Constraining the Escape Fraction with LEGUS-SIGNALS: A Pilot Study with NGC 628

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Why Should You Care?

What Is the Escape Fraction (f_{esc}) ?

The fraction of Lyman continuum photons (LyC) emitted by O, B stars that **escape from H II regions** into the interstellar medium (ISM).

$$f_{esc} = \frac{\mathrm{QH}^0 - \mathrm{QH}\alpha}{\mathrm{QH}^0}$$

LyC flux required to produce observed H II region

LyC flux from ionizing star

where $0 \leq f_{esc} \leq 1$.

Why Is It Important?

Quantifying f_{esc} can shed light on:

- Origin of diffuse ionize gas
- Energy budget of ISM in galaxies

How Did We Do It?

The Conventional Method

In nearby galaxies, QH^0 is obtained via spectroscopy on individual massive stars. However, beyond $\sim$ 3 Mpc, spectroscopy is **impossible**.

The Method We Explore

We use a combination of **cluster broadband photometry** and **stochastic stellar population synthesis**[1,2] to determine QH^0 from star clusters in NGC 628 ($D \sim 9.9$ Mpc).

The Sample Selection

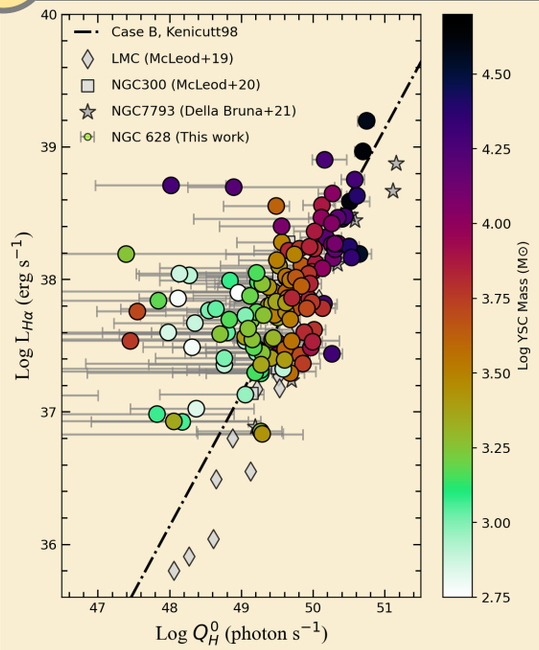
We match young star clusters (YSCs; $t \leq 10$ Myr) from the Legacy ExtraGalactic UV Survey (LEGUS) [3,4] to H II regions from the Star formation, Ionized gas, and Nebular Abundances Legacy Survey (SIGNALS) [5].

Final Sample Size:

142 H II region – young star cluster associations.

What Did We Find?

1 Hα Luminosity vs QH^0



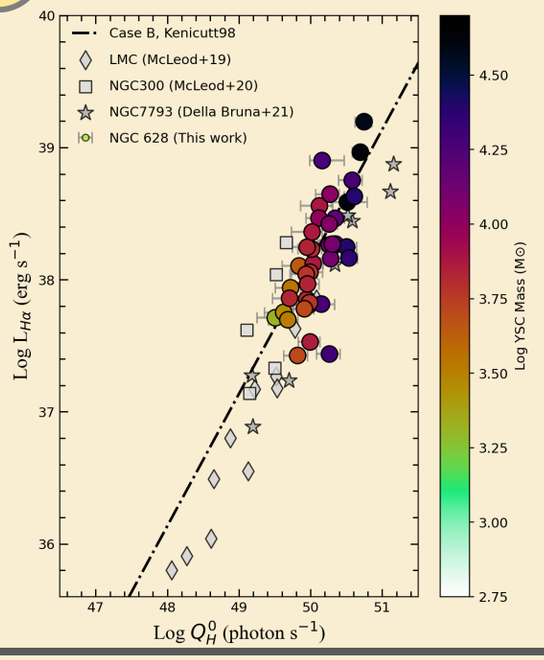
Problem

Most data points have large uncertainty in QH^0, due to the **stochasticity** of the initial mass function in the **low-mass regime**.

Solution

We truncate sample down to clusters with uncertainties in QH^0 < 0.5 dex. This effectively retain the high-mass end of clusters.

2 Hα Luminosity vs QH^0 (Imposing Error Constraint)



How Should You Interpret?

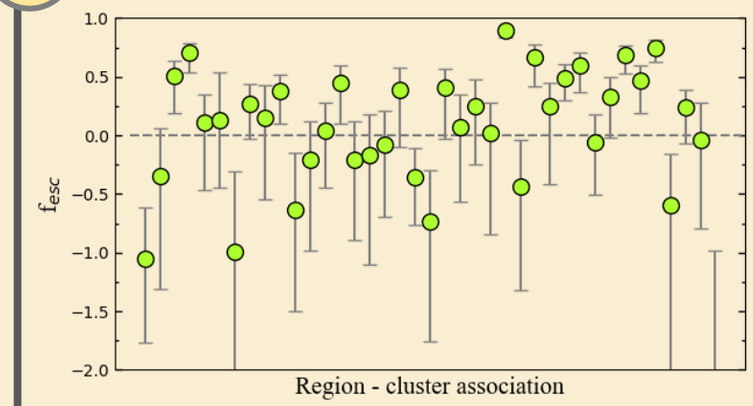
If data points are…

Along dashed line:
All LyC flux absorbed by H atoms in H II region and converted into observed Hα luminosity.

Below dashed line:
Some fraction of LyC flux escaped into the ISM.

Above dashed line:
Theoretically forbidden.
LyC flux is insufficient to support observed Hα luminosity.

3 The Escape Fraction



Most H II regions have 68% confidence interval within $0 \leq f_{esc} \leq 1$. However, the data are **highly scattered**, thus it is difficult to derive the mean f_{esc} from this sample.

Conclusion

We Find That

Using **photometry at level of individual clusters does not provide conclusive evidence** on the mean escape fraction, **unless more sophisticated statistical techniques** are used to treat the large uncertainties in QH^0.

What Could We Do In The Future?

Connect Properties of H II Regions to Underlying Stellar Populations

- With our H II region – YSCs associations, we can connect how the properties of these YSCs (i.e. age, mass) affect the properties of H II regions (e.g., pressure, metallicity).

Beyond NGC 628

- This method can be used for other galaxies in future LEGUS-SIGNALS observations.

References

[1] Da Silva et al., 2012, ApJ, 745, 145
[2] Krumholz et al., 2015, MNRAS, 452, 1447
[3] Calzetti et al., 2015, ApJ, 149, 51
[4] Grasha et al., 2015, ApJ, 815, 93
[5] Rousseau-Nepton et al., 2018, MNRAS, 477, 4152