Spatial Distribution of Metallicity in AGN Host Galaxies from the MaNGA Survey

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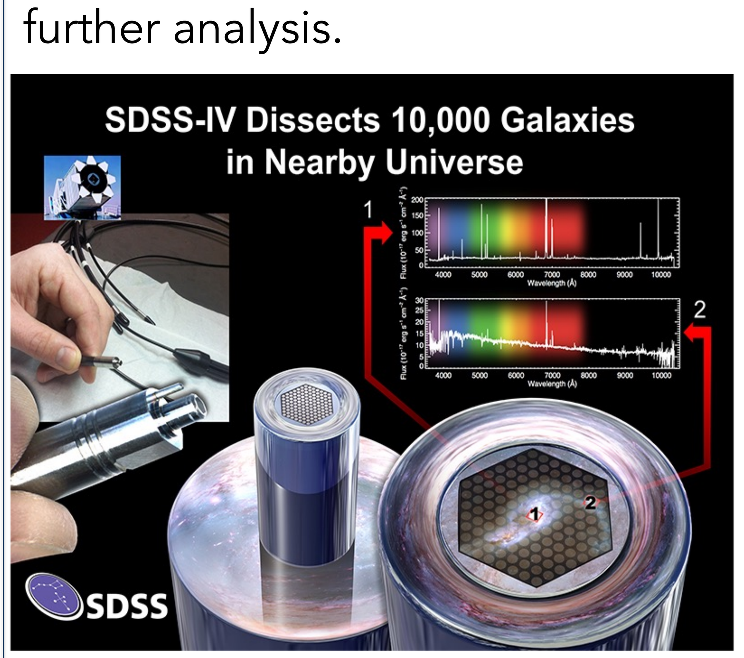
Abstract

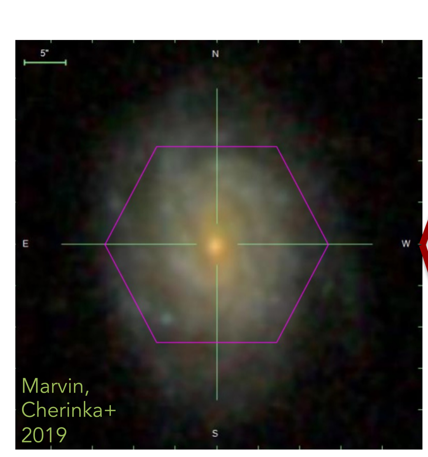
There currently exists no consistent profile for the radial metallicity of galaxies with Active Galactic Nucleus (AGN). Integral field spectroscopy (IFS) has enabled a considerable step forward in understanding galaxy evolution, providing mapped information on the kinematics of the gas and stars, and on galaxy properties, in terms of the level of gas ionization and its metal content (i.e., its chemical abundance). Using IFS data from the MaNGA survey, this research project aims to investigate the internal structures of a sample of AGN host galaxies, in terms of the shape of the metal distribution in the gas, whose trend with other galaxy properties (e.g., stellar mass) will help us obtain hints on the impact of AGN activity on galaxy evolution. The preliminary results from this project indicate that AGN regions have lower metallicities than do star-forming regions in the sampled host galaxies. On this basis, the calibrations for AGN metallicity need to be adjusted or redefined to account for the discontinuity in the radial metallicity profile.

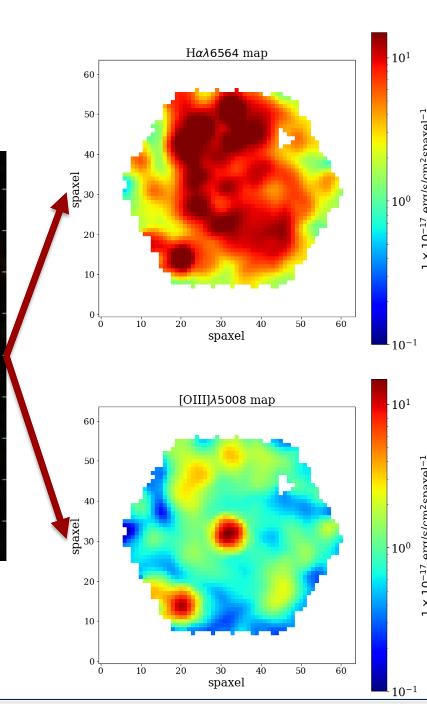
Introduction

Integral field spectroscopy measurement, such as the MaNGA data used in this project, is a form of data collection that records the complete visual spectrum of light over a two dimensional field of view in the sky. The spectra are associated with positions within the field of view, creating spaxels: Three dimensional data cubes that store x and y position as well as the flux of the light spectra as the z dimension. This project's analysis begins by importing MaNGA data and isolating all data cubes in a galaxy at a set wavelength. These wavelengths were determined by the known values of interstellar gas emission. In HII galactic star-forming regions, young massive stars emit radiation that ionizes gas in the surrounding interstellar medium. These emissions such as the Balmer series of Hydrogen occur at known wavelengths and can be used as tracers and diagnostics for the analysis of stellar mass, interstellar dust, and metallicity. This ionizing effect also occurs in the AGN where the accretion disc of a supermassive blackhole emits intense ionizing radiation. The wavelength isolated data cubes allow for the mapping of individual emission spectra wavelength across the whole galaxy (as can be seen with **Hα** and OIII in the bottom right) as well as the mapping of emission line ratios which are necessitated for radial metallicity analysis. At this point, the data for all spaxels was corrected for both galactic red shifting as well as dust extinction using a map of the Balmer decrement in order to yield accurate emission wavelength values for proper further analysis.

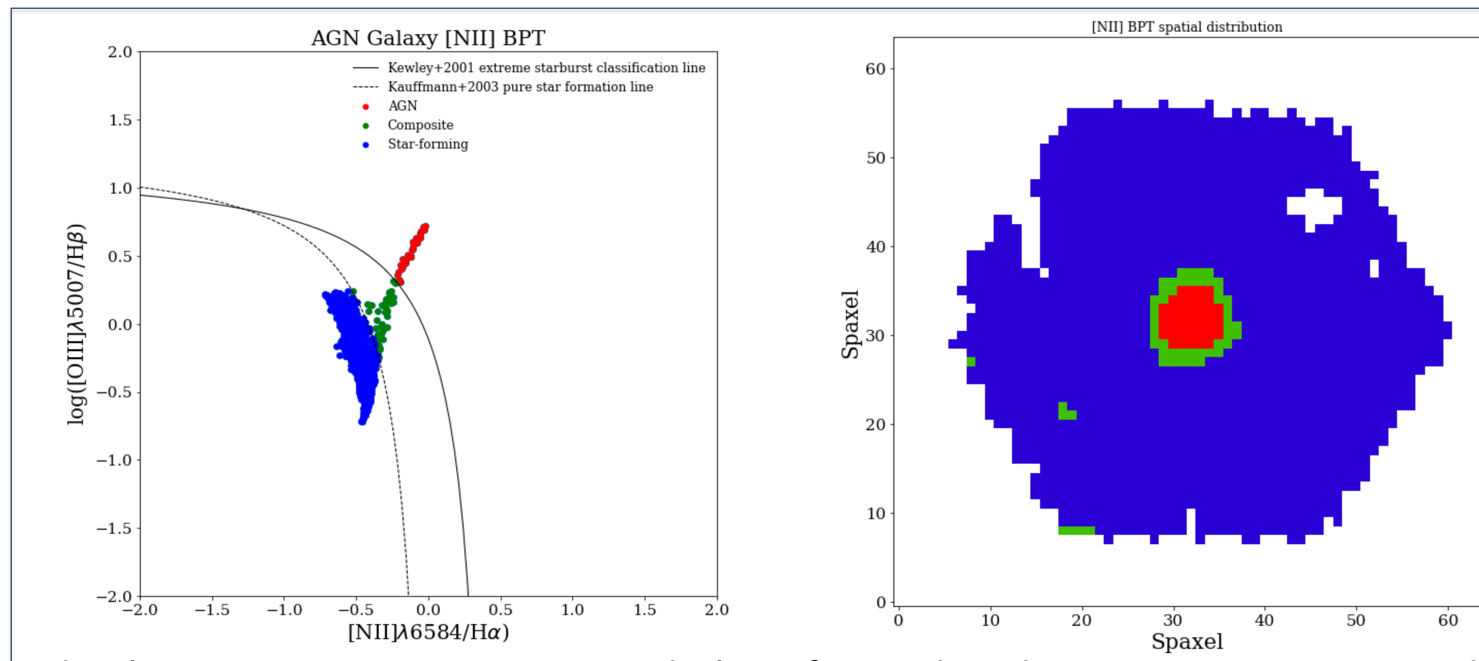


Dana Berry / SkyWorks Digital Inc., David Law, and the SDSS collaboration





AGN Classification



The last step in correcting and classifying the data was to partition the spaxels into regions that were classified as being dominated by either AGN or star-forming activity. Using NII BPT plot and mapping (shown above) as well as SII BPT classifications, the line ratio of NII, SII, and OIII emissions against the Balmer series of hydrogen was plotted for all spaxels. The spaxels were then classified using the Kewely 2001 extreme starburst classification curve and the Kauffmann 2003 pure star-formation curve as either AGN, composite/LIER, or star-forming. A mask for the AGN region shown in red and the star-forming region shown in blue were then constructed and used to apply several subsequent calibrations that are tuned to be applicable only within their masked regions.

Metallicity Mapping

Storchi-Bergman+ 1998 Calibrations for defined AGN region

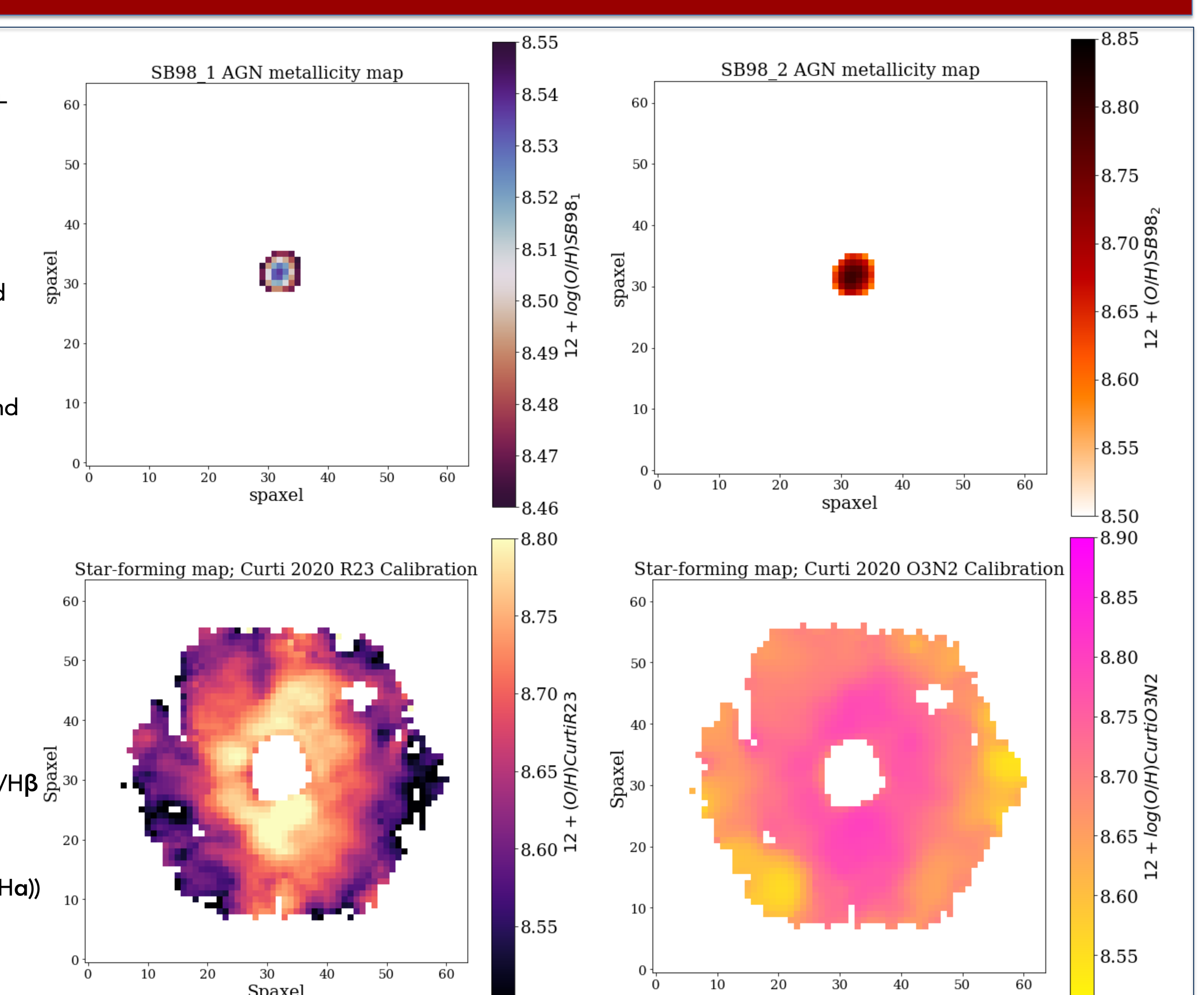
SB98 1: [NII]λ6548,6584 /Hα and [OIII] λ4959,5007/Hβ

SB98 2: [NII] λ6548,6584 /Hα and [OII]λ3727,3729/[OIII] λ4959,5007

Curti+ 2020 Calibrations for defined star-forming region

R23: Interpolated fit: ([OII]+[OIII] λ4959,5007)/Hβ

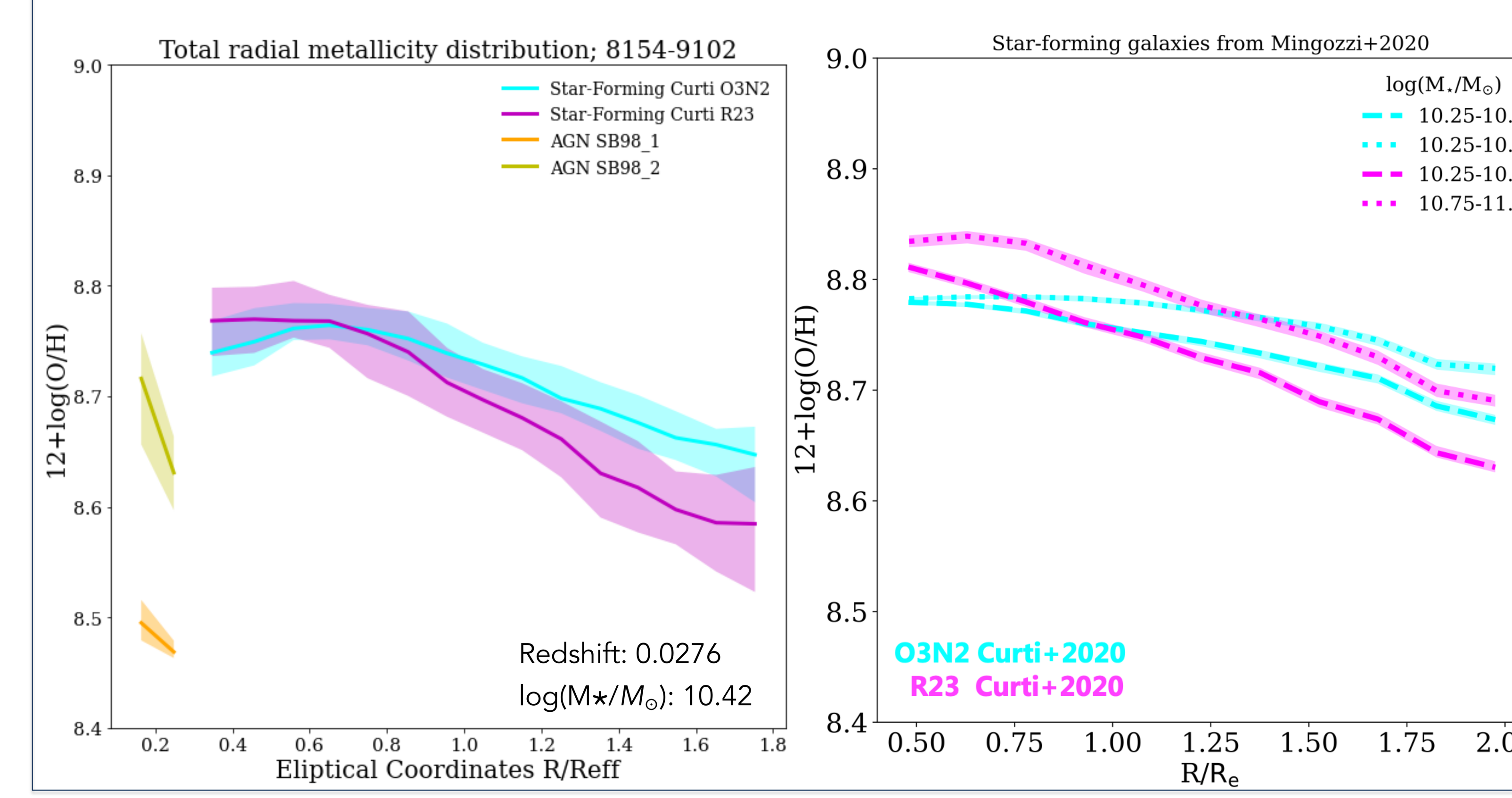
O3N2: Interpolated fit: ([OIII] λ4959,5007 /Hβ)/([NII] λ6548,6584 /Hα))



Within the two defined regions, two sets of metallicity calibrations were used. Storchi-Bergman+ 1998 Calibrations were used for the smaller central region of AGN spaxels and the Curti+ 2020 Calibrations were applied to the star forming regions. The use of four total calibrations was necessary as the AGN calibrations are inaccurate in star-forming regions and vice-versa. Additionally, each calibration uses different line ratios in its definition, so the use of multiple calibrations ensures that a discrepancy in one emission ratio does not skew the whole data set.

Results

From the previous four metallicity maps, a radial profile (bottom left) was compiled to characterize the metallicity of all four calibrations with respect to the effective radial coordinates of a sampled galaxy. This process was repeated for several AGN host galaxies all of which exhibited similar trends. Of note in the AGN hosts was the precipitous decrease in the AGN metallicity as well as the noticeable discontinuity in the profile at the transition between the two regions. These AGN radial profiles were then compared to the radial metallicity profiles of pure star-forming galaxies of similar stellar masses without AGN (bottom right) compiled by Mingozzi+ 2020. While the AGN host star-forming and pure star-forming profiles bear much similarity, there is a steeper slope in the decrease of metallicity in regions beyond and effective radius of 1 in AGN hosts.



Conclusions

- Radial metallicity profiles of analyzed AGN hosts are characterized by:
  - Lower metallicity within the AGN region
  - Steeper slope and more precipitous fall off of metallicity in regions beyond R>1 Re
- Future Research:
  - Expanding sample size to confirm the above AGN metallicity trend consistency across large number of host galaxies
  - Incorporate more metallicity calibrations to account for the discrepancies found between the Stoichi-Bergman and Curti calibrations as well as the conflict between the AGN calibrations

Acknowledgments

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