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A radio – optical study of resolved star formation in SAMI galaxies

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MOTIVATION

Despite many decades of effort, the relation between radio continuum emission and the star-formation rate (SFR) in galaxies is still not well understood [1]. The tight correlation between radio and far infrared flux used to derive local scaling relations between the radio continuum power and SFR breaks down for faint, low metallicity, low mass galaxies [2]. We are combining resolved radio continuum information with optical integral field spectroscopy (IFS) to:

- better understand the radio emission as a SFR tracer within galaxies,
- study low mass star-forming galaxies which fall off the radio-SFR relation for larger galaxies and,
- investigate whether the mix of thermal and non-thermal radio emission in star forming galaxy changes with galaxy stellar mass and metallicity.

SAMI GALAXY SURVEY

IFS provides spatially resolved information of a galaxy's properties as well as gas and stellar kinematics over an entire galaxy.

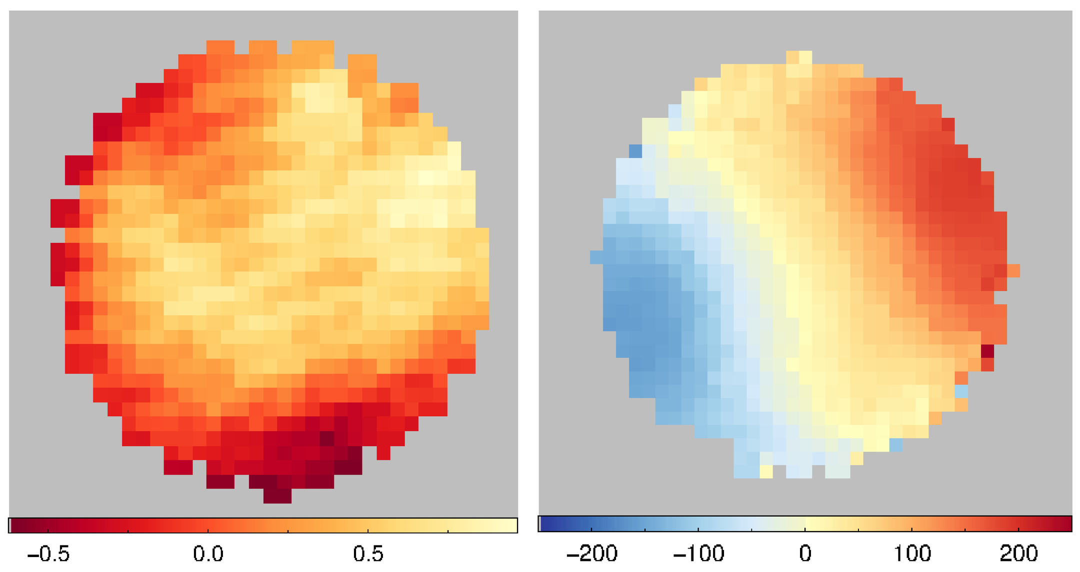

Figure 1. Left: *SAMI Hα emission line map of GAMA 106717, a disk galaxy at z=0.026. Scale is log(flux/10¹⁶ erg/s/cm²).* ***Right:*** *velocity of the emission line gas (km/s).*

We draw our data from the SAMI galaxy survey [3]. By 2016 the **Sydney- AAO Multi-Object Integral- field spectrograph (SAMI)** galaxy survey aims to observe 3400 galaxies including field and group galaxies from the GAMA [4] regions as well as nearby cluster targets, resulting in a sample large enough to study galaxy formation as a function of both environment and mass.

VLA, FIRST & NVSS

We have matched the 1.4GHz FIRST and NVSS radio continuum survey catalogues with the SAMI targets in the GAMA regions. The most important difference between the two radio surveys is that the NVSS is a lower resolution survey with a ~50" synthesized beam, whereas the FIRST survey has an angular resolution better than 5". 216 of the SAMI galaxies are in either FIRST or NVSS.

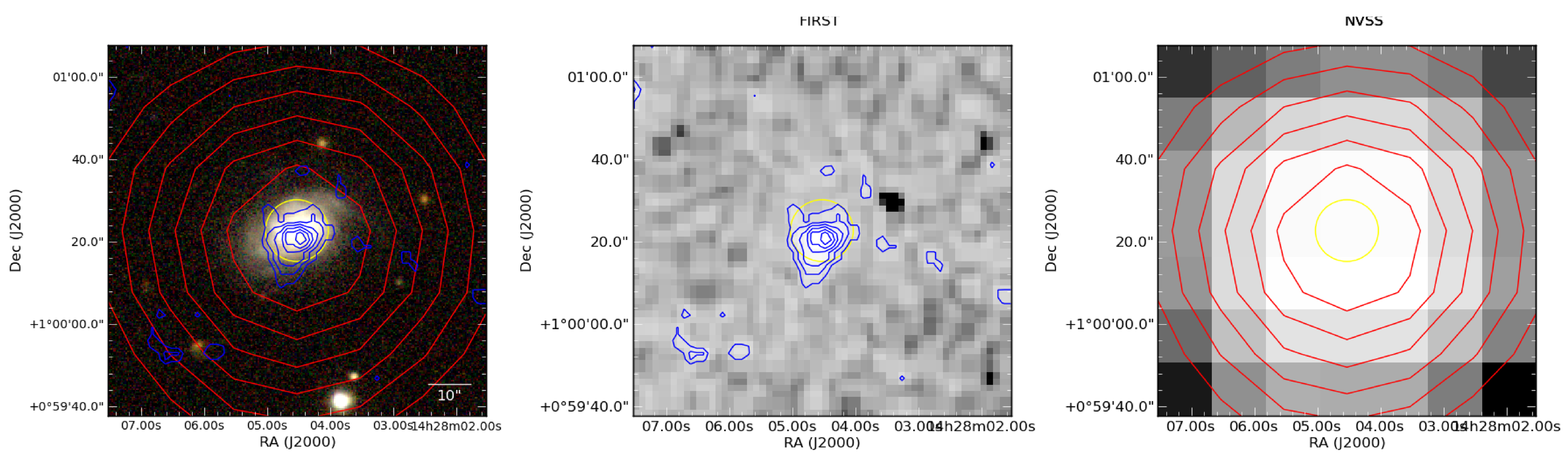

Figure 2 *Overlay of radio continuum emission from FIRST (blue contours, mid panel) and NVSS (red contours, right panel) on an SDSS image (left). This figure shows the galaxy GAMA ID 106717. The yellow circle in the centre of the panels indicates the SAMI fibre bundle field of view.*

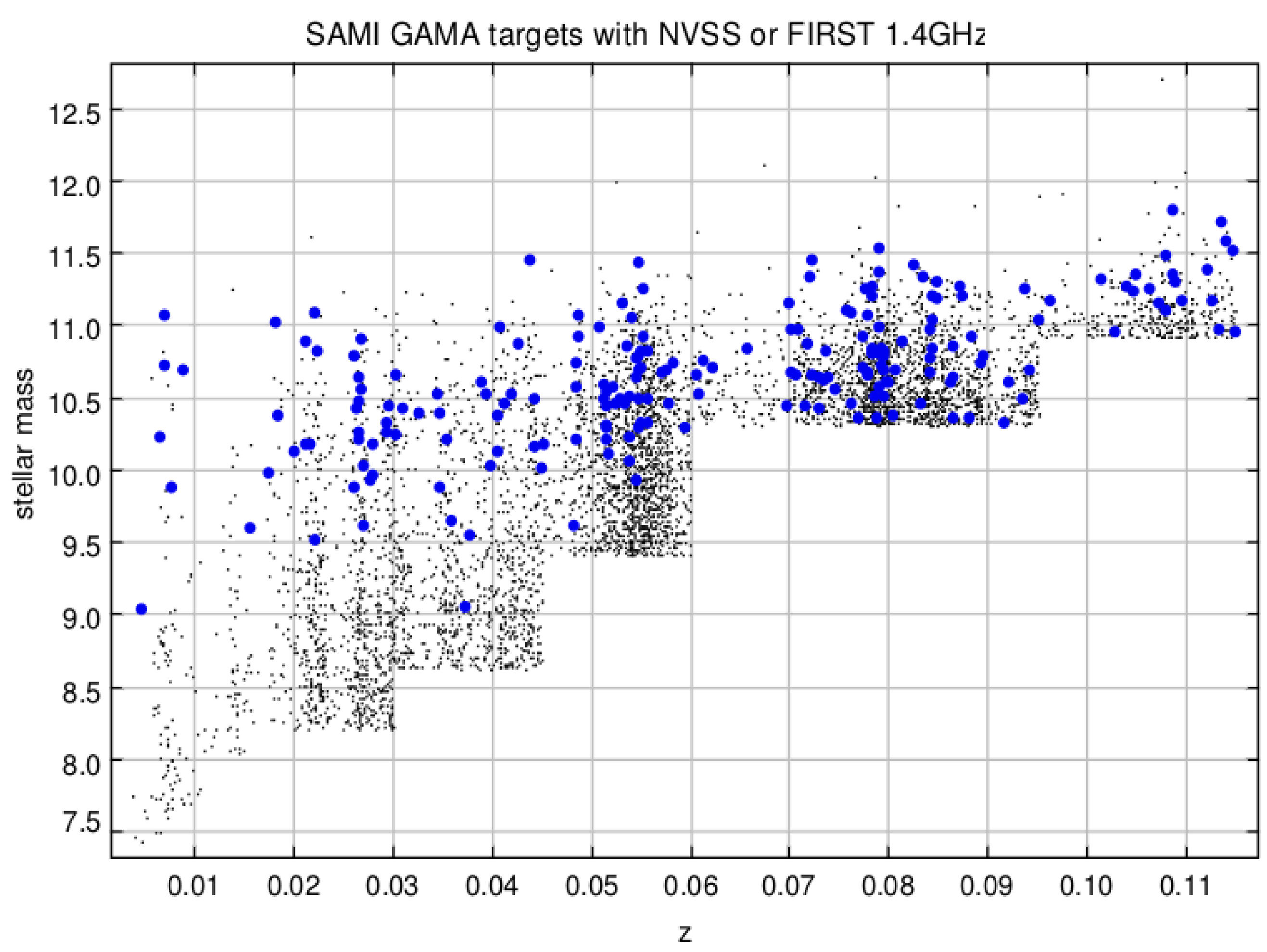

Figure 3 *Distribution of SAMI target galaxies in redshift vs stellar mass. Blue points are galaxies detected as radio sources by NVSS or FIRST, and the grey points are undetected galaxies.*
The catalogues primarily detect the higher stellar mass objects and therefore only provide data for SAMI galaxies above $10^{9.5}$ $M_{\odot}$.

OPTICAL RESULTS FROM IFS

IFS with SAMI allows us to detect contributions by shocks and AGN to the emission spectrum via emission line diagnostic ratios [5]. We can combine this information with spatial and kinematic information to separate components associated with different power sources (e.g. Figure 4) to investigate their effects on the radio continuum- Hα relation (see Figure 5).

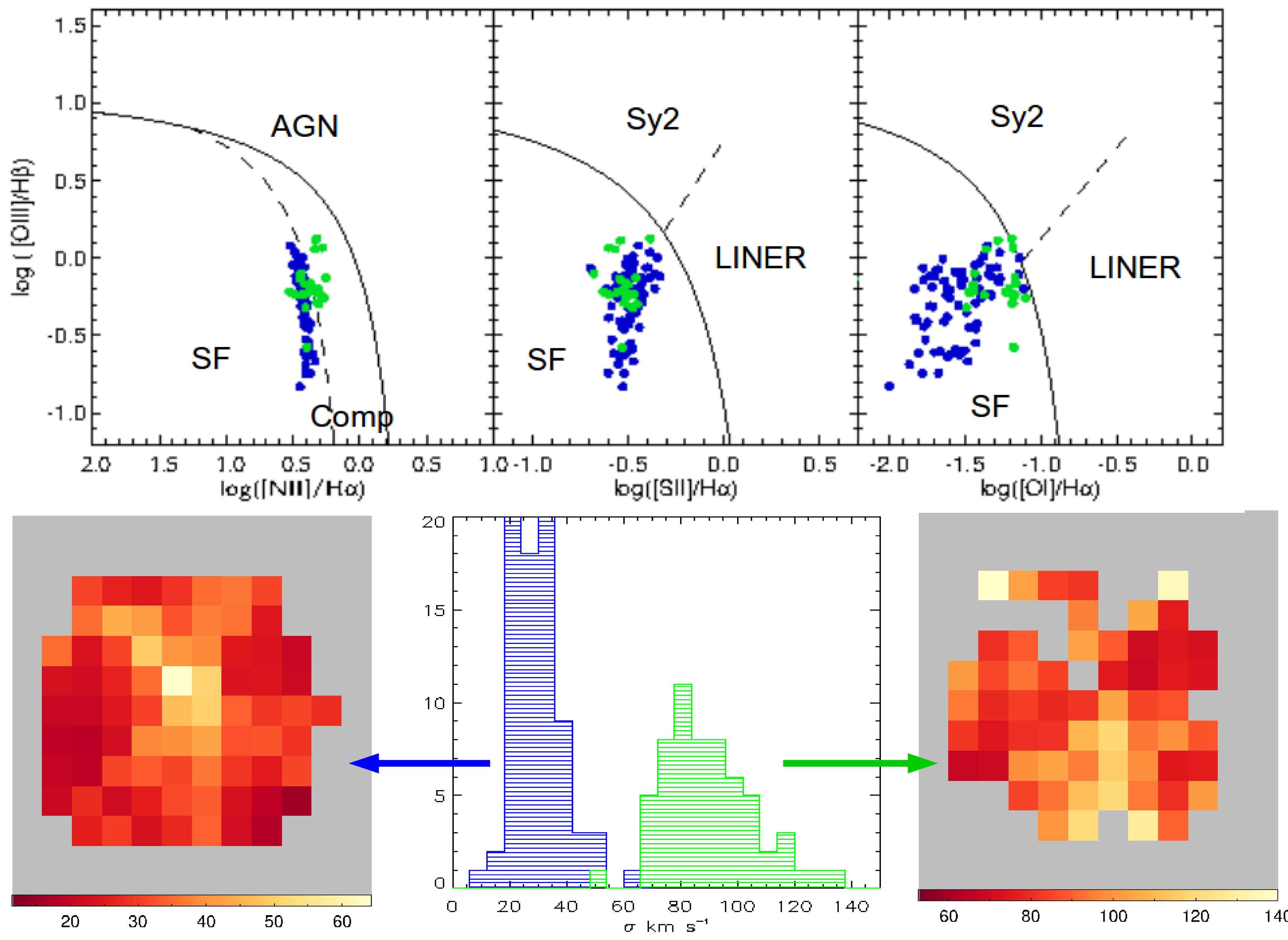

Figure 4. SAMI data of GAMA 106717. *In all panels blue is the narrow Gaussian component and green is the broader component.* ***Top****: Optical line diagnostic diagram [6] which can be used to separate the likely source of ionization. Galaxies lying to the left of the dashed line are typically purely star forming, galaxies lying above the solid line are AGN or LINERs, and those lying between these two regions tend to be influenced by a combination SF and a harder ionizing source, or shocks.* ***Emission line ratios enhanced in the broad component like this often correspond to shocks****.* ***Bottom Left:*** *Velocity dispersion map of low velocity dispersion component corresponding to star formation.* ***Bottom Center:*** *Velocity dispersion distribution for all components fit, separated by low (blue) and high (green) velocity dispersion.* ***Bottom Right:*** *High velocity dispersion component (possible shocks). The lower region shows the highest velocity dispersion.*

Hα vs 1.4 GHz STAR FORMATION RATES

We use modern star formation calibrations to calculate SFRs across our galaxies [7]. The Hα SFR is sensitive to stars younger than 10 Myr, whereas the 1.4GHz SFR calibration is sensitive to stars younger than 100 Myr and relies on the tight correlation between a galaxy's far-infrared and radio flux. If the galaxy shows evidence of shocks we calculate the Hα SFR using only the pure star forming component (the low velocity dispersion gas). Figure 5 shows a comparison of the radio and Hα SFR estimates. **We find in galaxies with evidence for winds, like GAMA 106717, that the observed radio emission is stronger than expected from the Hα-based SFR in regions where the gas velocity dispersion is high (see Fig. 5). We suggest that this excess radio emission may arise in the shocked galactic wind.**

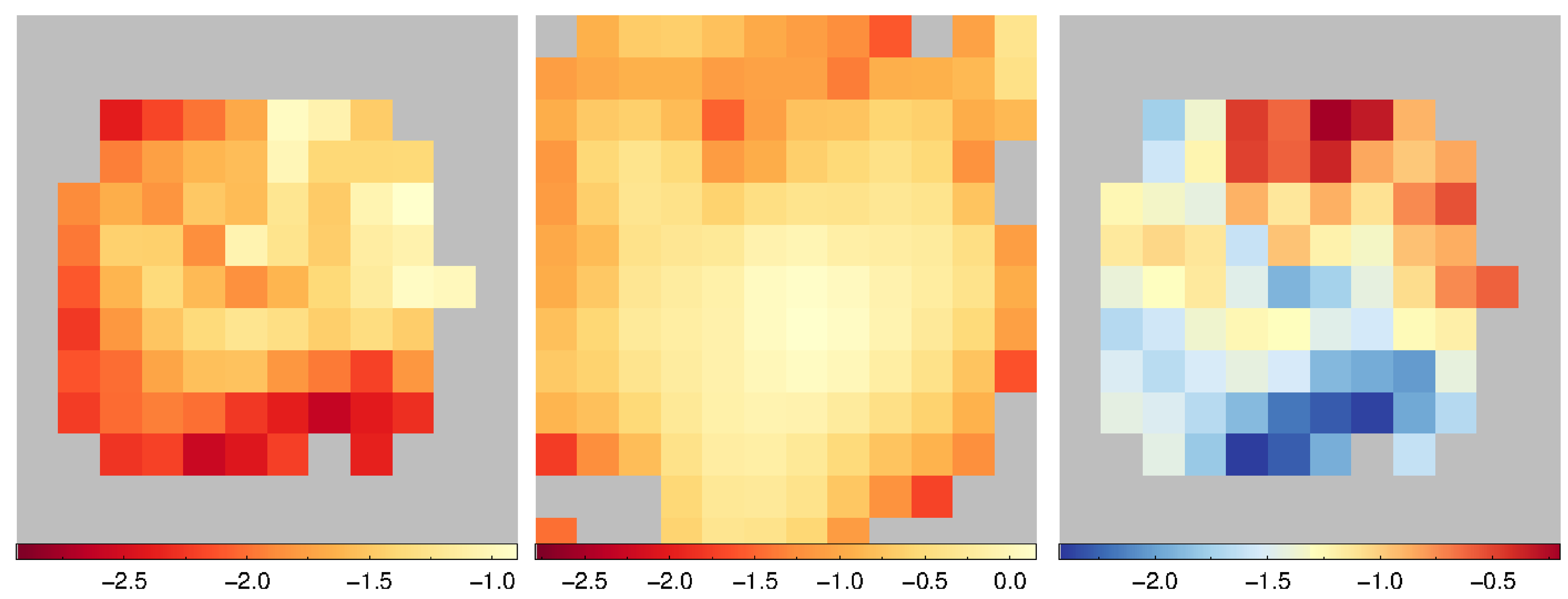

Figure 5. Analysis of GAMA 106717. Left*: We stack the SAMI spectra such that the pixel scale matches the FIRST images (1.8"). We then calculate the SFR from extinction corrected (using balmer decrement) Hα luminosity.* ***Center****: The radio SFR is derived from the 1.4 GHz flux density.* ***Right: The ratio of the two SFRs shows that for this galaxy, the radio SFR is much larger than the optical Hα SFR****, particularly where the has has the highest velocity dispersion.*

FUTURE WORK

- VLA time has been awarded to extend our sample of radio detections to galaxies of lower stellar mass. We will observe at 1.4 GHz and 6GHz to make spectral index maps, and separate the thermal and non-thermal radio emission.
- Could wind galaxies be more prominent in radio selected star forming samples? Half of our current sample of radio detected galaxies show evidence of shocked gas. We will model these galaxies to better understand the radio and optical emission.
- Compare with HI observations.

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sami galaxy survey