Stellar Population Properties and Evolution Clues in Nearby Galaxies : A Case Study of M101

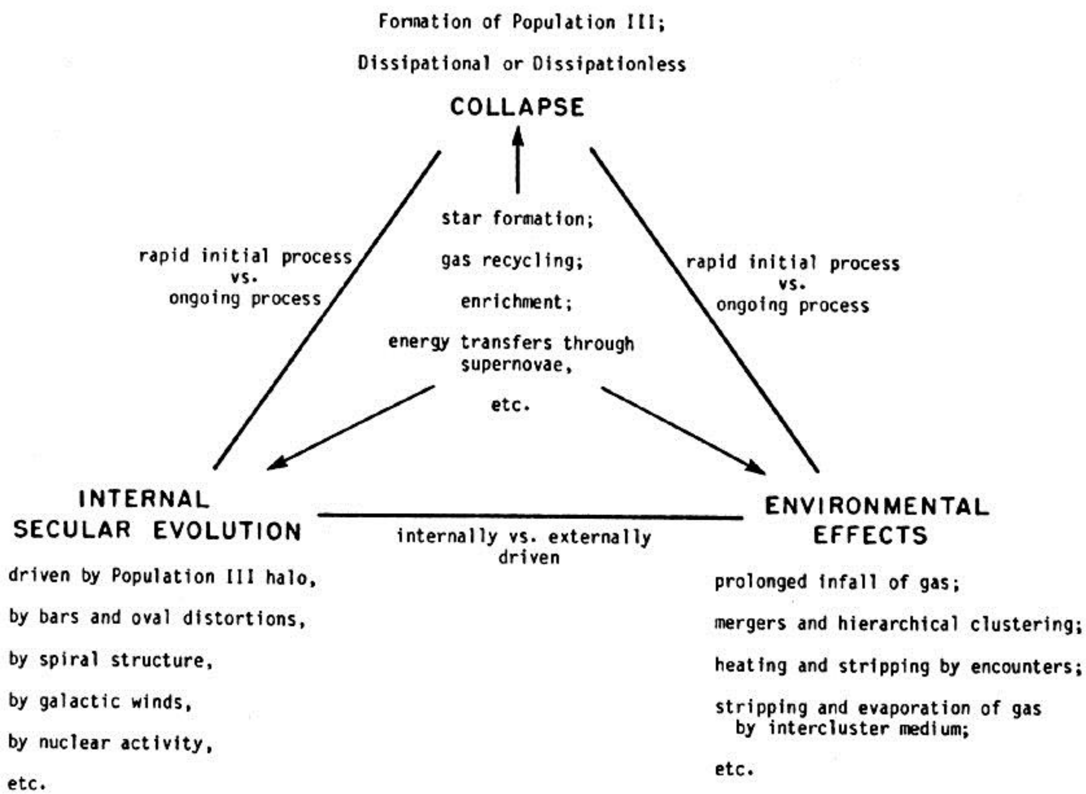
Lin Lin

Shanghai Astronomical Observatory (SHAO)

Collaborators: Hu Zou (NAOC), Xu Kong (USTC), Yewei Mao (PMO)

Galaxies Formation and Evolution

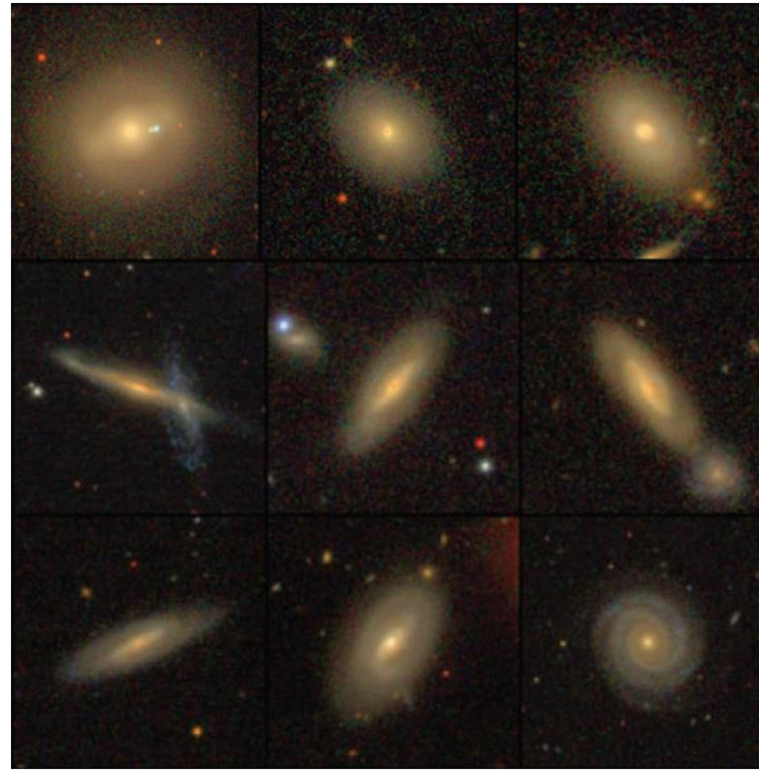
- **Merger & Secular evolution**

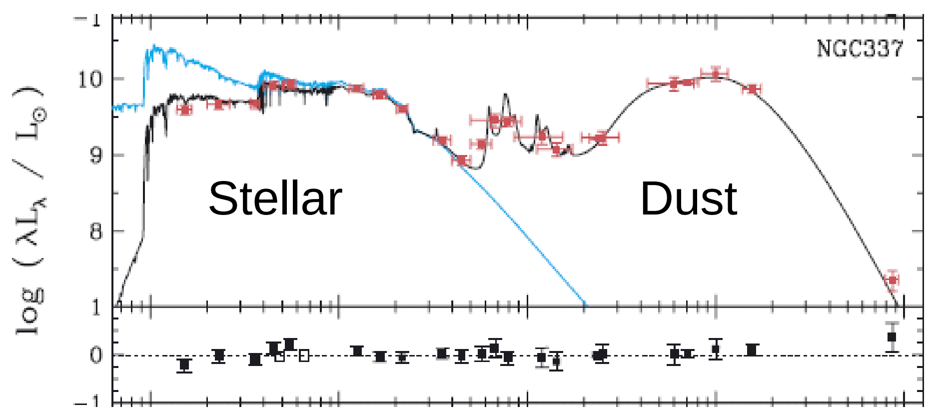


Zwicky 1957; Kormendy 1982,2004

Motivation

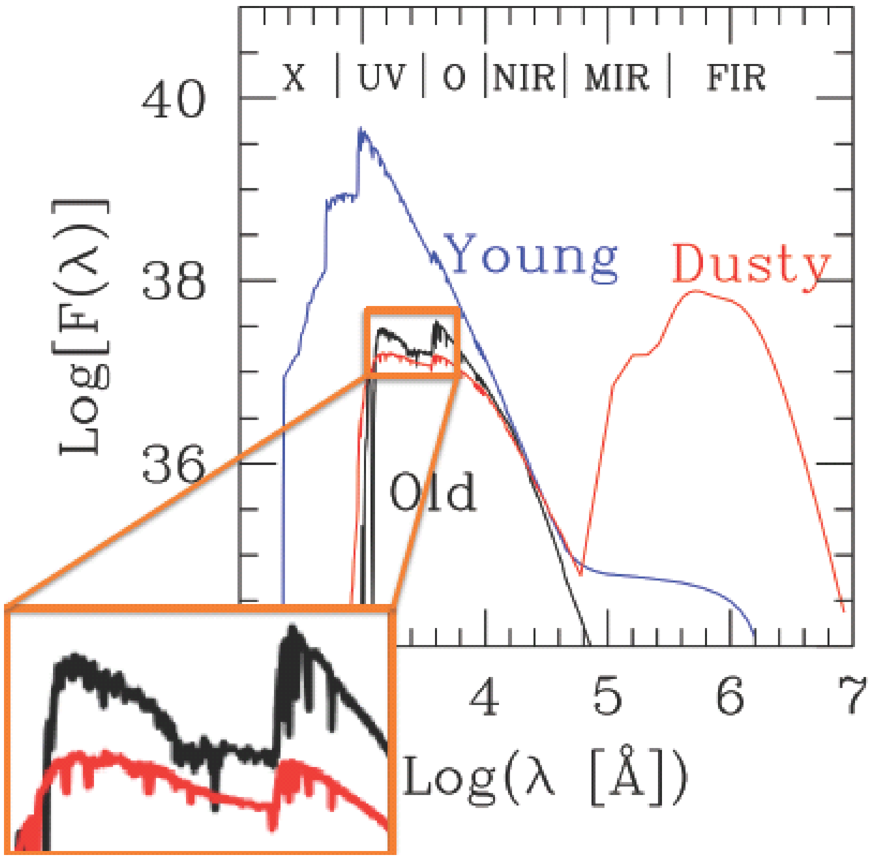
- **Why nearby galaxies?**
  - spatially resolved
  - large angular size
- **Why spirals?**
  - elliptical galaxies
  - spirals
- **HII regions**
  - easily observed
  - constraint chemical evolution
- **stellar population**
  - Stellar population synthesis





Age/Metal/Dust/SFH degeneracy

AGE-DUST Degeneracy



Compare the red and black models:

A young, dusty stellar population can have a UV-optical-nearIR Spectral Energy Distribution similar to that of an old, dust-free stellar population.

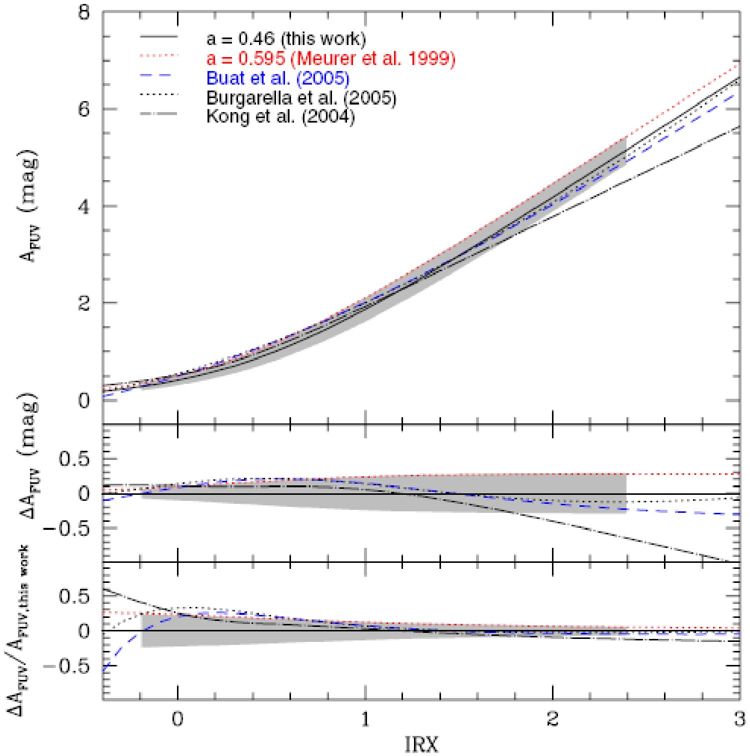
The only obvious discriminants, which may or may not be observable, are the ionized emission lines and the 4,000 Å break (called, e.g., $D_n(4000)$ in Kauffmann et al. 2002).

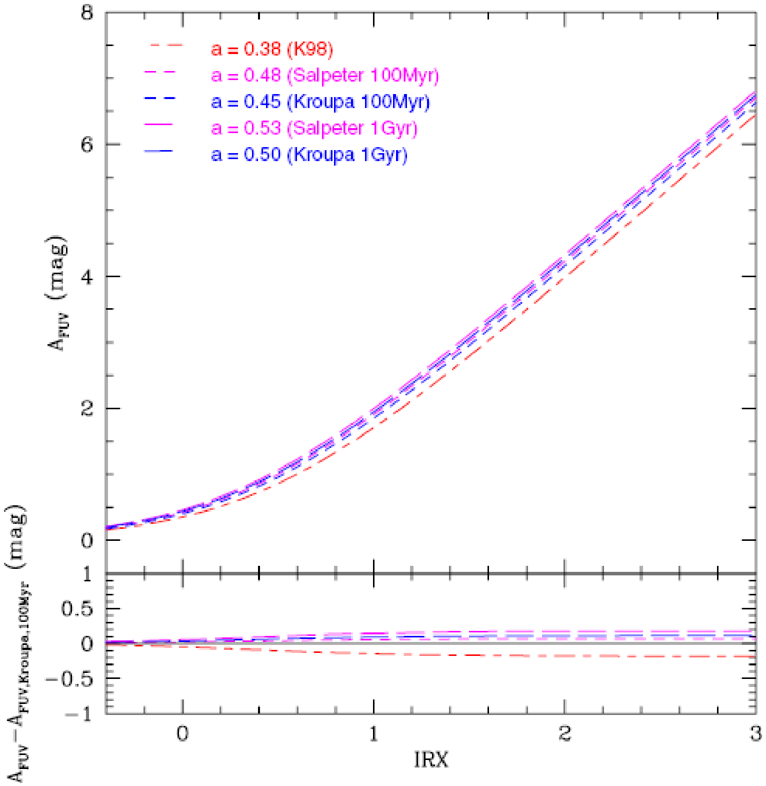
IRX≡TIR/FUV

- From Calzetti's Lecture

IRX vs. A_{FUV}

$$A_{FUV} = 2.5 \log(1 + a_{FUV} \times 10^{IRX}),$$





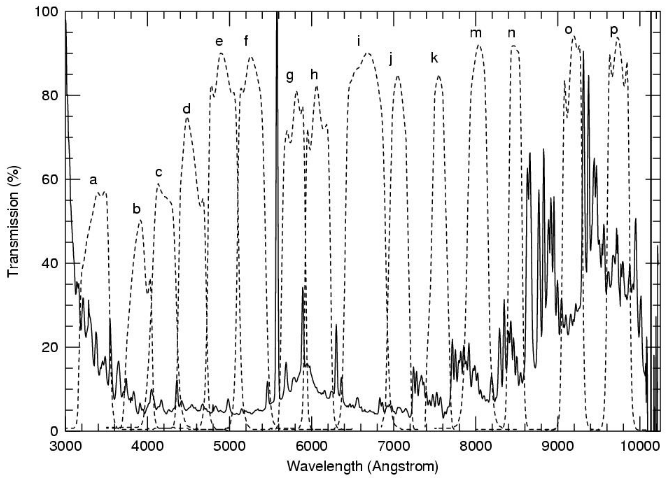
For star-forming galaxies or star formation regions.

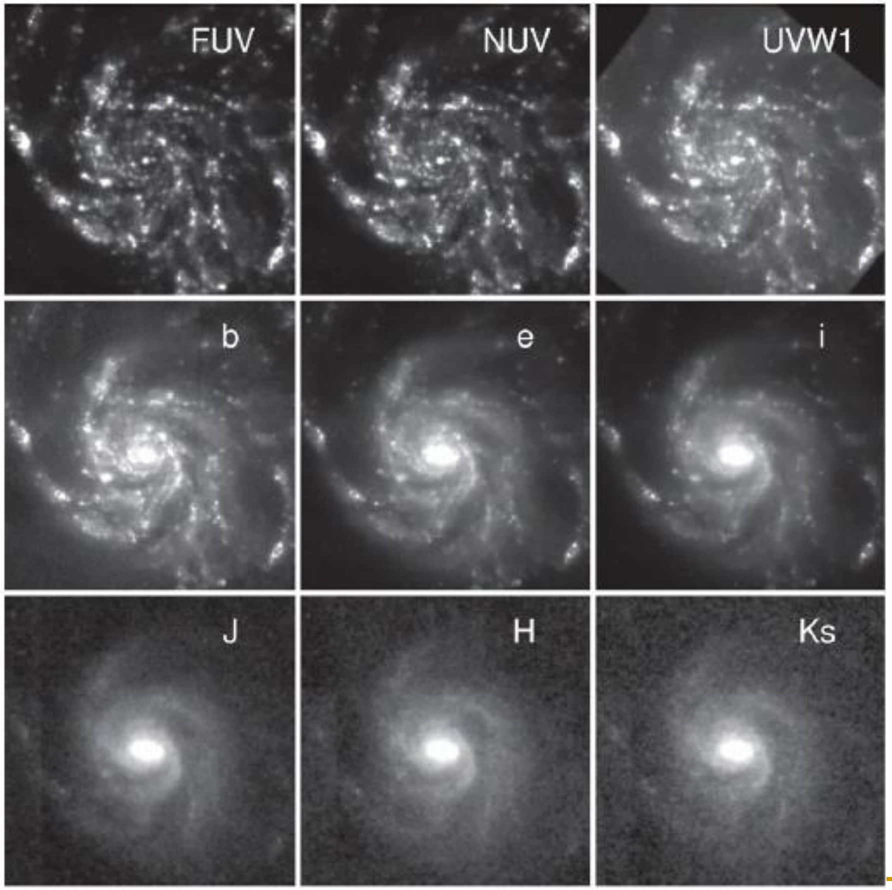
Hao et al. 2011

Multiband Observations

* Beijing-Arizona-Taiwan-Connecticut (BATC) survey

* GALEX (FUV, NUV)
* XMM (UVW1, U)
* 2Mass (J, H, K)
* Spitzer (3.6, 4.5, 8, 24um)





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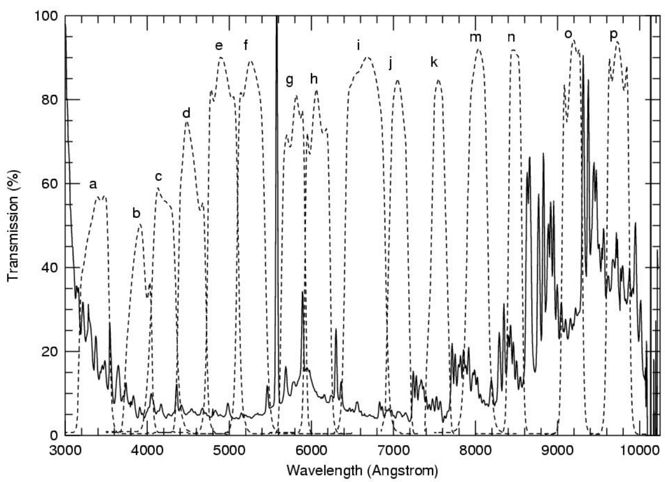
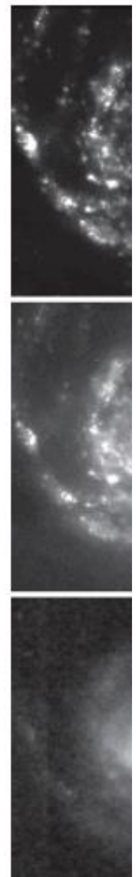
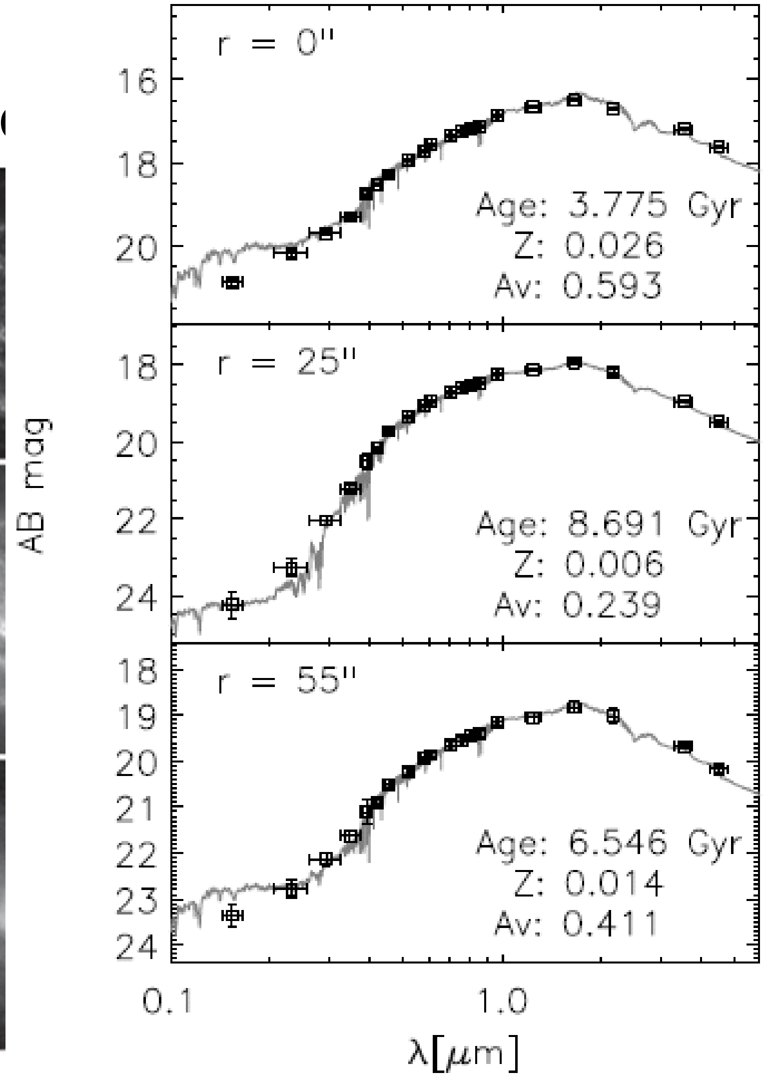
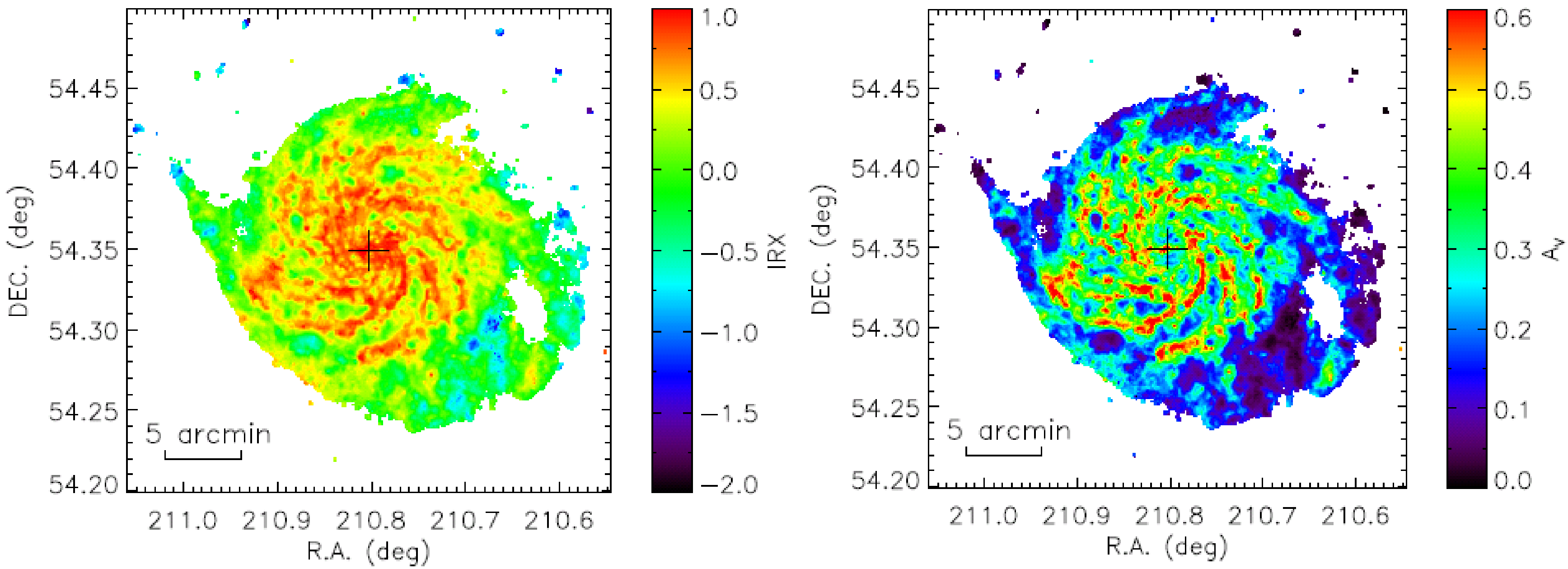






IRX & Extinction Maps

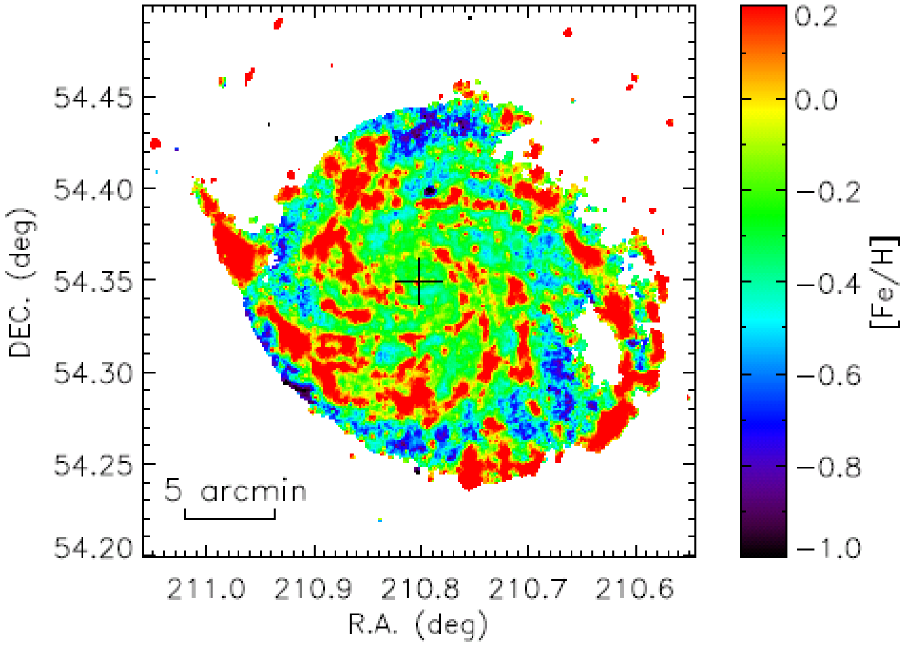


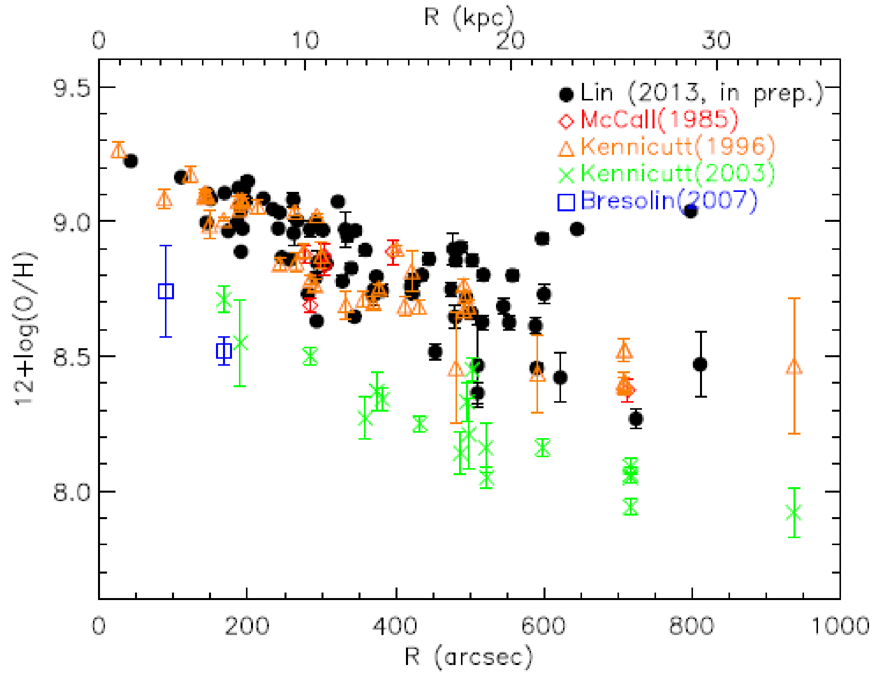
Inner disk region: Maximum IRX but small Av. It shows a considerable fraction of the TIR flux is contributed by old stellar populations.

Radial gradient: Obvious radial gradient. The stellar disk is optically thicker in the inside than in the outside.

Spiral arm: Inner parts seems to exhibit higher IRX or Av than the outer parts.

Matallicity Map



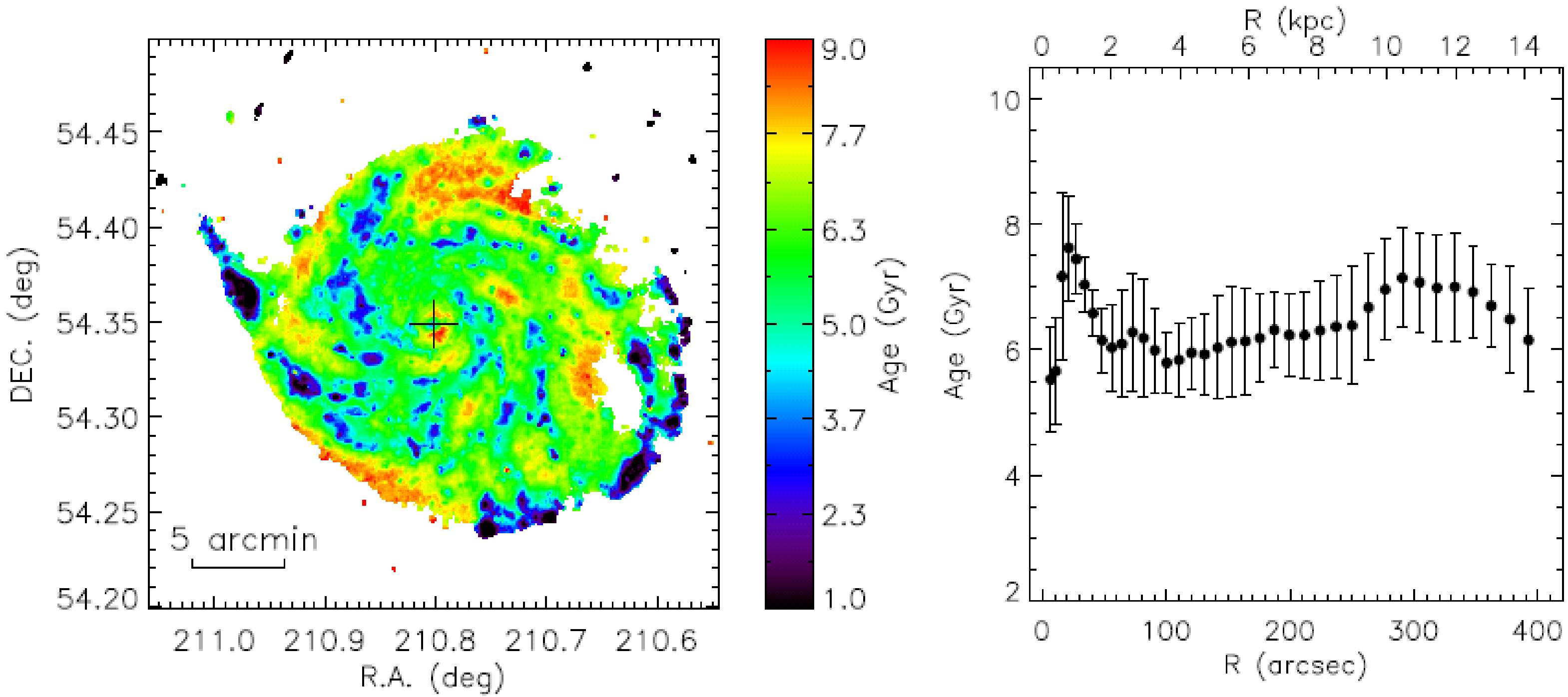


Spiral arm: more metal-rich than inter-arm regions

Radial Profile: -0.011+/-0.006 dex/kpc.

It is much flatter than gas-phase abundances of HII regions -0.045 dex/kpc.

Age Distribution

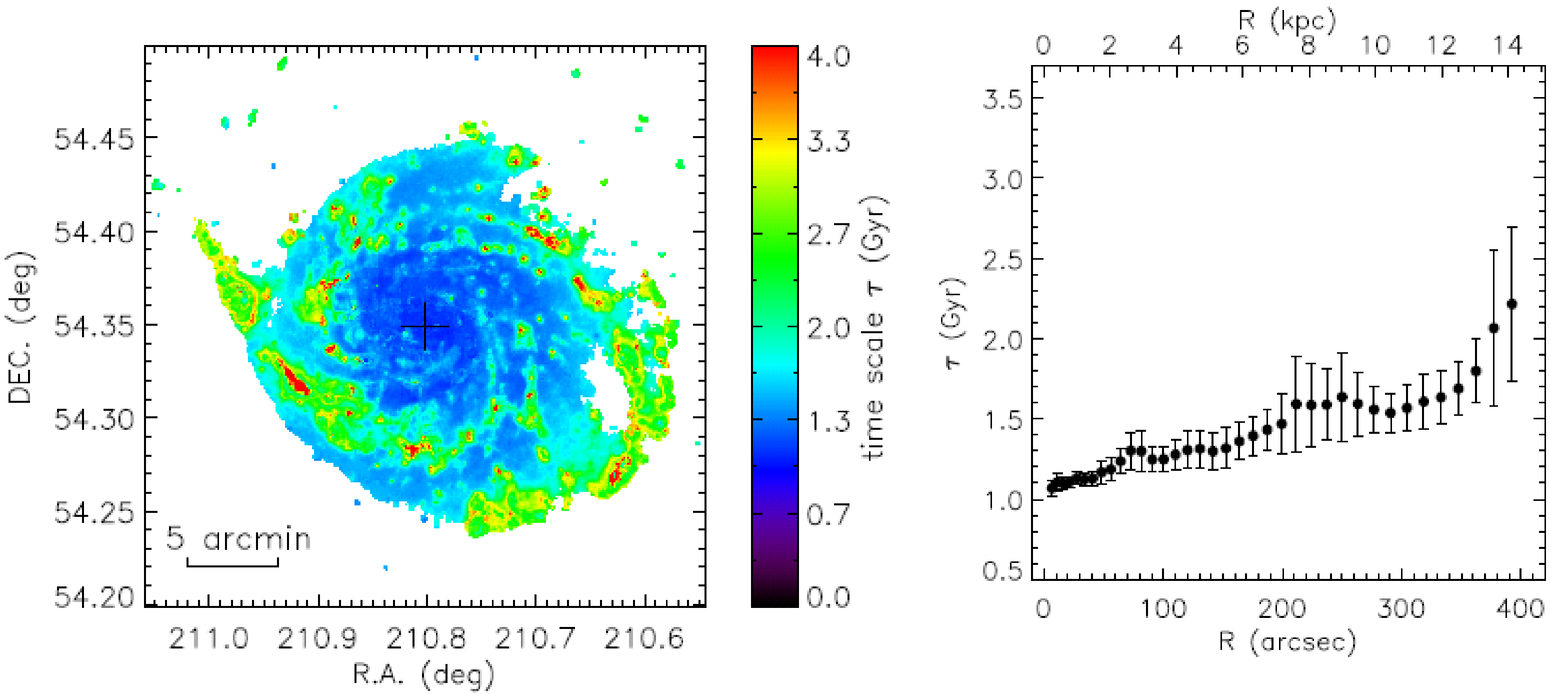


Disk: inner disk is dominated by intermediate-age population.

outer disk is quite flat.

Bulge: young stellar population.

Star Formation Timescale

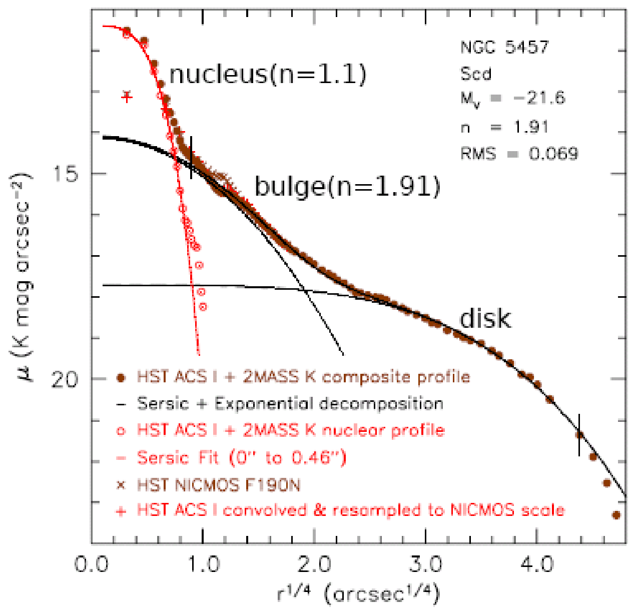


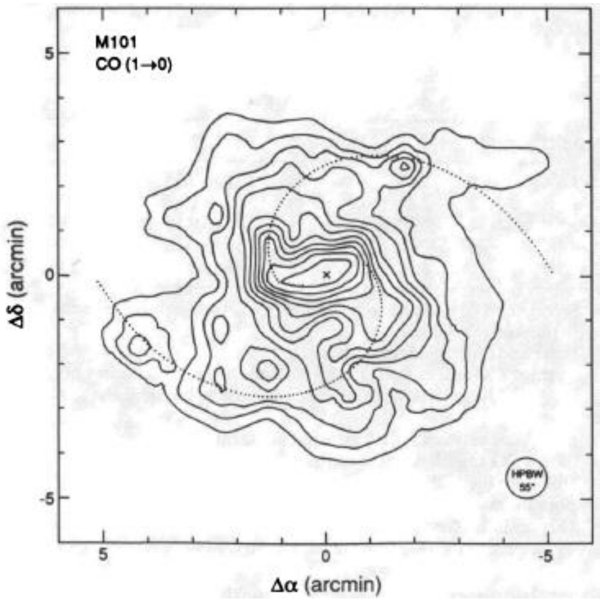
Timescale: increase steadily from the center to the outskirt.

Inside-out disk growth scenario: the early gas infall or collapse in a small/inner region and the outer disk was enriched/growth later.

Pseudo-bulge

HST BVI image
20’’.5×20’’.5





Rotation velocity ~210 km/s ; *velocity dispersion* ~ 25 km/s

Sersic index ~ 1.9 (n_{bulge}< 2)

Mildly active star formation rate

Younger than surrounding inner disk

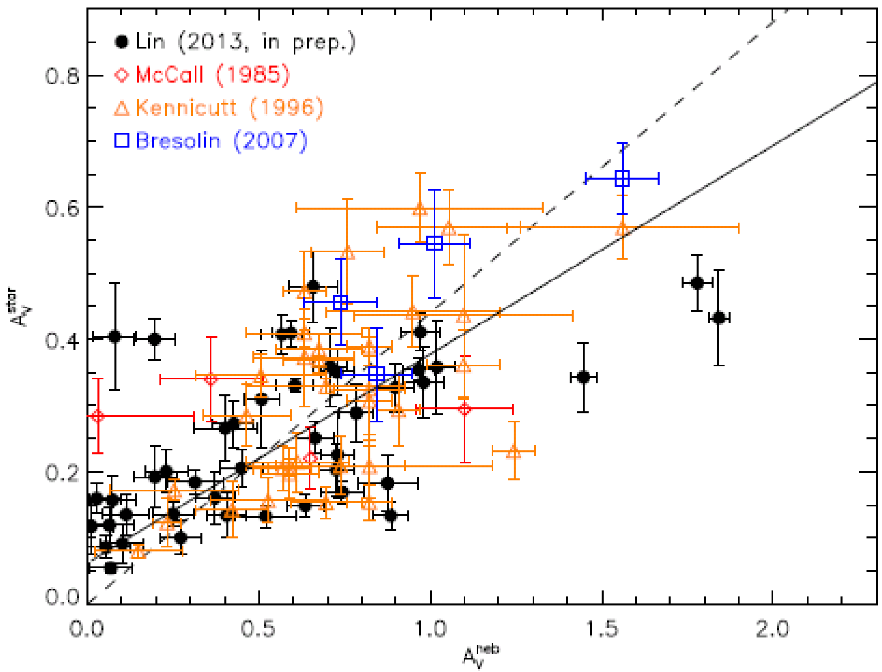
A pseudo-bulge !

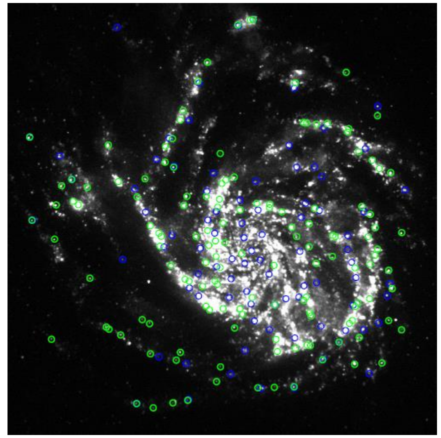
Kenny et al. 1991; Fisher et al. 2009; Kormendy et al. 2010

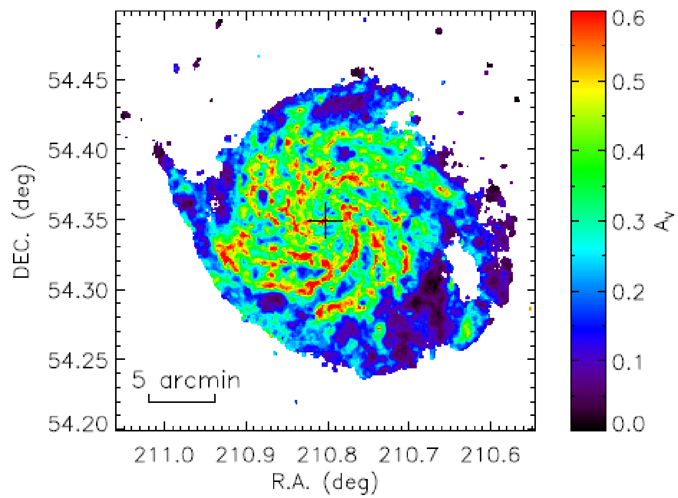
Summary

- Multiband data can help us to reduce degeneracy.
- We constrain dust attenuation with IRX-A_FUV relation. It is strongly correlate to a second parameter of birth rate *b*.
- We present spatially resolved Age/Metal/Av/SFH maps of M101. Properties in Bulge/Inner disk/Outer disk are different.
- There are clear gradients of different parameters, supporting the so-called “inside-out” growth scenario.
- The bulge in M101 is a pseudo-bulge.

Av_stellar vs. Av_gas







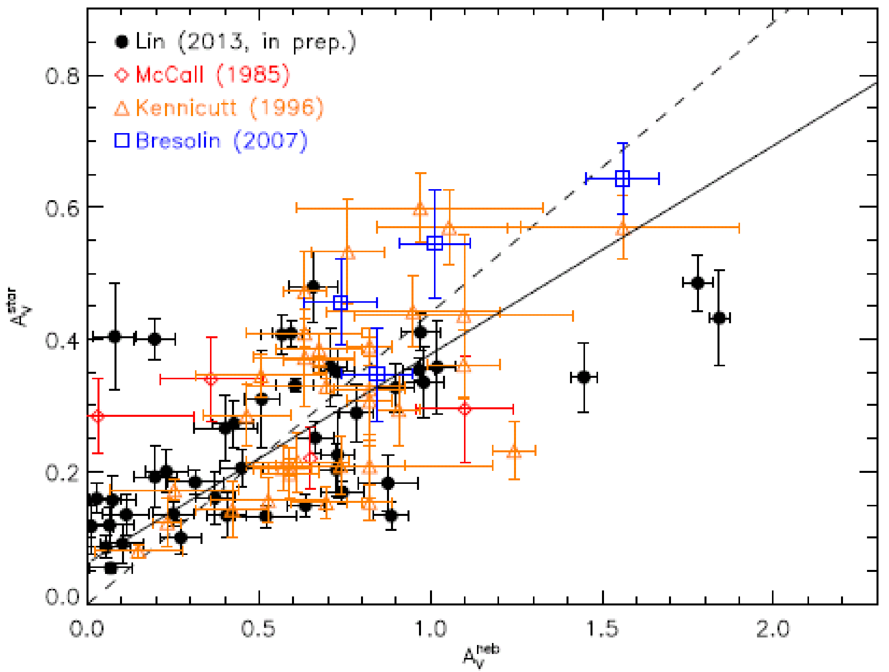
- Different between Av_stellar and Av_gas
- Av_stellar vs. Av_gas

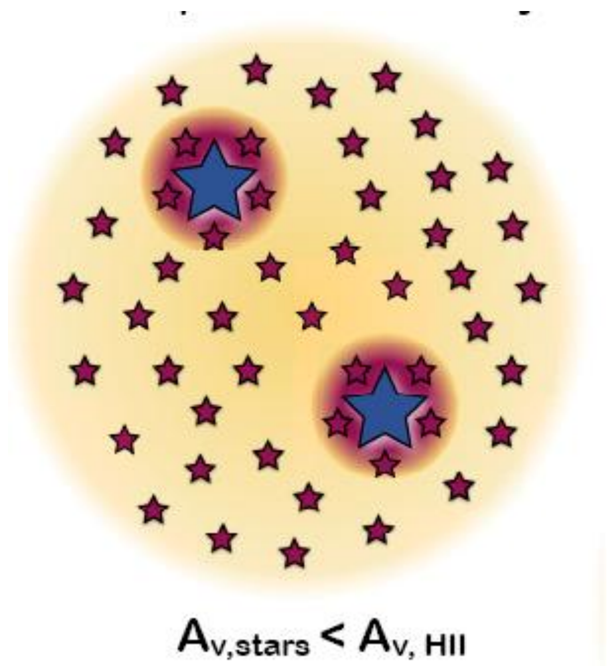
$$A_V^{\rm star} = 0.44 A_V^{\rm neb}$$

ref: Calzetti 2001

$$A_{\rm V}^{\rm star} = 0.32\,(\pm\,0.01)\,A_{\rm V}^{\rm neb} + 0.06\,(\pm\,0.01)$$

Av_stellar vs. Av_gas





Two-component dust model

Price et al. 2013

- Different between Av_stellar and Av_gas
- Av_stellar vs. Av_gas

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