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The formation of the young massive cluster B1 in the Antennae galaxies (NGC 4038/NGC 4039) triggered by cloud-cloud collision

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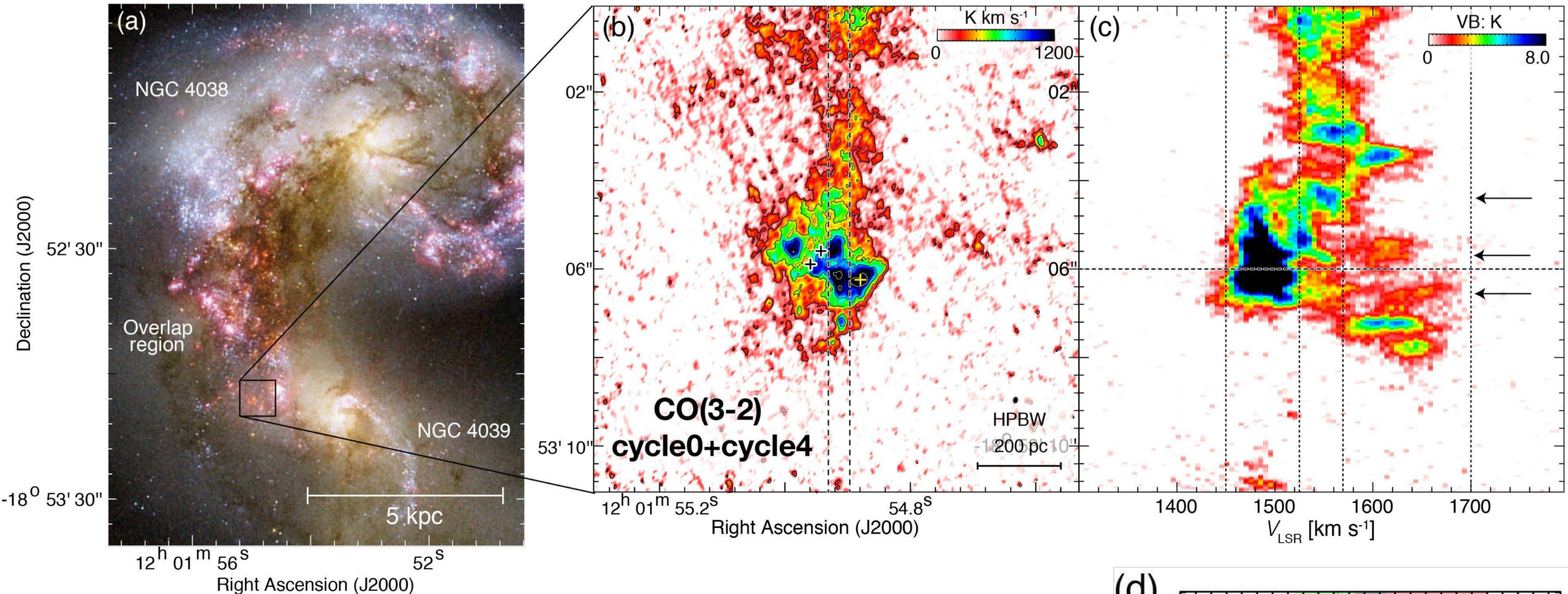
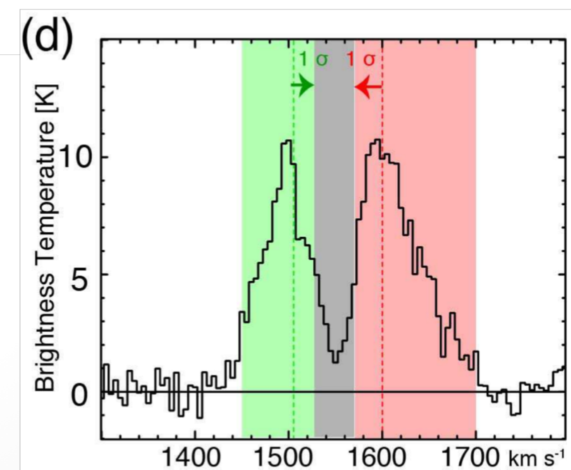
Abstract

The Antennae Galaxies is one of the starbursts in major mergers. Tsuge et al. (2020) showed that the five giant molecular complexes in the Antennae Galaxies have signatures of cloud-cloud collisions based on the ALMA archival data at 60 pc resolution. In the present work we analyzed the new CO data toward the super star cluster (SSC) B1 at 14 pc resolution obtained with ALMA, and confirmed that two clouds show complementary distribution with a displacement of ∼70 pc as well as the connecting bridge features between them. The complementary distribution shows a good correspondence with the theoretical collision model (Takahira et al. 2014), and indicates that SSC B1 having ∼10^6 $M_\odot$ was formed by the trigger of a cloud-cloud collision with a time scale of ∼1Myr, which is consistent with the cluster age. It is likely that SSC B1 was formed from molecular gas of ∼10^7 $M_\odot$ with a star formation efficiency of ∼10 % in 1 Myr. We identified a few places where additional clusters are forming. Detailed gas motion indicates stellar feedback in accelerating gas is not effective, while ionization plays a role in evacuating the gas around the clusters at a ∼30-pc radius. The results have revealed the details of the parent gas where a cluster having mass similar to a globular is being formed.

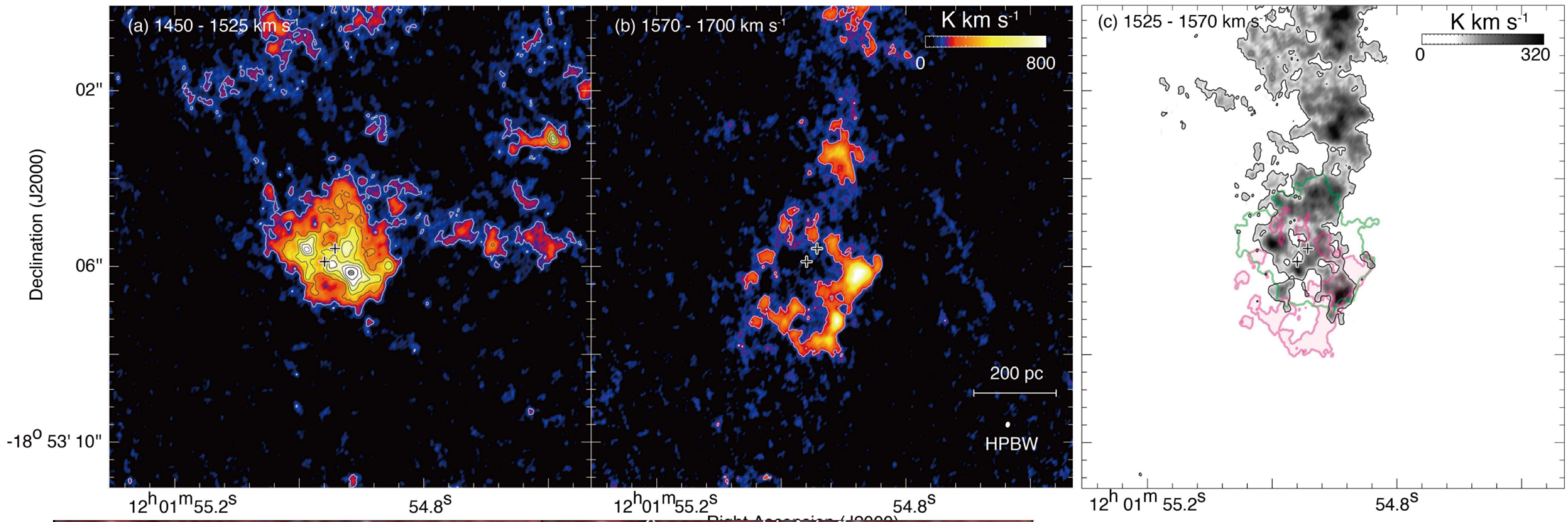
Изучают звездное сверхскопление SSC B1 в «Антенах» в CO

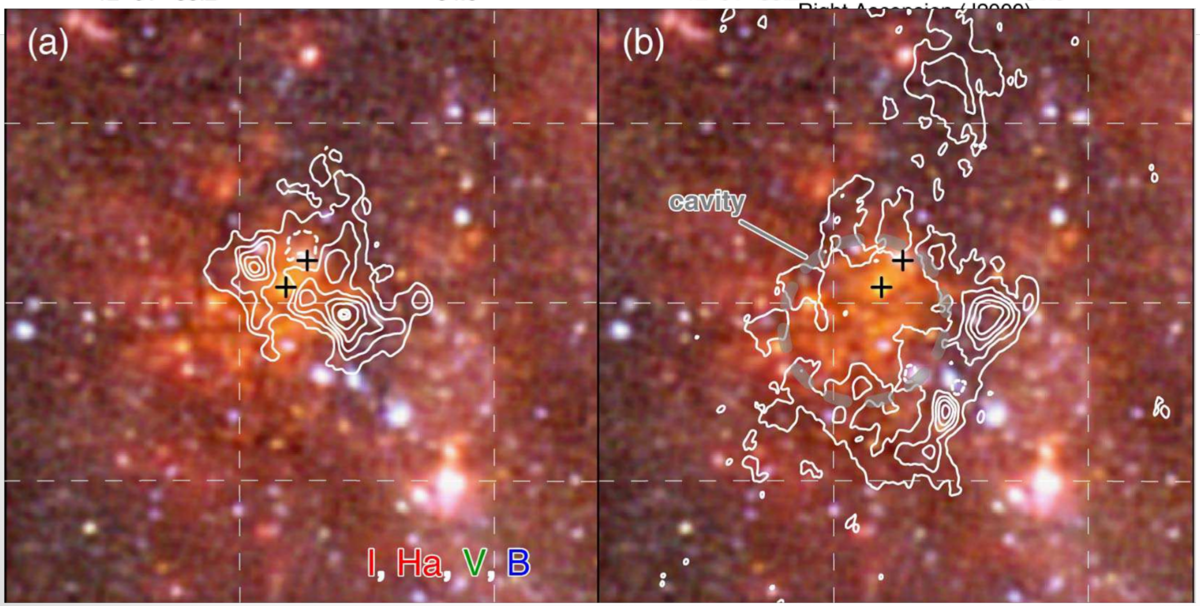


Наблюдения на ALMA в 2016 + старые наблюдения с разрешением хуже в 4 раза (Whitmore et al. 2014):
Beam = 0.15″x0.11″ (разрешение 14 пк)
Maximum recoverable scale (MRS) = 2.64″
Разрешение по скорости – 5 км/с

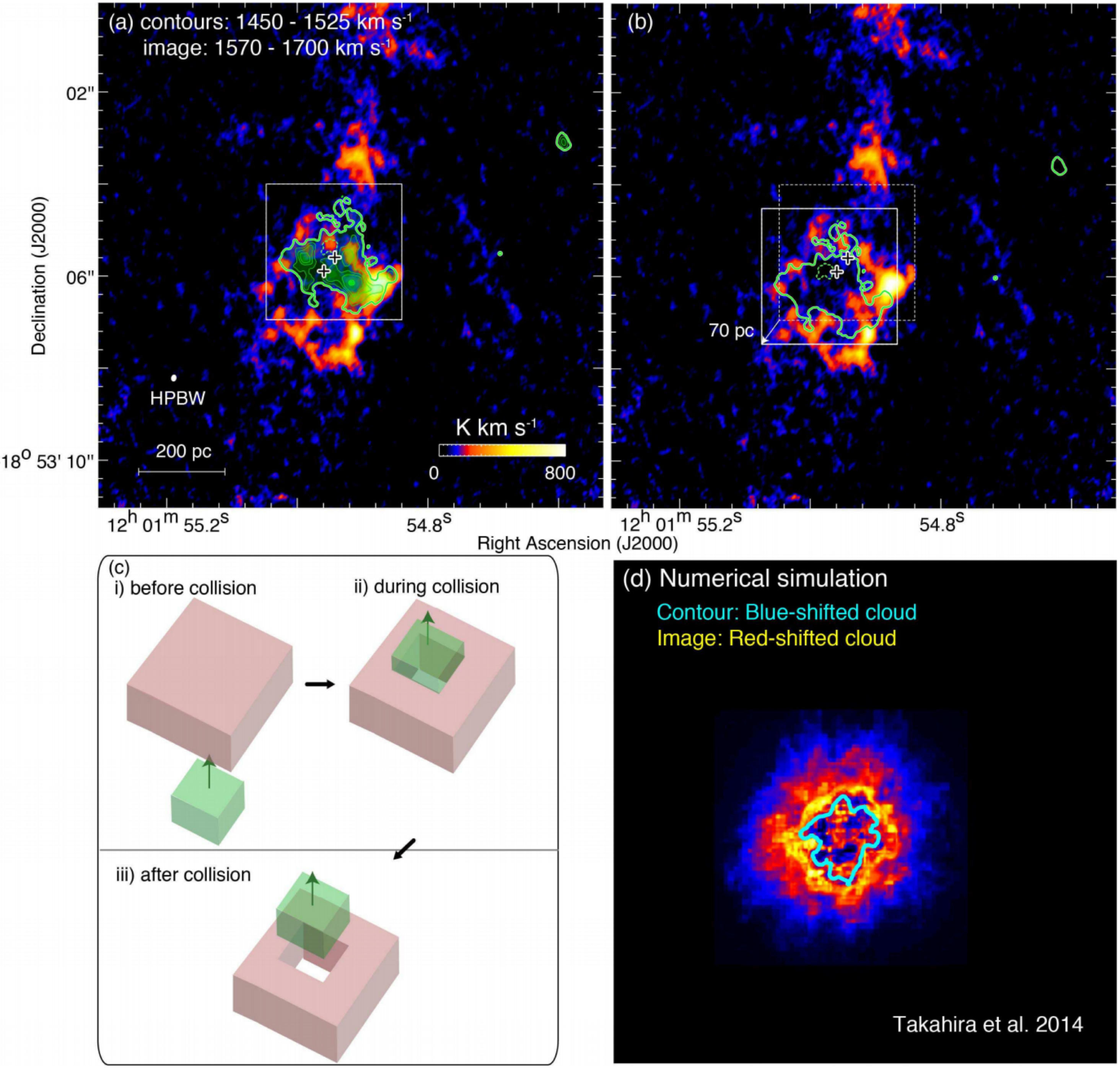


Синяя компонента Красная компонента «Мост» между ними





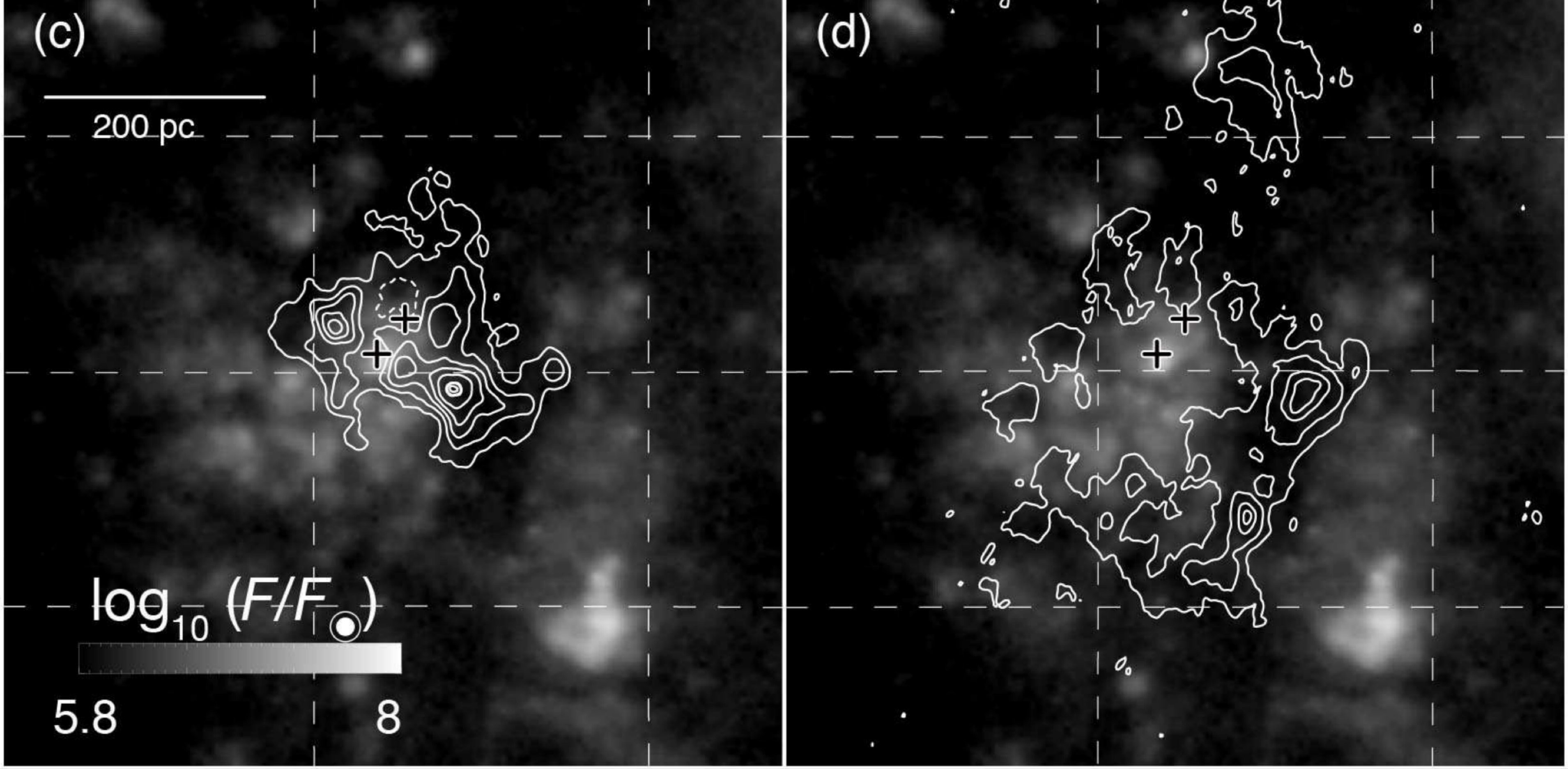
Выделяются два пространственно и кинематически разделенных облака, проецирующихся друг на друга.
Размер – 120 и 90 пк, масса – (4-6)x10^7 и (1.6-2.4)x10^7 Msun



Формы красного и синего облаков комплементарны, что является указанием на их столкновение с прохождением друг через друга

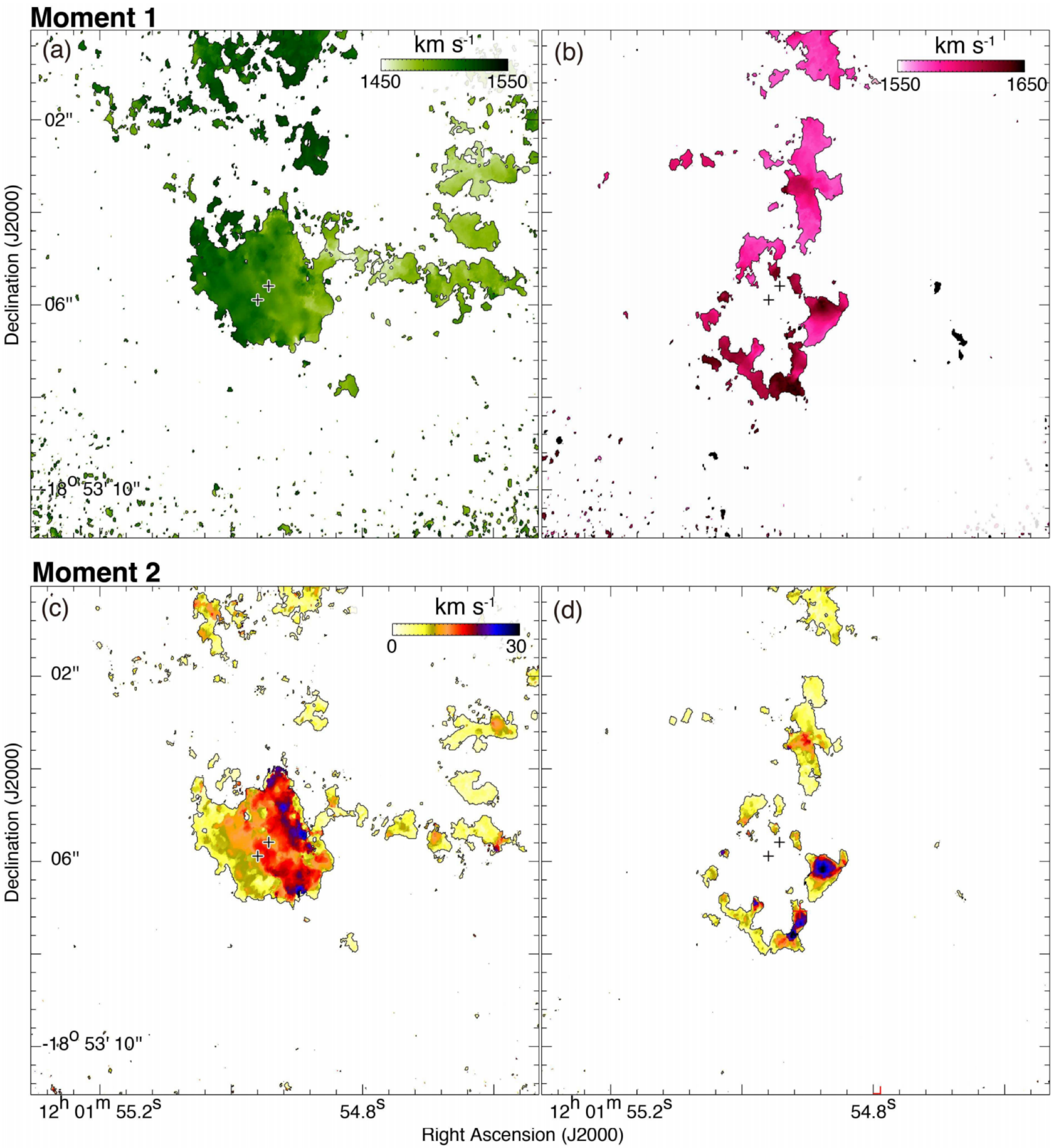
Расстояние между облаками – 70 пк, PA=126°
Скорость ~100 км/с =>
прошло около 0.7 Myr (0.4-1.4) если варьировать угол столкновения

Возраст скопления – 1-3.5 Myr



Оболочка, образованная «красным» облаком, запаолнена эмиссией Halpha с характерным размером 120 пк – как и для облака. Порядка 300 О звезд.

Из всего этого вывод – два облака CO связаны с формированием SSC B1
Масса SSC B1 около (4.2-6.8)x10^6 Msun => суммарной массы газа облаков вполне достаточно для формирования SSC за 1 Myr с эффективностью 5-8%
Высокое давление МЗС: (1.6–2.5)×10^8 K cm^{-3}, что соответствует условиям, требуемым для формирования SSC (согласно Elmegreen & Efremov 1989, 1997)



Не видят никаких проявлений фидбэка, кроме фотоионизации.
В их случае доминирующий вклад в динамику газа от столкновения облаков.

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The importance of the diffuse ionized gas for interpreting galaxy spectra

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Abstract.
Diffuse ionized gas (DIG) in galaxies can be found in early-type galaxies, in bulges of late-type galaxies, in the interarm regions of galaxy disks, and outside the plane of such disks. The emission-line spectrum of the DIG can be confused with that of a weakly active galactic nucleus. It can also bias the inference of chemical abundances and star formation rates in star forming galaxies. We discuss how one can detect and feasibly correct for the DIG contribution in galaxy spectra.

Keywords. ISM: abundances, galaxies: abundances, galaxies: ISM.

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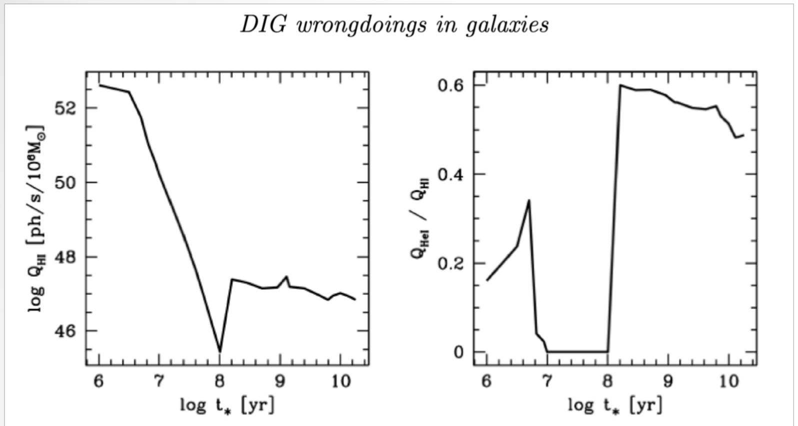
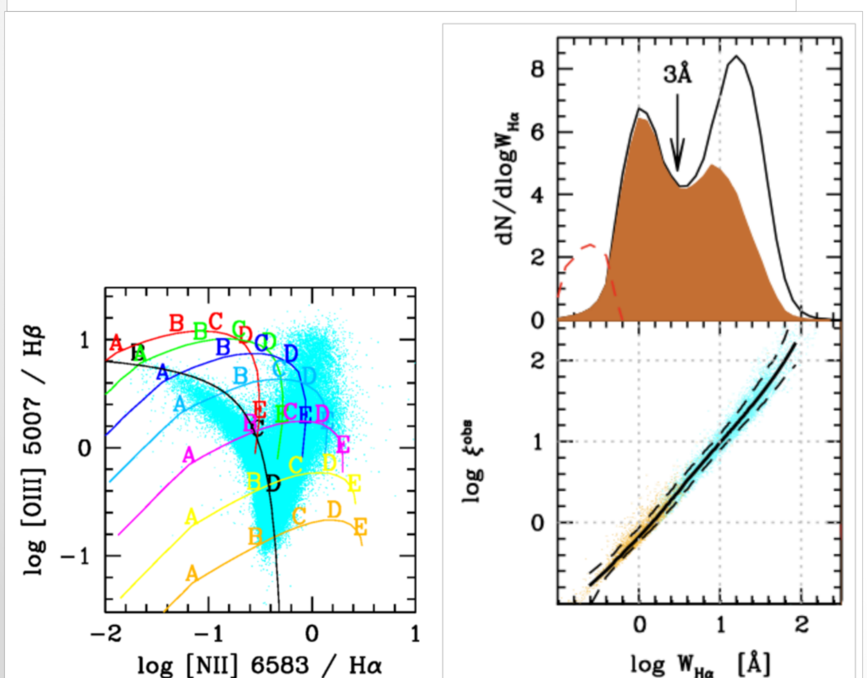
1. Introduction

A lot can be learned from studying the integrated spectra of galaxies. The power is in the numbers: a large statistical sample tells us about trends in astrophysics, but also about dispersions in those trends. Empirical relations thus constructed can provide useful guidance for chemical evolution models.

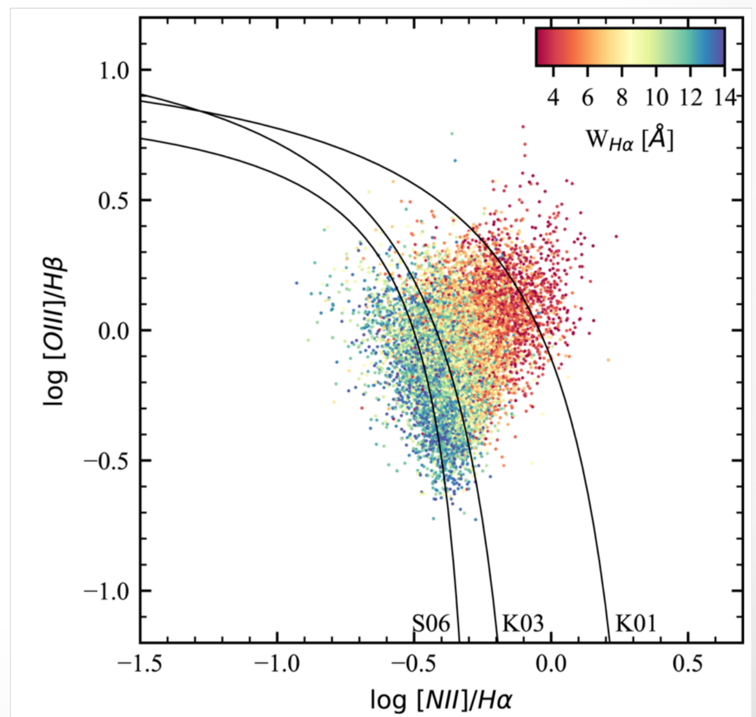
Как можно выделить DIG?:

- Поток в Halpha (например, Zhang et al. 2017)
- [SII]/Ha (например, Kreckel et al. 2016)
- EW_Halpha (Lacerda et al. 2018)





HOLMES = HOt Low Mass Evolved Stars (в частности – post-AGB)



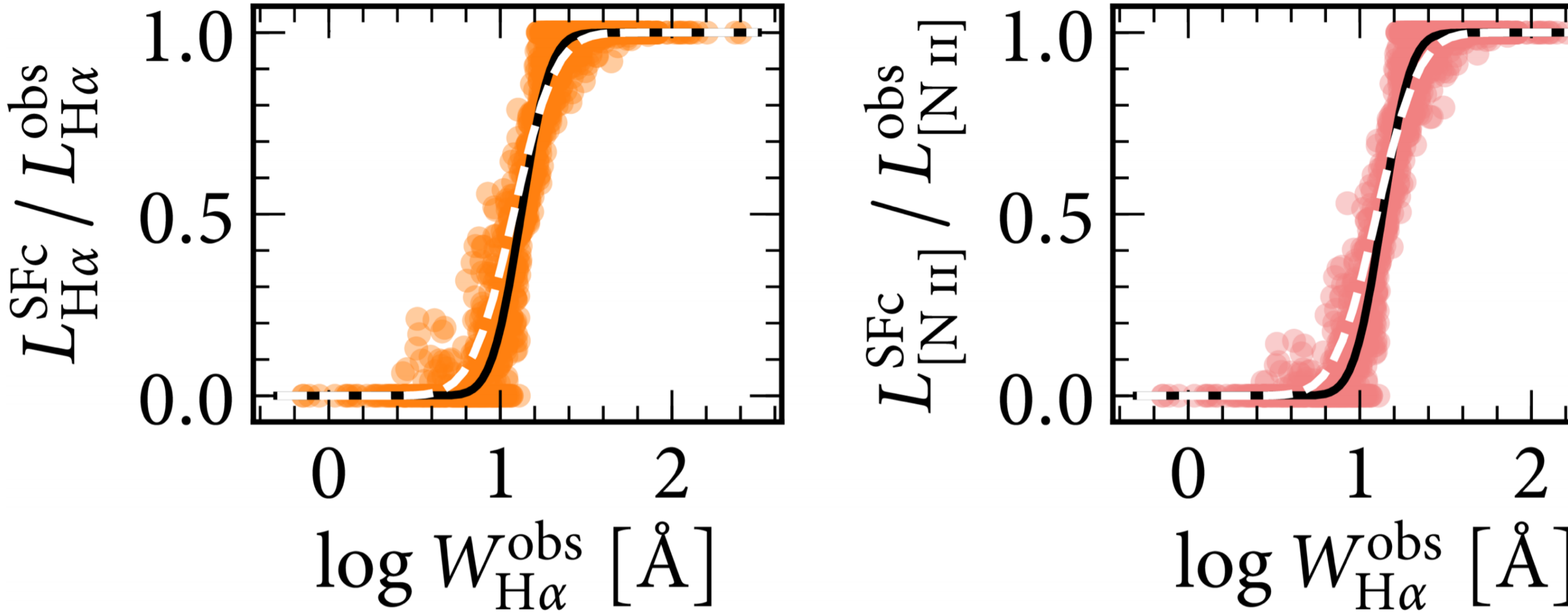


Figure 5. Correction for DIG emission appropriate for SDSS observations, based on 1409 MaNGA star-forming galaxies. Panels show the Hα and [N II]λ6584 line luminosities in SFc spaxels normalised by the total luminosity versus total $W_{H\alpha}$, where all measurements were taken within a circular $0.7R_{50}$-diameter aperture. The solid line shows a fit to the data; the dashed line shows a fit for measurements made in $2.0R_{50}$-diameter apertures. (Figure adapted from VA19.)

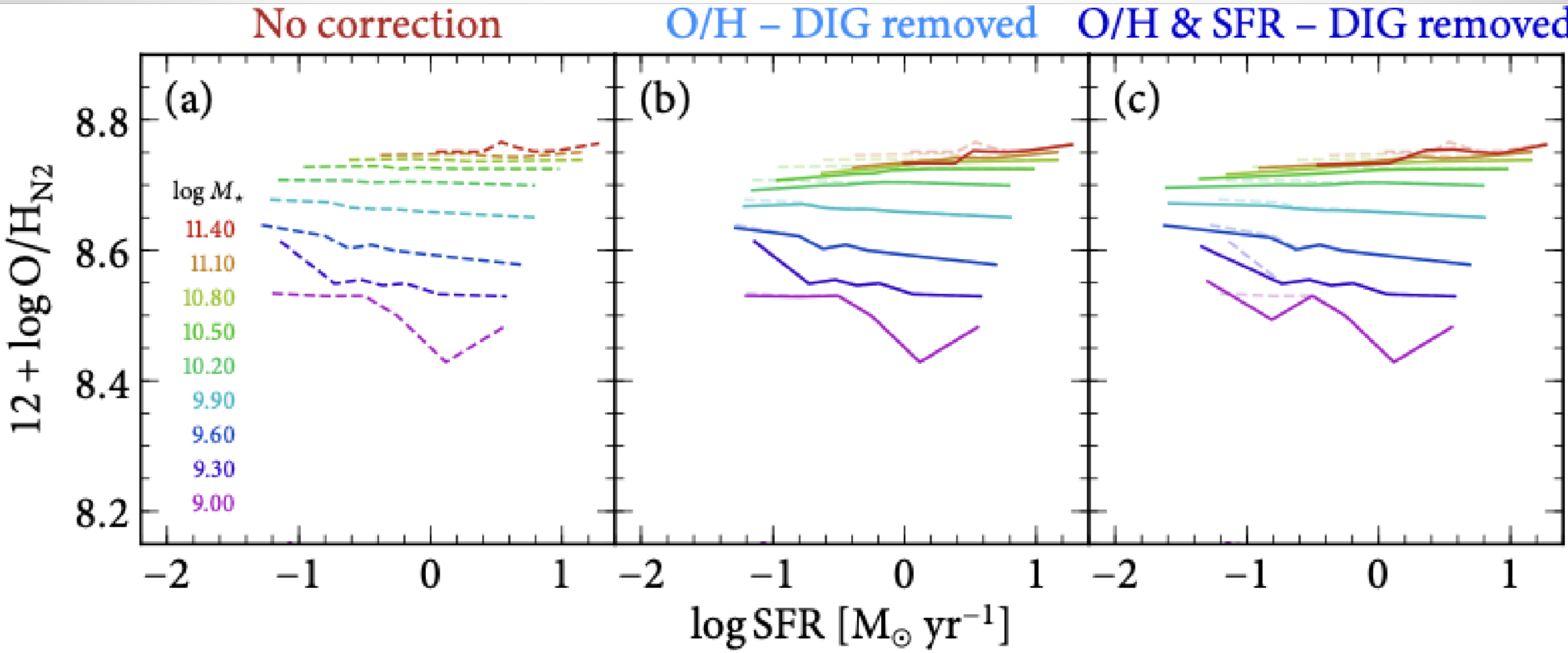
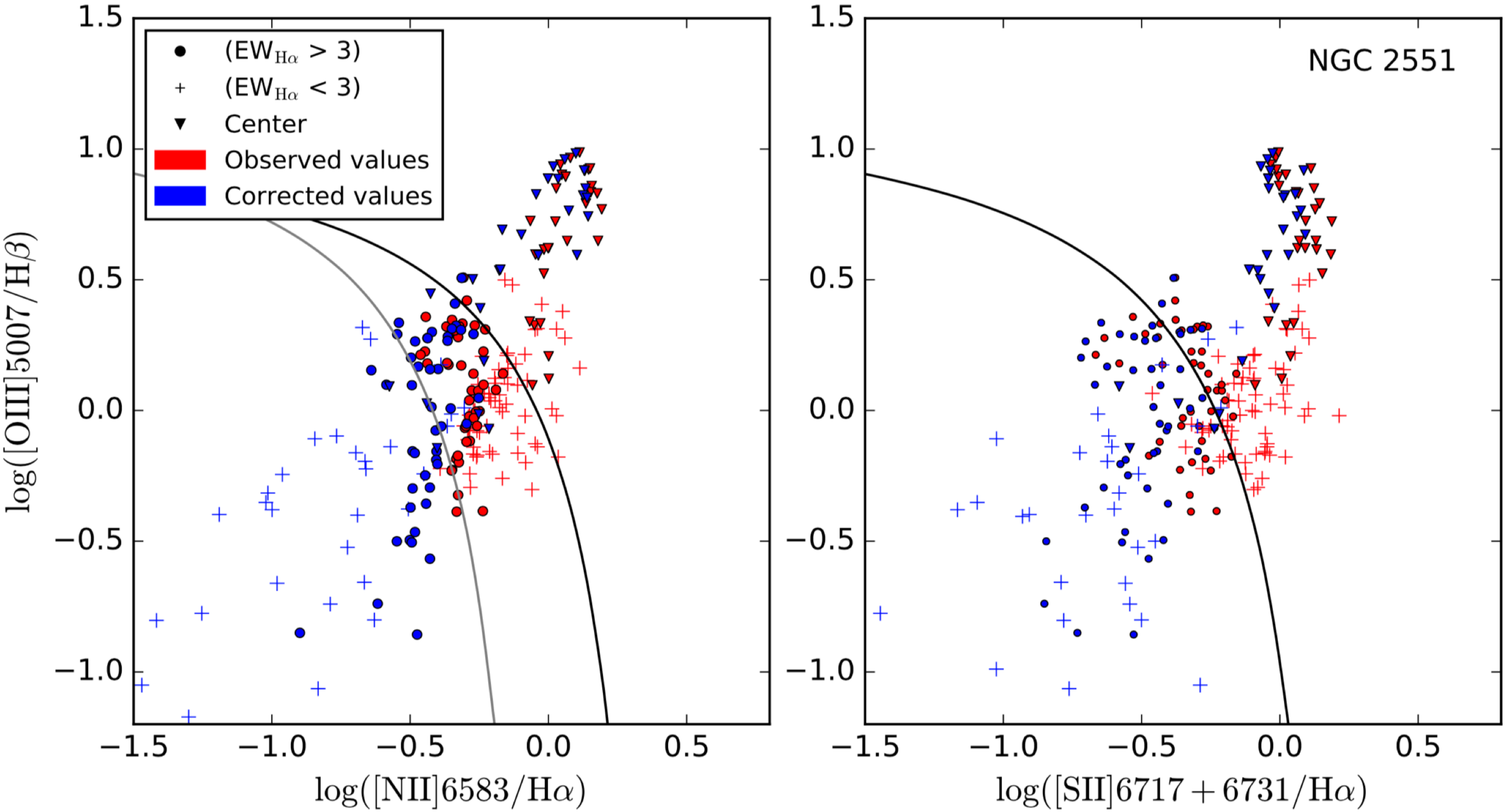
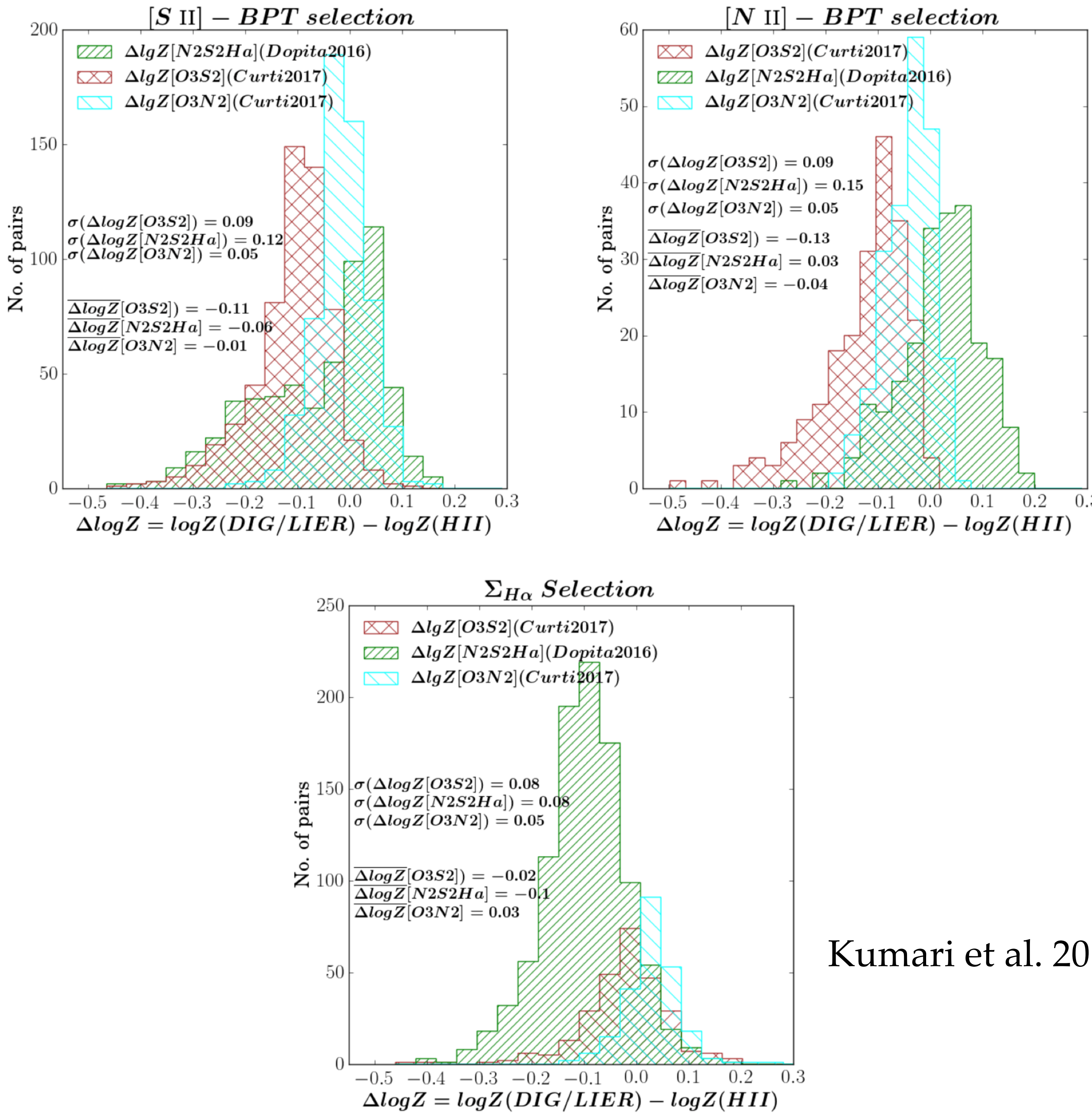


Figure 6. O/H as a function of SFR for ∼ 10,000 SDSS star-forming galaxies in stellar mass bins (whose centres are given in the left handside panel). O/H has been calculated using the [N II]λ6584/Hα index. (a) M–Z–SFR relation with no correction. This is repeated (as dashed translucent lines) in the two other panels for comparison. (b) Correcting [N II]λ6584 and Hα for the DIG contamination (using the fits shown in Fig. 5) prior to calculating O/H. (c) Correcting Hα prior to obtaining the SFR as well. (Figure adapted from VA19.)

DIG от HOLMES не влияет на оценки металличности. В случае MANGA – возможно из-за пространственного разрешения.



Sil'chenko, Moiseev, Egorov (2019)



Kumari et al. 2019