# Study of ionized regions in HII galaxies

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# Star formation history imaging in HII galaxies

(PhD Thesis in process)

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# Introduction

- HII galaxies (what is known)
  - Identified by Sargent & Searle (1970) from Zwicky's (1971) catalog
  - Spectra dominated by emission lines similar to the one of HII regions (Terlevich et al. 1991; Kehrig et al. 2004)

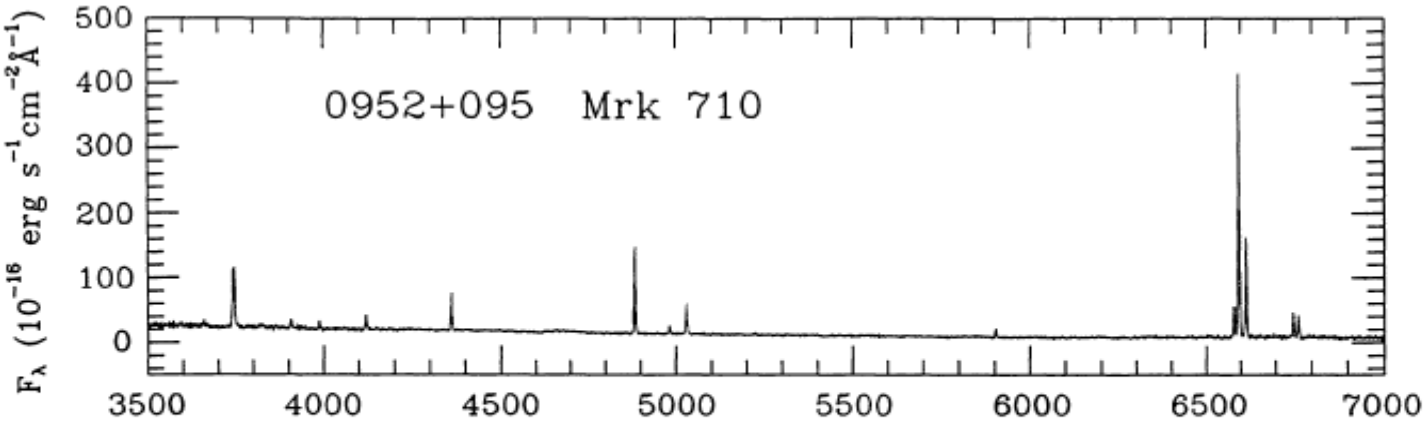


FIGURE 4a. Mrk 710: [OIII/OII] $= 0.42$, $W_{H\beta} = 41$ Å. This object is a prototype of a low excitation HII galaxy presenting strong [OII], [NII] and [SII] lines, and weak [OIII], [NeIII] and HeI lines. The low value of $W_{H\beta}$, and the presence of a bump at $\lambda \approx 4680$ Å, characteristic of WR stars, suggest that Mrk 710 is an evolved object with an age close to 4 million years. The blue featureless continuum and the absence of a Balmer jump ($\lambda \approx 3646$ Å) indicate that OB stars still dominate the optical continuum.

Terlevich et al. (1991)

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  - Isolated galaxies and Interacting/Colliding systems (Campos-Aguilar & Molles 1990; Telles & Terlevich 1995; Taylor et al. 1995)
  - Different galaxy type, most of them Blue Compact Dwarf (Loose & Thuan, 1985; Telles et al. 1997)
  - Internal structure composed of blobs of star formation (Loose & Thuan, 1985; Cairós et al. 2001, Monreal-Ibero et al. 2009)

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**Ideal star formation laboratories**

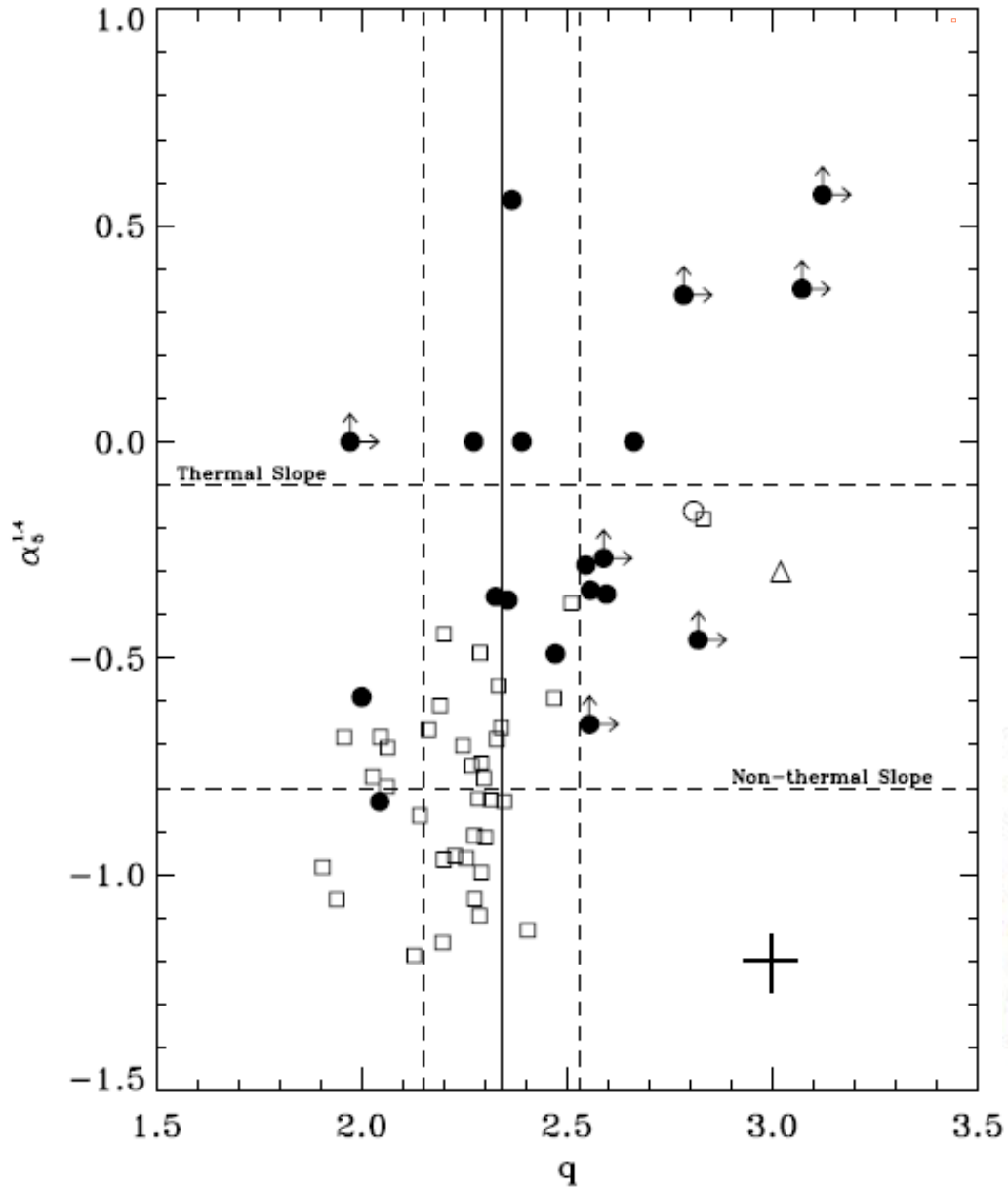
# Introduction

- HII galaxies
  - How is the star formation distributed along the galaxy?
  - How much of the young stellar mass is in clusters?
  - Are massive compact stellar clusters ($M \sim 10^5 M_{sun}$) common in HII galaxies?
  - How does the star forming region affect the ISM arround it?
  - What triggers star formation?

# Motivation

- Rosa-González et al. (2007)

Studied 31 HII galaxies from Terlevich et. al (1991) with 1.4 GHz fluxes lower than expected.




$$q = \log\left(\frac{\mathrm{FIR}/3.75\times10^{12}\ \mathrm{Hz}}{S_{1.4\,\mathrm{GHz}}}\right)$$

FIG. 9.—Estimated $q$-parameter for the galaxy sample plotted against the radio spectral index between 1.4 and 5 GHz (*filled circles*). The solid line shows the value of $q$ found by Roussel et al. (2003). Two vertical dashed lines show the 1 $\sigma$ error of this determination. Two well-studied *nascent* galaxies are plotted: NGC 5253 (*open circle*; Turner et al. 1998) and NGC 4418 (*triangle*; Roussel et al. 2003). The squares correspond to a sample of normal galaxies extracted from Ho et al. (1997). The horizontal dashed lines show the theoretical values of the slope for the cases of thermal and nonthermal emission. The cross at the bottom right corner represents a typical error bar of mean uncertainties of about 15% for both *IRAS* and radio data.

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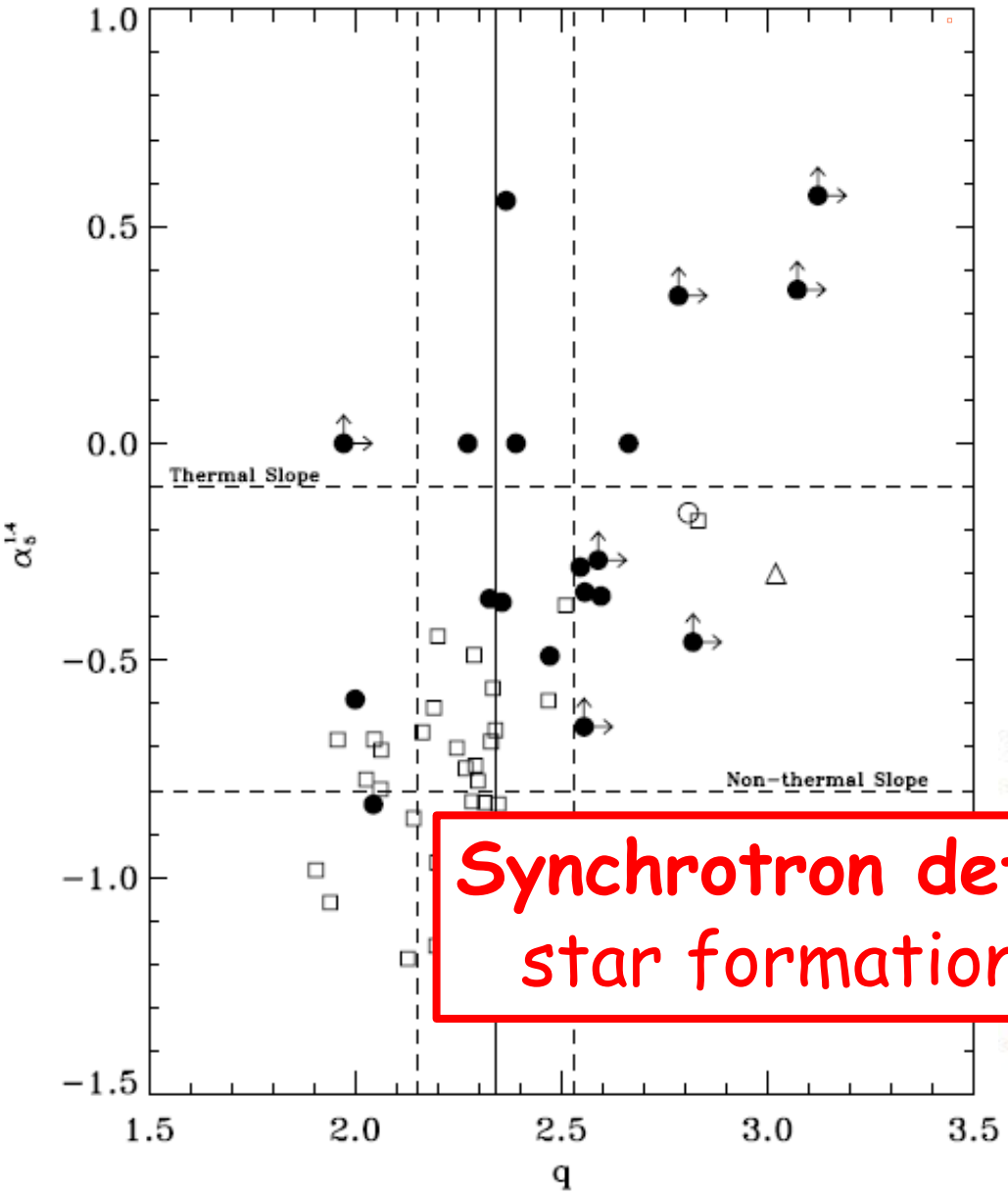


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**Synchrotron defficient →**
**star formation younger than 4 Myr**

# Objective

**Characterize star formation bursts in HII galaxies and their impact on the ISM**

HII galaxies photometric study using wide and narrow (Hα and [OIII] λ5007) filters

How does the star formation history “look” along the galaxy?
Do all young clusters have the same age?
How is the ISM affected by the young clusters?
What fraction of mass is in young/old stars?

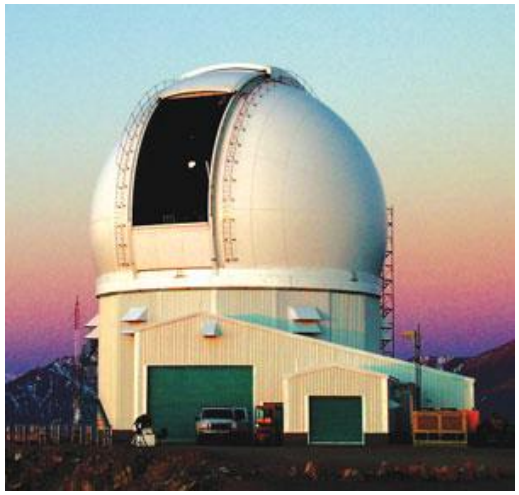
# Sample of galaxies

- Optical images of 5 HII galaxies with young bursts of star formation (Rosa-González et al., 2007)

| Galaxy | R.A. | DEC. | Distance (Mpc) | Log M ($M_{sun}$) | EW(Hβ) |
|---|---|---|---|---|---|
| Tol 0957-278 | 09:59:21 | -28:08:00 | 18 | 5.9 | 29 |
| Mrk 1318 | 12:19:10 | +03:51:21 | 26 | 5.8 | 121 |
| Mrk 52 | 12:25:43 | +00:34:22 | 35 | 7.8 | 29 |
| UM 533 | 12:59:48 | +02:02:57 | 17 | 5.7 | 101 |
| Tol 1358-328 | 14:01:21 | -33:03:50 | 21 | 5.5 | 166 |

# Star forming regions

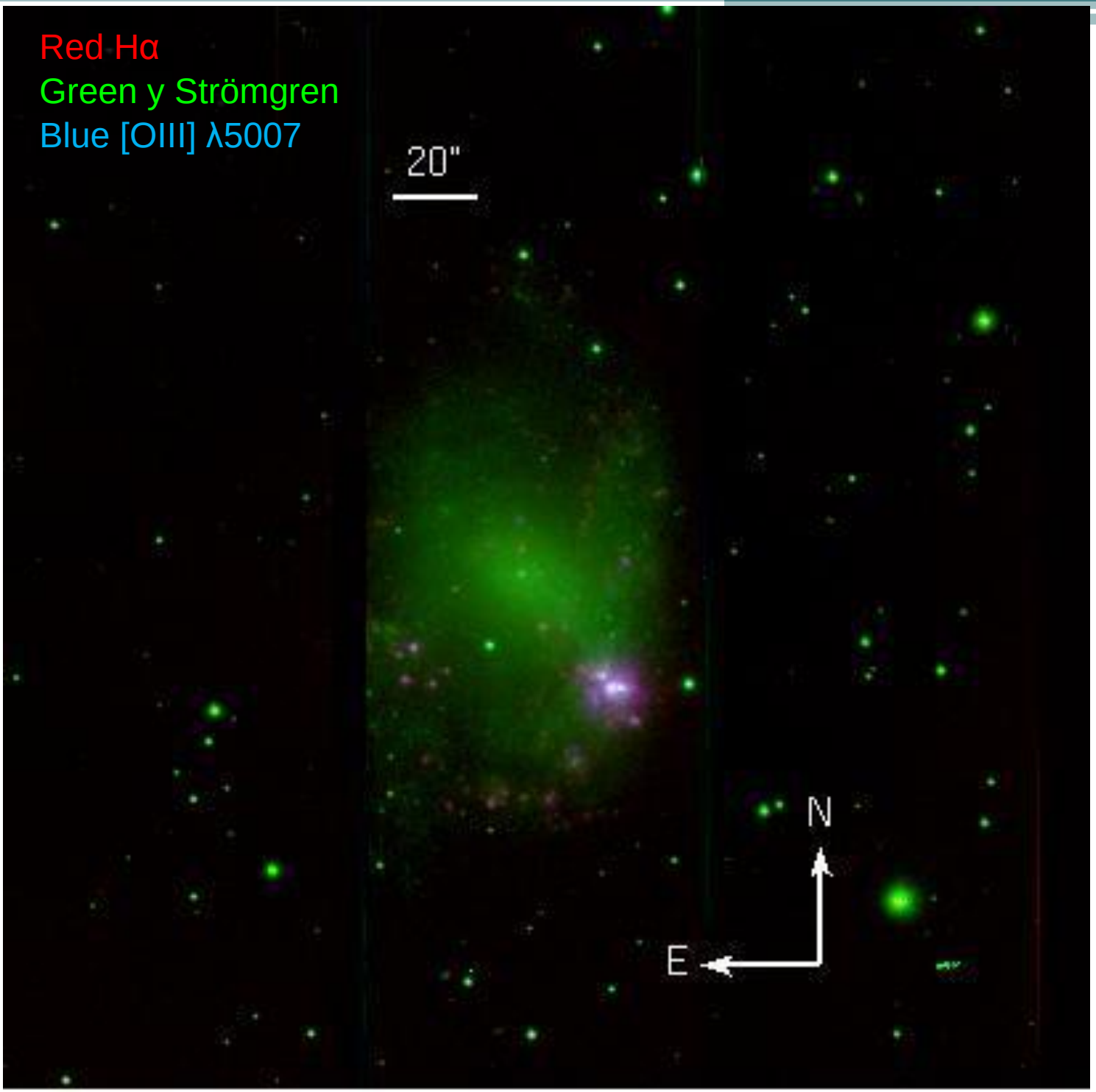
- Photometry with narrow band filters (SOAR, SOI)
  - Hα+[NII]
  - [OIII] λ5007
  - y Strömgren



✓ Identify star formation regions

✓Estimate ages and excitation intensity [OIII]/Ha

✓Analyse diffuse emission structure (filaments, bubbles, etc)


Red Hα
Green y Strömgren
Blue [OIII] λ5007
20"
N
E

# Hα-continuum identified HII regions

- Identified HII regions candidates using SExtractor (Bertin & Arnouts, 1996)
- Requirements to be an HII region:
  - Area > $4\pi(FWHM/2)^2$
  - Ellipticity < 2.5-3.2
  - Elliptical minor semi-axis ≥ 0.75(FWHM/2)

| Galaxy | Num | Radius (pc) | Log $L_{H\alpha}$ (erg s-1) | Log Q($H^0$) |
|---|---|---|---|---|
| Tol 0957-278 | 26 | 57-213 | 36-40 | 48-51 |
| Mrk 1318 | 16 | 71-260 | 37-40 | 49-52 |
| Mrk 52 | 77 | 100-363 | 36-41 | 48-53 |
| UM 533 | 12 | 63-144 | 36-40 | 48-51 |
| Tol 1358-328 | 144 | 42-186 | 35-40 | 46-52 |

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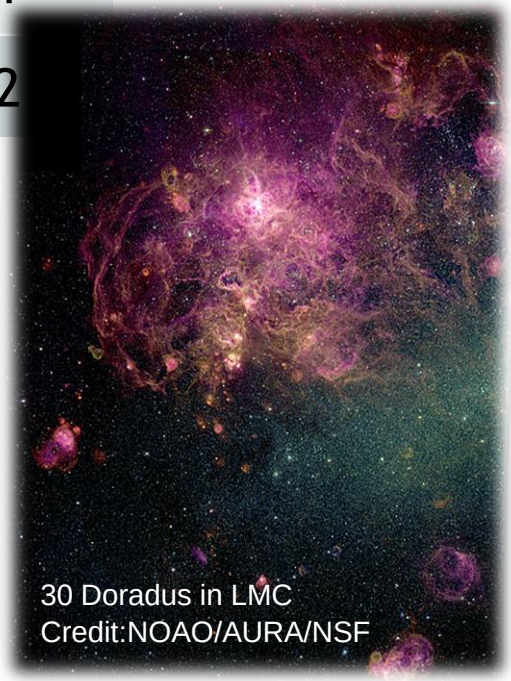
| HII region | Radius (pc) | Log $L_{H\alpha}$ (erg s-1) |
|---|---|---|
| 30Dor | 185 | 40 |
| NGC 592 | 180 | 38 |
| Orion | 5 | 37 |


30 Doradus in LMC
Credit:NOAO/AURA/NSF

# Star formation history

- Narrow band filters (SOAR)
  - Hα+[NII]
  - [OIII] λ5007
  - y Strömgren
- Broad band filters
  - SOAR 4.1m (U,B,R,and I)
  - SDSS 2.5m (u',g',r',i',z')

✓ Separate new/old stellar component

✓Estimage age and mass of stellar clusters using stellar evolution models (SSP)

✓Characterize star formation history along the galaxy

# Star formation history

Diagram proposed by Campbell & Terlevich (1984)

- Narrow band filters (SOAR)
  - Hα+[NII]
  - [OIII] λ5007
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- Broad band filters
  - SOAR 4.1m (U,B,R,and I)
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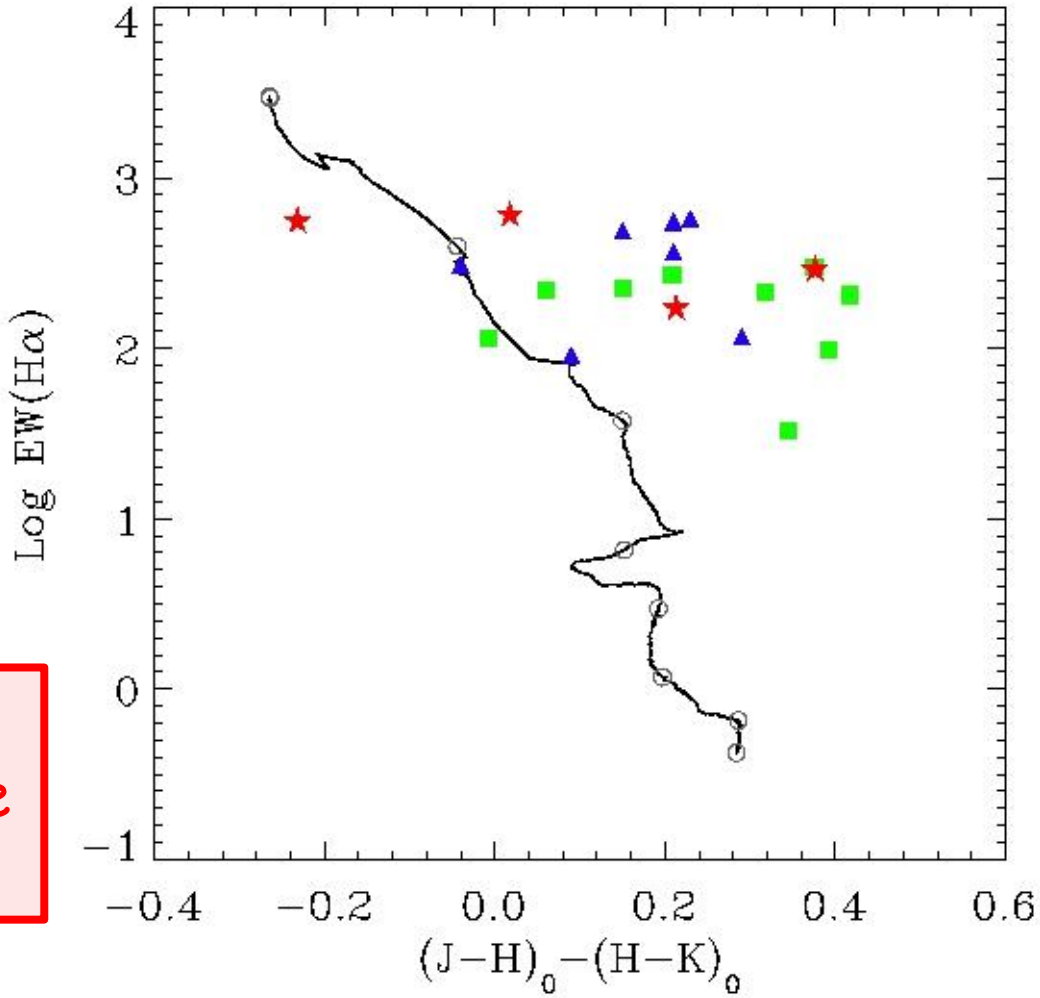
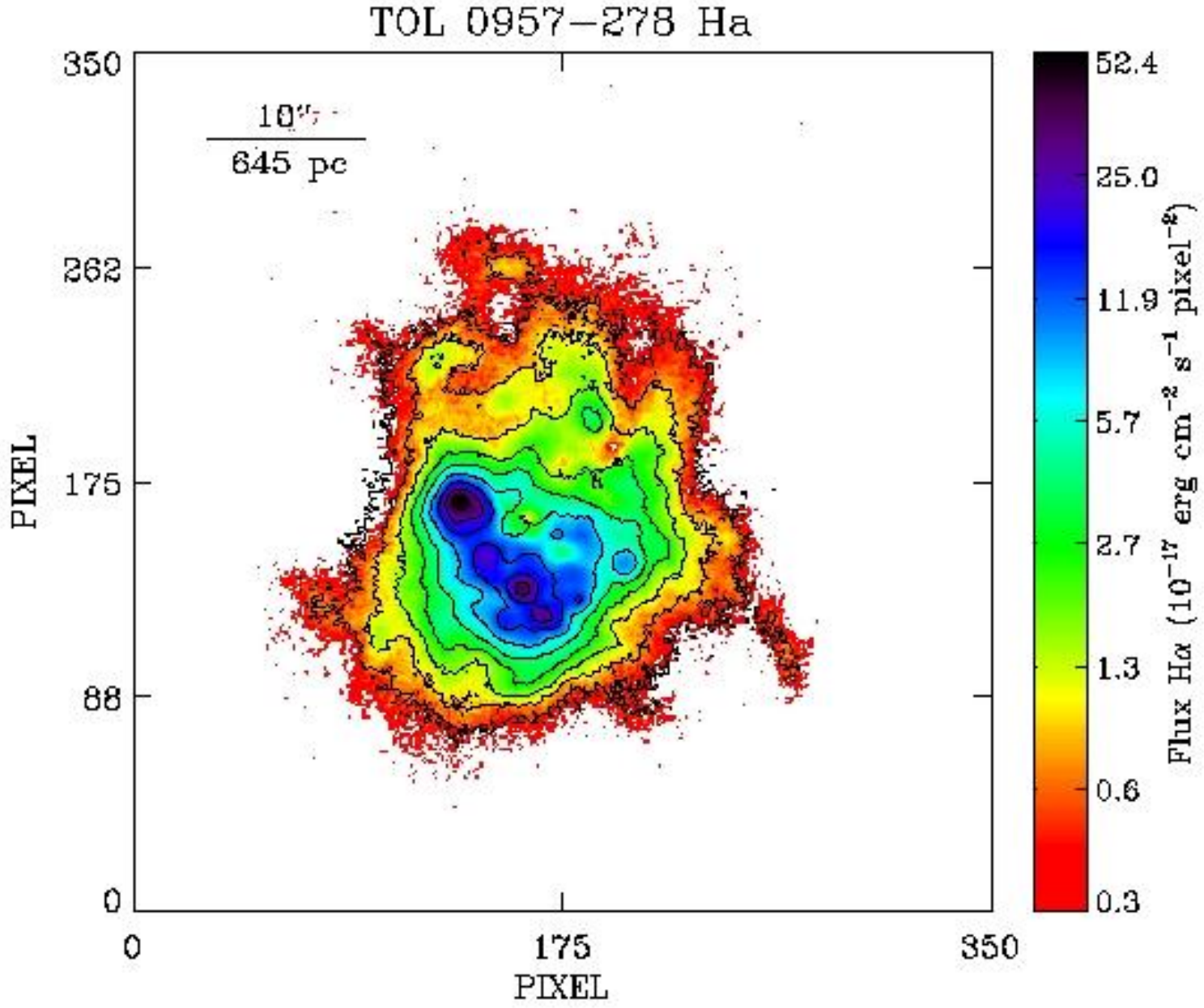
Need of infrarred (J, H, Ks) images to better constrain age and mass of star clusters




Evolution of the NIR index and the EW(Hα) of a single stellar population from 1 to 35 Myrs on the diagram proposed by Campbell & Terlevich (1984). Open circles traces the ages: 1, 10, 20, 35 Myrs (top-left to bottom-right). HII galaxies taken from the Terlevich et al. (1991) catalog are plotted with green squares, red stars represent galaxies that have been observed with SOAR telescope for this project. The EW(Hα) was taken from the catalog and the NIR index was calculated using an aperture with a radius of 4.5 arcsec on 2MASS images.

# Thank you

# Hα emission line maps



# Next steps

- Optical images
  - [OIII]/Hα, EW(Hα) and EW([OIII]) analysis ofHII regions
  - Diffuse emission structure analysis  (filaments, bubbles)
  - Stellar young and old component analysis  (Cairós et al. 2002)
  - Star formation history at hundreds of parsecs resolution
- On our minds…
  - Radio continuum images
  - Spectra