Probing the Physics of Seyfert Galaxies using a Spectroscopic and Multiwavelength data

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Abstract:

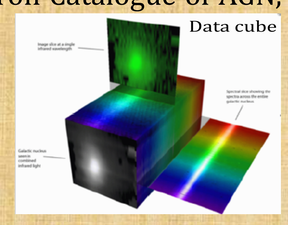
Here were present the current status of the Siding Spring Southern Seyfert Spectroscopic Snap-shot Survey, consisting about 130 nearby Active galaxies which are within a redshift of 0.02. The majority of the sample objects are Seyfert galaxies, including Seyferts of both type 1 and type 2. We present results based on multi-wavelength data for these objects, with which we explore the physical properties such as the correlation between the radio-infrared emission, systematic differences between the Seyfert type 1 and Seyfert type 2 galaxies, and the relationship between the radio and optical morphology.

Accreting supermassive black holes or Active Galactic Nuclei (AGN) are well known to generate outflows of ionised gas, as well as synchrotron-emitting bipolar jets of plasma. While there are thousands of AGN now known and characterised, the fundamental processes by which accretion around the black hole launches bipolar jets that could reach nearly relativistic speeds and scales of upto even a mega-parsec, is still not well-understood. Furthermore, evidence suggests that the growth of the central supermassive black holes and their host galaxies go hand in hand, implying complex feedback mechanisms between the two processes. The nearest accreting supermassive black holes and their host galaxy structures can be studied in great detail, and their emission line regions are accessible to the optical waveband. The extreme-ultraviolet photons from the accretion disc around the supermassive black hole photoionises the gas in the nuclear environment of the galaxy and produces high-excitation emission lines. In addition, the star-forming regions in the galaxy also produce HII regions and associated radio emission. The bipolar plasma jets could drive the hot gaseous outflows but shock-ionisation could also play a role. Spectroscopy gives us a handle on the abundance gradients across the galaxy as well as the kinematics of the gas via the Doppler shifts and Doppler broadening of the emission lines. The radio structure, which we determine both from archival VLA data and from our observations with the GMRT, probes both star formation and the accreting central black hole. We are thus able to investigate the interaction of the AGN processes with those of the host galaxy.

The S7: The Siding Spring Southern Seyfert Spectroscopic Snap-shot Survey

The Australian National University 2.3m telescope at Siding Spring Observatory.

S7 project aims to investigate the physics of nearby active galaxies by studying the morphology, kinematics, excitation and abundance structure of about 120 nearby AGNs. The main component of this investigation involves a spectroscopic survey with an Integral Field Unit called WiFeS (Dopita+ 2007) which is mounted on the 2.3m Australia National University telescope at Siding Observatory. An integral field unit obtains spatially resolved spectra of the sky, i.e., a spectrum for every pixel of the two-dimensional image of an extended object in the sky, thus giving a "data-cube" (cf figure, right) with two spatial dimensions and one wavelength dimension, from which the abundances as well as the kinematics of the extended ionisation regions can be derived. The sample of AGN for the survey was selected from the Veron-Cetty & Veron Catalogue of AGN, which is the most comprehensive compilation of known AGN. They were filtered by:

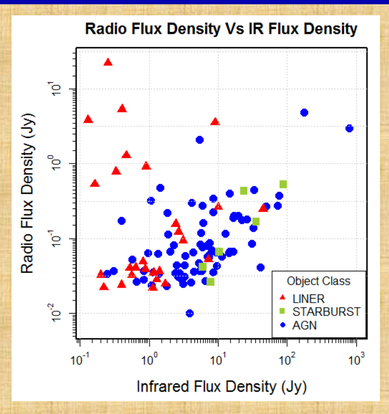


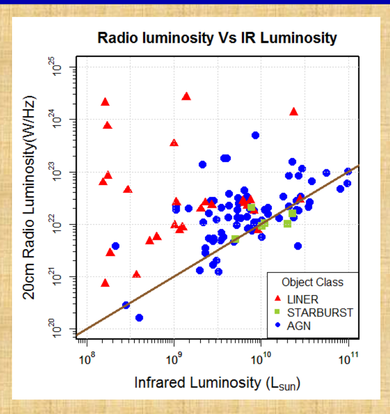
- Declination < 10 ˚ North – Accessible from Siding Spring Observatory
- Galactic Latitude |bII| > 10 ˚ – For most galaxies in order to reduce the Galactic extinction effects
- Redshift < 0.02 – to obtain several spatial beam elements across the galaxy, and to have the SII line in WiFeS spectral range
- Radio flux density >20mJy – To enable radio imaging follow-up (for dec<-40 objects that lacked measurements radio detectabilty was used)

Status of the Survey

- Of the 127 galaxies in our sample, about 80 have been observed with WiFeS on the Siding Spring 2.2m telescope.
- Summary results for 60 of them have been published in Dopita+(2015) in addition to detailed studies of individual galaxies (Dopita+14, Dopita+15, Schaerwachter+15)
- The first data release from the survey is available
- Follow-up observations at radio wavelengths are underway with the Australia Compact Telescope Array (ATCA) & GMRT *(cf accompanying poster presented by P. Muralimohan)*

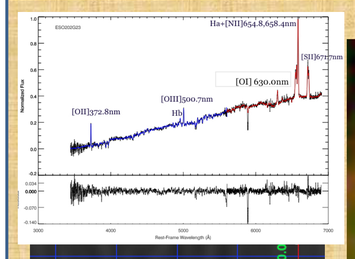
The Radio-IR correlation for the sample

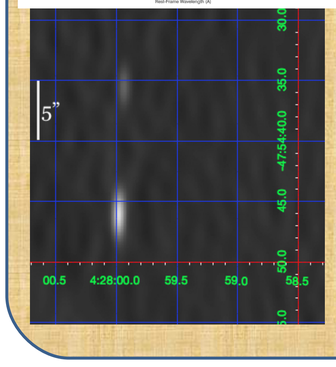


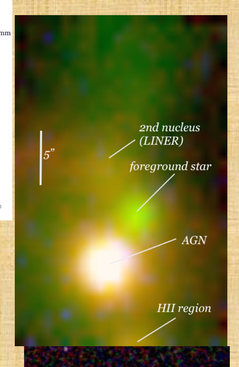


Left panel: The 1.4GHz radio flux density plotted against the 60micon IRAS flux density: at low IR flux densities, our radio flux density cut-off of 20mJy is evident. The galaxies in the AGN catalogue that were found to be star bursts from our WiFeS spectra are shown in green. Right panel: The 1.4GHz luminosity vs the 60micron luminosity. The black line represents the standard radio-infrared correlation for star-forming galaxies (e.g., Dopita 2005). For several galaxies, the 1.4GHz emission and the 60micron emission are from star-forming regions. The morphological data are consistent with this trend: many of the 1.4GHz features in the radio images are associated with high Hα + NII emission. However, a majority of the sample show a significant radio excess which is clearly associated with the AGN, with extreme excess objects being the "radio-loud" AGN of the sample with high kinetic power radio jets.

ESO202-G023: The Carafe Galaxy

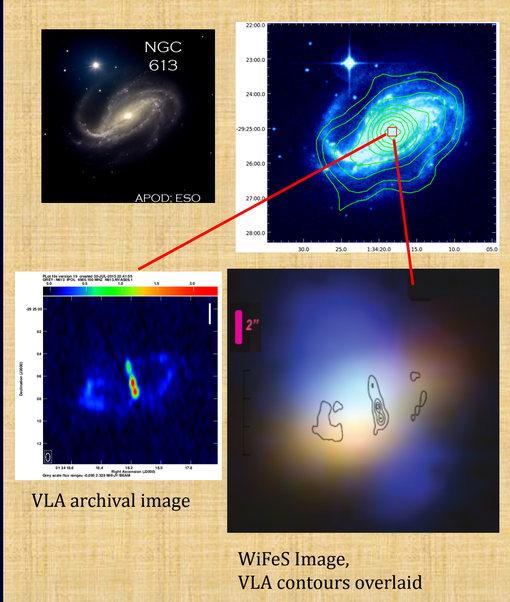






ESO202-G023 also known as the Carafe Galaxy is a galaxy so named because of its "carafe-like" appearance in optical images. (2MASS image, bottom right panel). Our WiFeS image (top right panel) shows the [OIII] emission in blue, red continuum+Hα+NII and [NII] line only in green. The central region of the galaxy was found (e.g., Rifatto+2001) to contain two nuclei which are seen in our WiFeS data though the 2nd nucleus is barely visible. A foreground star is visible to the North-west of the brighter nucleus. The HII region observed by Rifatto+2001 is also seen. A preliminary integrated nuclear spectrum is shown (above, right), with the emission lines labeled. Our preliminary ATCA image at 5.5GHz (left panel below) shows both nuclei to be radio emitters (~4mJy and ~0.9mJy, respectively).

NGC 613



VLA archival image

WiFeS Image, VLA contours overlaid

NGC613 is a barred spiral galaxy (VLT image top left) with a weak inner ring of star formation. The 1.4GHz radio contours from the NVSS survey (green) overlaid on the optical image (top right) clearly show that the elongated structure of this radio emission follows the stellar distribution. Hummel+(1987) had shown that inner brighter radio emission was linear (archival VLA image, left). At bottom right is our WiFeS image showing the [OIII] emission (colour-coded blue) and the Hα+NII emission (colour-coded gold). The inner radio structure is shown overlaid (black contours). The Hα+NII emission appears to have a ring-like structure aligned with the bar of the galaxy and the large-scale radio emission, and has associated diffuse radio emission with a steep radio spectrum, as is expected of star-forming regions. The very inner radio structure is linear, suggestive of jets from the AGN, and is aligned with the double-lobed [OIII] emission that forms a rather spectacular Extended Narrow-line Region.

Summary

- We are investigating a sample of 127 nearby active galaxies which is primarily driven by a spectroscopic survey using an integrated field unit.
- We have obtained data cubes in the optical wavelength range with a typical seeing of 1"-2".5 for over 60% of our sample
- The spectral resolution of the data, R is ~3000 (blue) and 7000 (red)
- Our first data release is available at *http://miocene.anu.edu.au/priv/S7DR1/*
- Our sample objects were selected to enable follow-up radio imaging in order to investigate the connection between the synchrotron emitting radio jets from the AGN and star formation in the nuclear environment, which has bearing on the observation that the growth of the central supermassive black hole and that of the galaxy go hand in hand.
- From our observations so far nearly all the Seyfert galaxies have an extended emission-line region, often within a starformation ring of a few kpc across, which may be interpreted as the Inner Lindblad Resonance.
- When our spatial resolution is sufficient, we see the Narrow-line region showing elongated and sometimes biconical morphology, aligned with the inner radio jet.

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