Enhancement of CO(3–2)/CO(1–0) Ratios and Star Formation Efficiencies in Supergiant HII Regions

MIURA, Rie E.[1/2], KOHNO, Kotaro[3/4], TOSAKI ,Tomoka[5], ESPADA, Daniel[1/6/7], HIROTA, Akihiko[1]
KOMUGI, Shinya[1], OKUMURA, Sachiko K.[8], KUNO, Nario[1/7], MURAOKA, Kazuyuki[9]
ONODERA, Sachiko[10], NAKANISHI, Kouichiro[1/6/7], SAWADA, Tsuyoshi[1/6], KANEKO, Hiroyuki[1/7/11]
MINAMIDANI, Tetsuhiro[1], FUJII, Kosuke[1/2], KAWABE, Ryohei[1/6]

1: NAOJ, 2: University of Tokyo, 3: Institute of Astronomy, 4: Research centre for Early Universe, 5: Joetsu University of Education, 6: Joint ALMA Observatory, 7: Graduate University for Advanced Studies, 8: Japan Woman's University 9: Osaka Prefecture University, 10: Meisei University, 11: University of Tsukuba

Based on wide-field and high-sensitivity (1σ = 16−32 mK in T_{mb} for a velocity resolution of 2.5 km s^{-1}) CO(J=3−2) observations with a spatial resolution of 100 pc using the ASTE 10 m telescope [1], we present evidence that super giant HII regions (GHRs) and other disk regions of the nearby spiral galaxy, M33, occupy distinct locations in the correlation between molecular gas, Σ_{H_2}, and the star formation rate surface density, Σ_{SFR} [2]. Star formation efficiencies (SFEs), defined as $\Sigma_{SFR}/\Sigma_{H_2}$, in GHRs are found to be ~1 dex higher than in other disk regions (Fig. 1). The CO(3−2)/CO(1−0) integrated intensity ratio, $R_{3-2/1-0}$, is also higher than the average over the disk (Fig. 2). Such high SFEs and $R_{3-2/1-0}$ can reach the values found in starburst galaxies, which suggests that GHRs may be the elements building up a larger-scale starburst region. Three possible contributions to high SFEs in GHRs are investigated: (1) the I_{CO}-N(H_2) conversion factor, (2) the dense gas fraction traced by $R_{3-2/1-0}$, and (3) the initial mass function (IMF). We conclude that these starburst-like properties in GHRs can be interpreted by a combination of both a top-heavy IMF and a high dense gas fraction, but not by changes in the I_{CO}-N(H_2) conversion factor. We suggest a scenario that the parental molecular gas would tend to get denser in the accumulated gas around the first generation stars, while rapidly consumed by SF, eroded, and dissipated due to more massive stars in GHRs. This results in high SFE and densities.

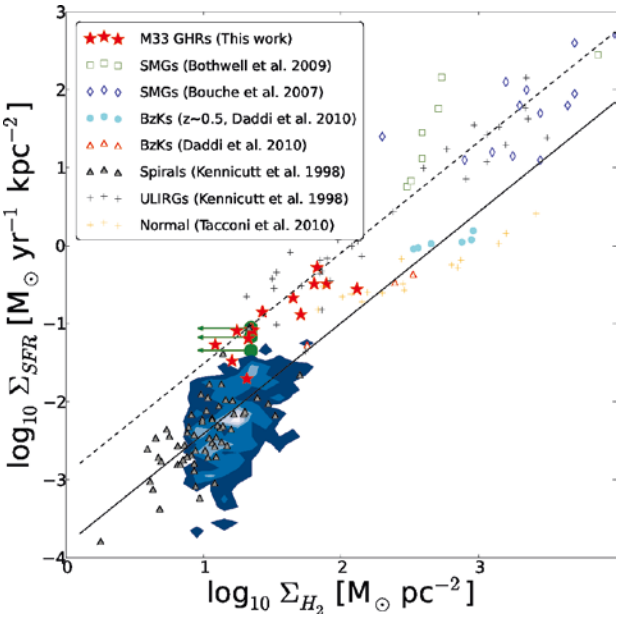

Figure 1: SFR vs. molecular gas surface densities for GHRs (red filled stars, NGC 604 and NGC 595) and for non-GHRs (blue filled contour) in M33, compared with that of other galaxies from [3] (and references therein).

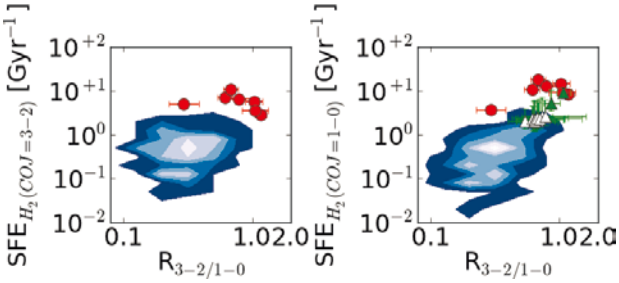

Figure 2: Plot of the $R_{3\text{-}2/1\text{-}0}$ vs. $SFE_{H_2\,(CO\ J=3-2)}$ (left) and $SFE_{H_2\,(CO\ J=1-0)}$ (right). Data for GHRs are shown as red points, while that for non-GHRs as blue contours. The data points in several annuli of starburst galaxy M83 are shown as green filled (unfilled) triangles, representing the centre (disk).

References

[1] Miura, R. E., Kohno, K., et al.: 2012, *ApJ*, **761**, 37.
[2] Miura, R. E., et al.: 2014, *ApJ*, **788**, 167.
[3] Daddi, E., et al.: 2010, *ApJ*, **714**, L118.