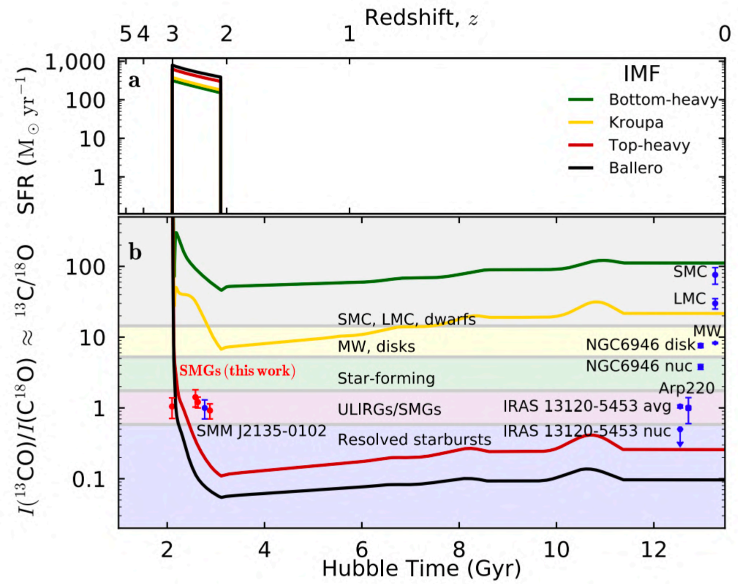
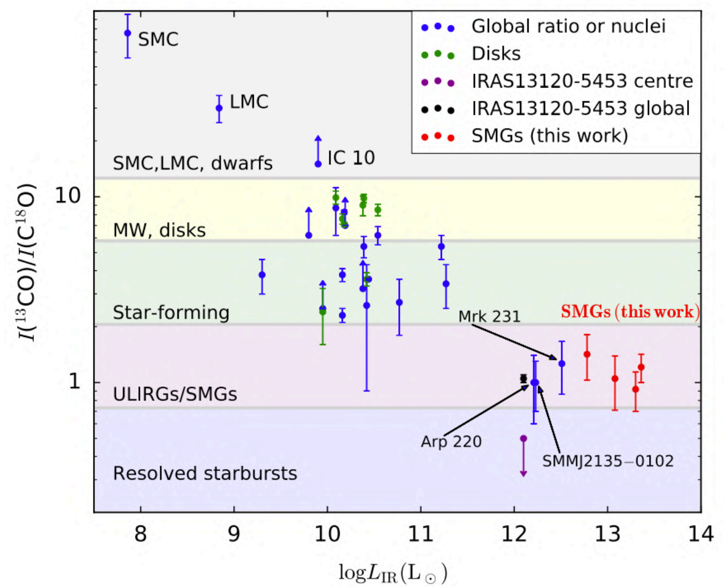
Isotope ratios and ages in the starburst galaxy NGC253

Dazhi Zhou[1], Paul van der Werf[1]
[1] Leiden University, Leiden, the Netherland

The initial mass function (IMF) is one of the most important concepts in modern astronomy. It describes the initial distribution of masses for a population of stars. Determining whether it is universal throughout time and space is always the prior goal for astronomers.



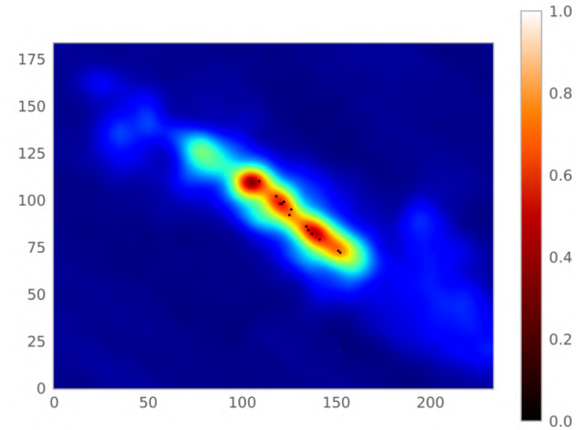
Based on observations and the chemical evolution model (Romano et al. 2017), Zhang et al. (2018) proposed that **the low $^{13}C/^{18}O$ reveals a top-heavy IMF** and **there are more massive stars in the starburst galaxies** than in normal galaxies. (Top figure: Theoretical time evolution of $^{13}C/^{18}O$ for different IMF. Bottom figure: The isotope ratio as a function of total infrared luminosity in the rest frame) However, they do not rule out that **the same effect can be also produced by a very young starburst**.



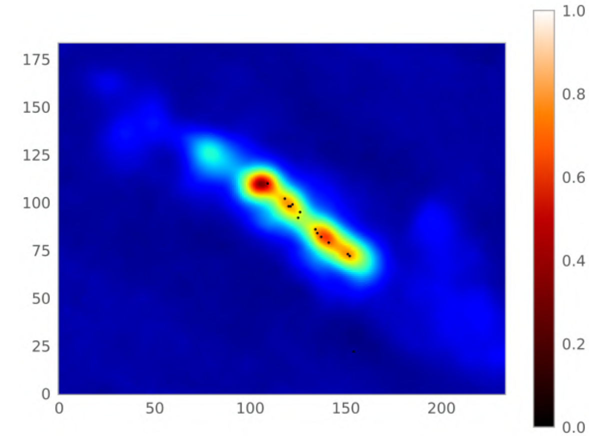
In order to determine whether the young starburst has the contribution, we compare a number of super star clusters (SSCs) with well-determined ages to the corresponding isotope ratios.

The Measurement of the Isotope Ratio

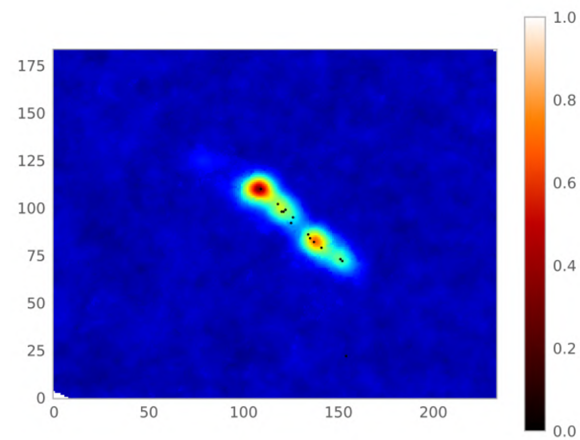
It turns out that ^{13}CO and C^{18}O should be both optically thin (Though some exceptions could exist, they would not significantly affect our conclusion). They share a similar frequency, critical density, and upper energy level. We use these two isotopologues in three different rotational transitions (3-2, 2-1, 1-0) to trace the relative variation of ^{13}C and ^{18}O abundances. H^{13}CO$^+$ and HC^{18}O$^+$ are also used, but large uncertainties are expected because of their low abundances. The figures demonstrate integrated line intensity maps of ^{13}CO(3-2), C^{18}O(3-2), H^{13}CO$^+$ (4-3), HC^{18}O$^+$(4-3).



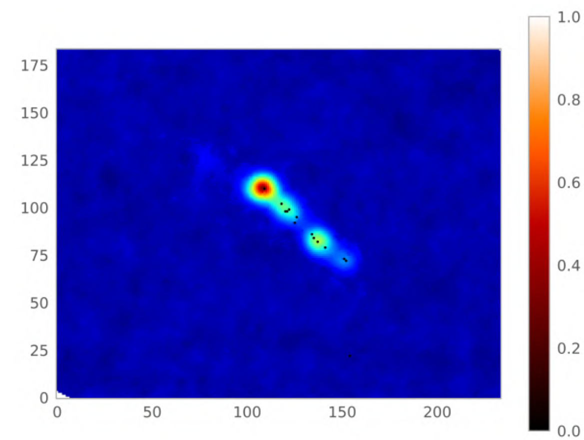
^{13}CO (3-2)



C^{18}O (3-2)



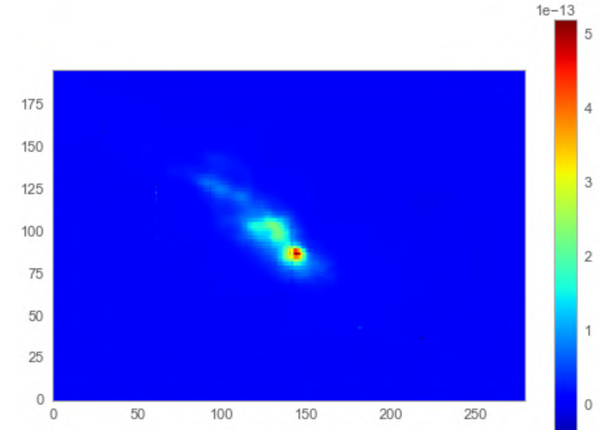
H^{13}CO$^+$ (4-3)



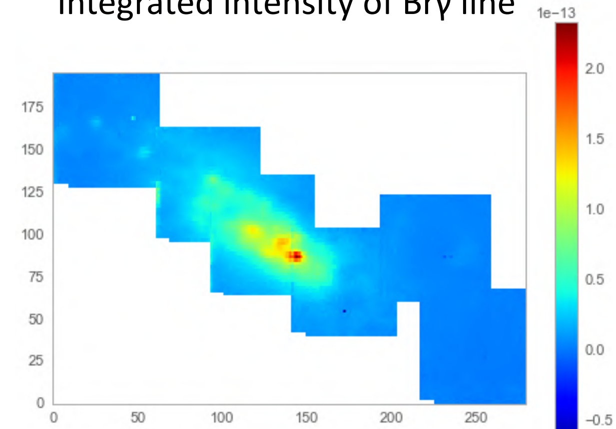
HC^{18}O$^+$(4-3)

The Estimation of the Ages

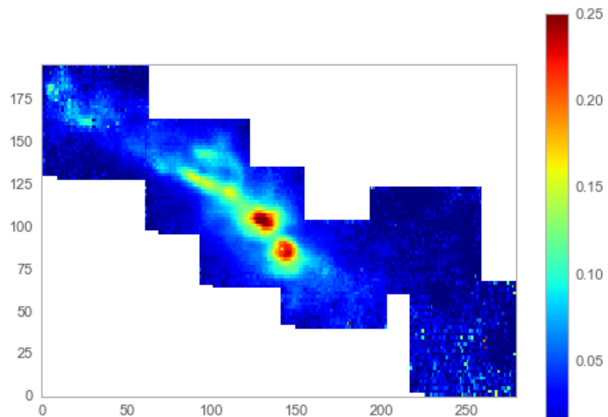
The equivalent width of the Brγ line is used for the age estimation. It can be simply regarded as the ratio of the Brγ to the K band continuum. Because Brγ comes from young star formation and K continuum stands for the older medium, the equivalent width can be treated as a function of age. We use the Starburst99 to get the ages for every pixel. The relation is derived from a zero-age instantaneous starburst with twice solar metallicity and a fixed mass of 10^6 M_{sun}.



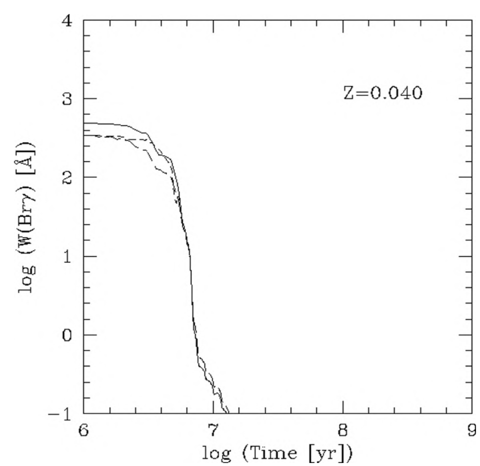
Integrated intensity of Brγ line



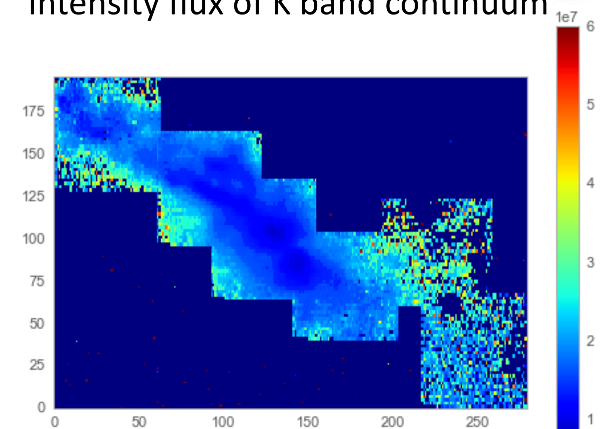
Intensity flux of K band continuum



The equivalent width of Brγ line



The instantaneous starburst model with twice solar metallicity



The age estimation

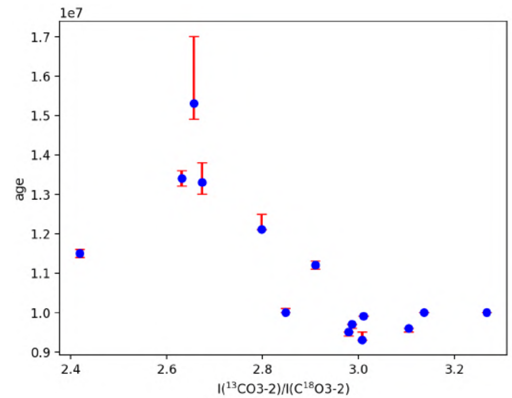
The Correlation Analysis

We analyze the correlation between the isotope ratio and the ages from CO and HCO^+ isotopologues, from 14 SSCs and pixel by pixel analysis separately.

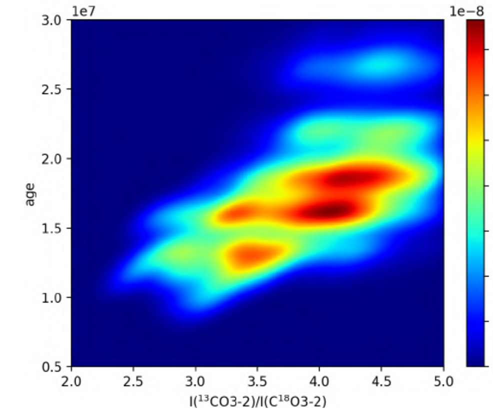
In CO analysis, for 14 SSCs, they have a negative relation. It is probably because those clusters are very young. Only some of the clusters have massive stars that end their main sequence phase and produce ^{18}O. However, a positive correlation is showed from the pixel by pixel analysis. The possible reason is the existence of the elder stars. They produce ^{13}C and increase the ratio.

In HCO^+ analysis, the opposite correlation may come from the time lag effect. HCO^+ is the dense gas tracer and it is sensitive to the star formation activity. The isotope abundance in HCO^+ changes faster than in CO.

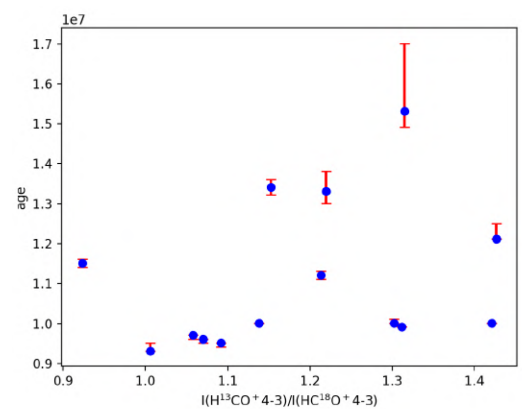
From the result, we know that **very young clusters could be also a possible explanation of the very low isotope ratio**, but we still cannot conclude that whether such a low ratio is caused by ages instead of the top-heavy IMF. To confirm our result, detailed modelling of enrichment and chemistry is needed.



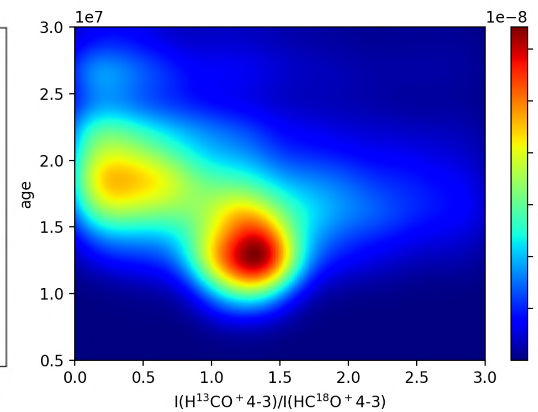
The correlation from CO(3-2) in 14 SSCs.



The heat map of the correlation from CO(3-2). The temperature represents the number density of points in the region.



The correlation from HCO^+(4-3) in 14 SSCs.



The heat map of the correlation from HCO^+(4-3).