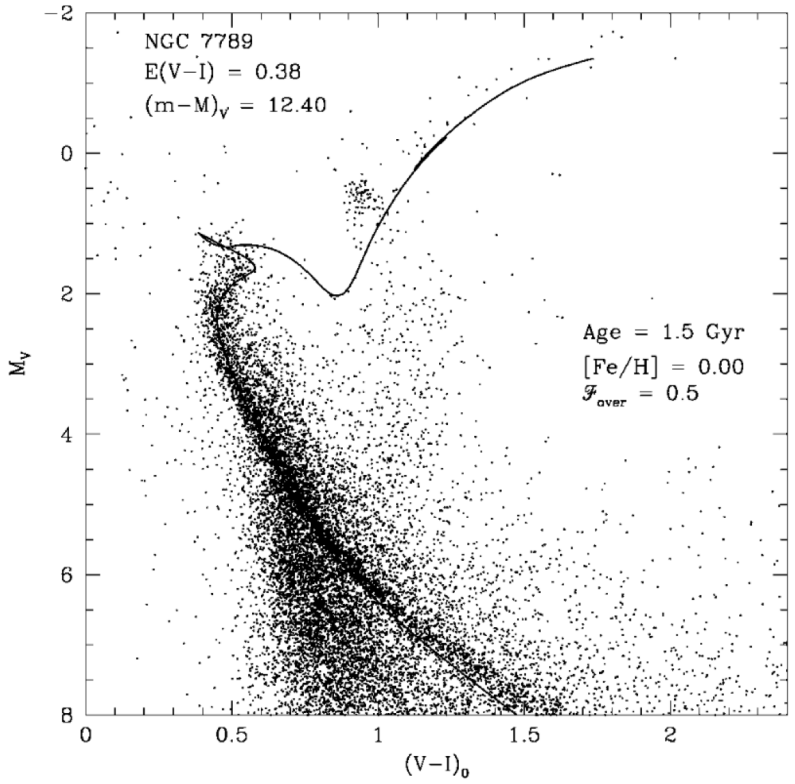

Max. convective overshooting




Gim 1998

Medium convective overshooting




Gim 1998

# Determining the Distance

- Have the distance modulus (m-M)

$$m - M = 5 \log(d) - 5$$

rearrange to solve for d

$$d = 10^{(m-M)/5 + 1}$$

- Yay we have the distance!

# Range of Distances

- $d = 10^{(m-M)/5 + 1}$
- NGC 4590 with $(m-M)_V$ of 15.31 = 11,534 pc*
- ~200x further than previous rung
- But less complicated to use other methods, if possible

*Forbes (2008) says 10,000 pc

TABLE 2. Main Sequence Fitting Distances

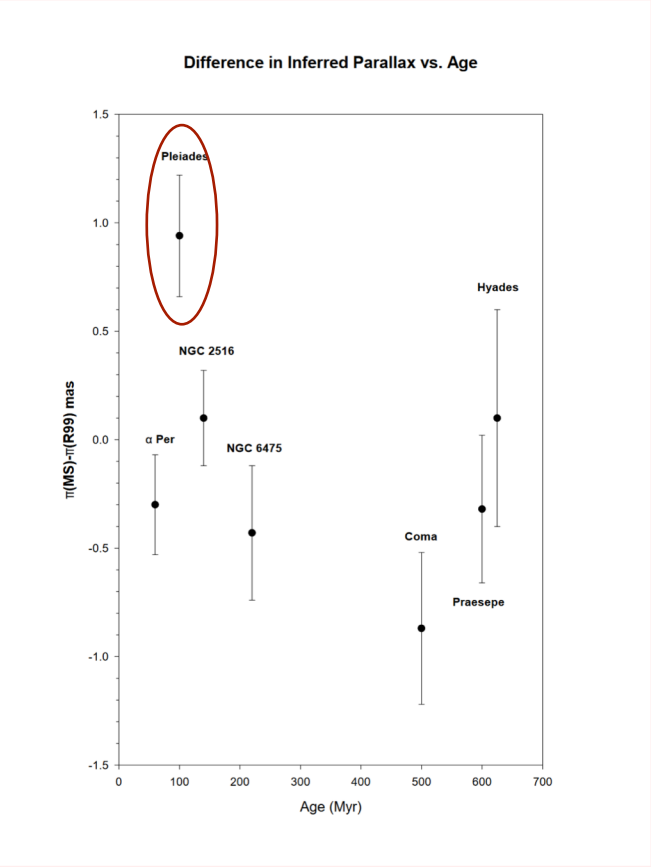
| Cluster | $(m-M)_O$ | $E(B-V)$ | $(m-M)_V$ | Reference |
|---|---|---|---|---|
| 47 Tuc NGC 104 | 13.56 | 0.04 | 13.69 | 1 |
| | 13.44 | 0.055 | 13.62 | 2 |
| NGC 288 | 15.00 | 0.01 | 15.03 | 1 |
| | 14.83 | 0.033 | 14.94 | 2 |
| NGC 362 | 14.86 | 0.056 | 15.04 | 2 |
| M68 NGC 4590 | 15.18 | 0.040 | 15.31 | 2 |
| M5 NGC 5904 | 14.52 | 0.02 | 14.58 | 1 |
| | 14.41 | 0.03 | 14.51 | 3 |
| | 14.49 | 0.035 | 14.60 | 2 |
| M13 NGC 6205 | 14.38 | 0.021 | 14.45 | 4 |
| | 14.45 | 0.02 | 14.51 | 1 |
| | 14.41 | 0.02 | 14.47 | 3 |
| | 14.39 | 0.020 | 14.45 | 2 |
| M92 NGC 6341 | 14.72 | 0.025 | 14.80 | 2 |
| | 14.68 | 0.02 | 14.74 | 5[a] |
| NGC 6397 | 12.24 | 0.19 | 12.85 | 1 |
| NGC 6752 | 13.16 | 0.04 | 13.29 | 1 |
| | 13.20 | 0.04 | 13.33 | 3 |
| | 13.21 | 0.035 | 13.32 | 2 |
| M71 NGC 6838 | 13.19 | 0.28 | 14.09 | 1 |
| M30 NGC 7099 | 14.82 | 0.039 | 14.94 | 2 |

REFERENCES. — (1) Reid 1998; (2) Gratton *et al.* (1997); (3) Chaboyer *et al.* (1998); (4) Grundahl *et al.* (1998); (5) Pont *et al.* (1998).

Chaboyer 1999

# Big Problem in ~2000

- Either HIPPARCOS has some unaccounted error
- Main sequence fitting is a flawed technique
- Models are missing a key component
  - Metallicity or age related to luminosity

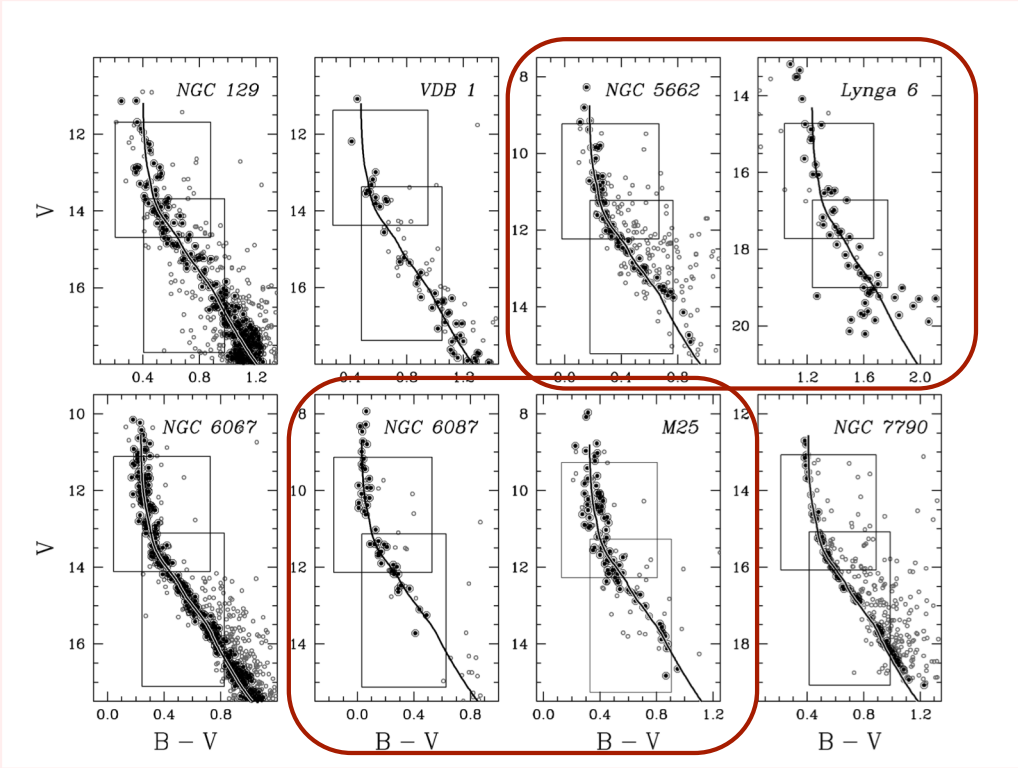



All of the above?

Pinsonneault 2000

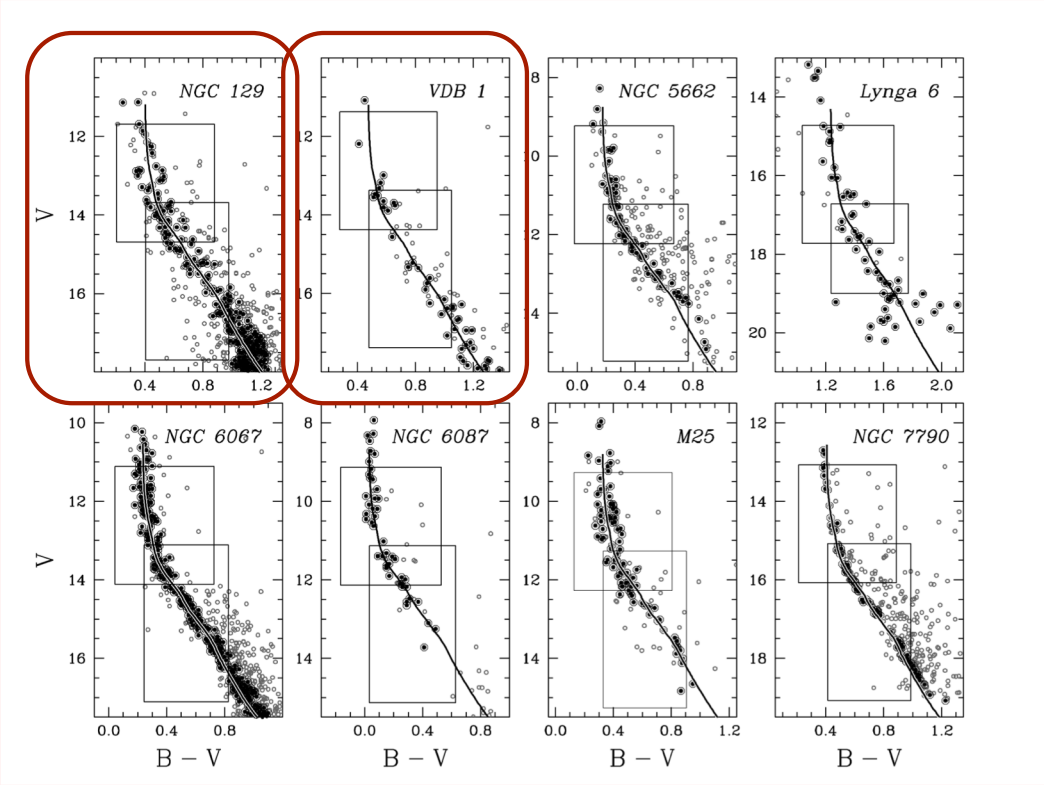
# Problems

- Apparent distance
  - Young systems (less than 100 Myr) haven't settled
  - Higher metallicities appear dimmer
- Harder to fit clusters that only have bright stars



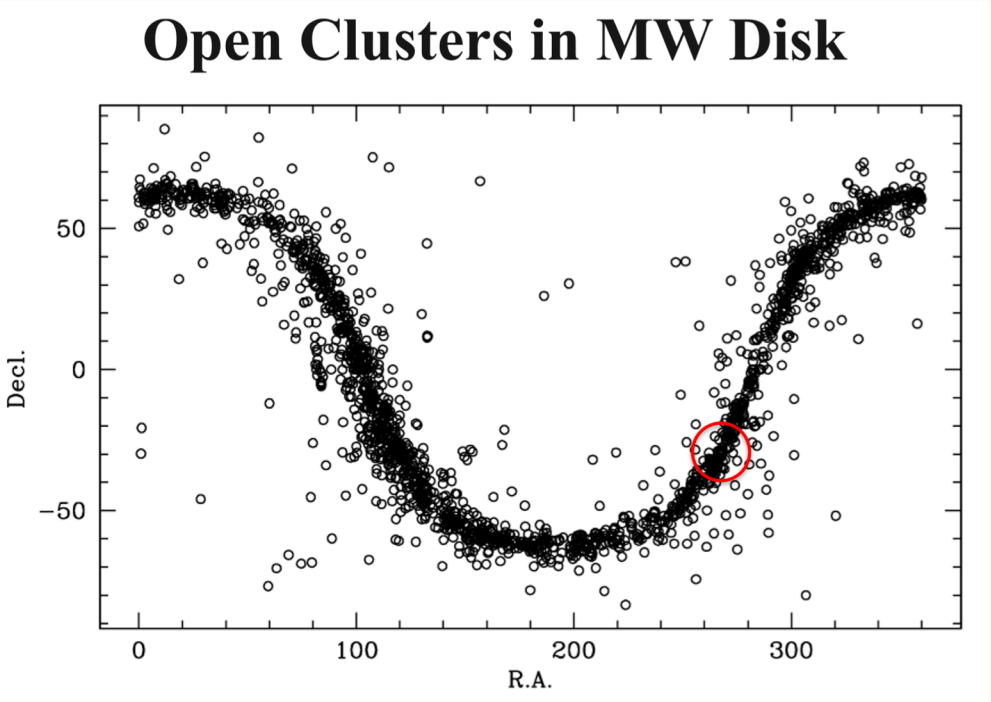
# More Problems

- Not a clear main sequence, harder to fit
- Blue stragglers
- Membership confidence
  - Circles
    - Open: Rejected
    - Bulls-eyes: Included
  - Boxes
    - Top: Reddening found
    - Bottom: Distance found



# Other Errors

- Error in photometry
- Extinction errors
- Lots of dust!
- Only measuring photometry in one color
- Systematic errors everywhere

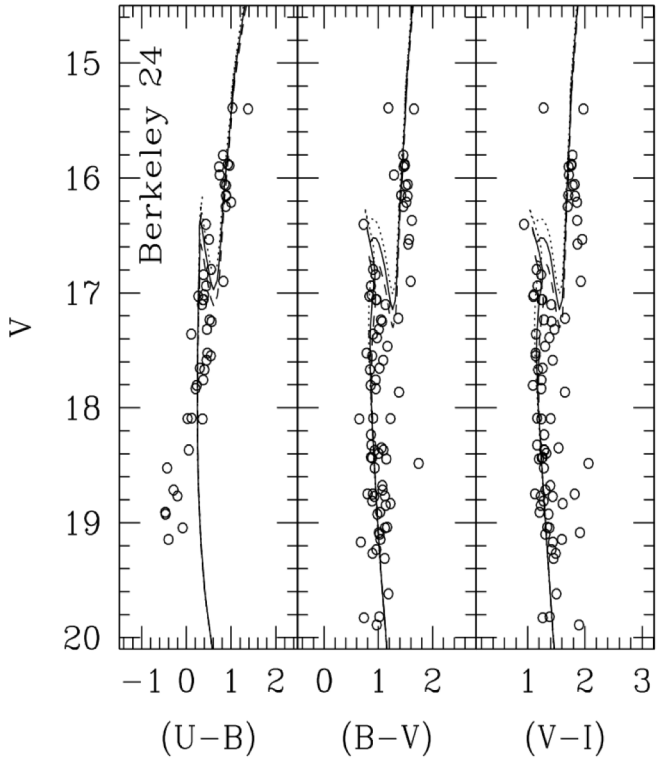



Henry, 2020

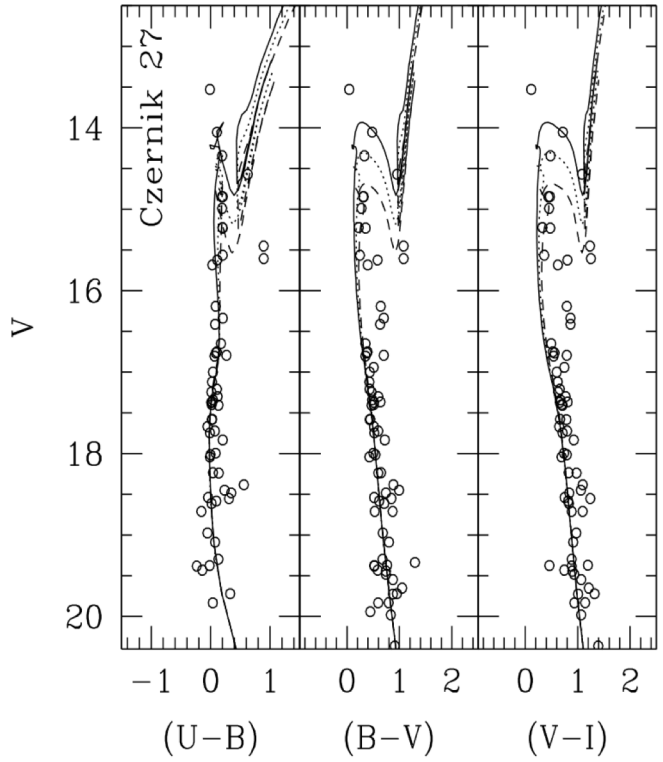
# Bisht, 2019

<u>Be 24:</u>
4.80±0.2 mag
4.4±0.5 kpc

<u>Cz 27:</u>
14.30 mag
5.6±0.2 kpc




log(age) = 9.25 ,9.30 and 9.35




log(age) = 8.70 ,8.80 and 8.90

# References

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