The Interplay among Black Holes, Stars and ISM in Galactic Nuclei
Proceedings IAU Symposium No. 222, 2004
T. Storchi-Bergmann, L. C. Ho & H. R. Schmitt, eds.

DOI: 10.1017/S1743921304002595

On the radio continuum, molecular gas content and optical emission of Markarian galaxies with Seyfert nuclei

Dalia S. Reichert, Everton Lüdke and Rogemar A. Riffel

Universidade Federal de Santa Maria, CCNE - Departamento de Física - LARIE, Campus Universitário, 97150-900 Santa Maria RS, Brazil

Abstract. In this paper we interpret C and X-band radio continuum observations of a sample of Markarian galaxies. The results are briefly discussed. Seyfert 2 galaxies show sistematically higher HI mass-to-blue magnitude than Seyfert 1 galaxies, as well as higher radio to far-infrared luminosities. The observational properties are interpreted in terms of simple non-thermal and dust emission. We obtained radio brightness temperatures, equipartion magnetic fields and total magnetic densities for the disks. Upper limits for thermal densities are derived from simple free-free emission. Star formation rates and mean supernova rates are estimated for individual Markarian galaxies. The SFR values of the most luminous Markarian galaxies are considerably higher than those found in compact blue dwarf galaxies and also in gas-rich, early-type spirals.

1. Introduction

The observed radio continuum of Seyfert galaxies normally appears as a mixture of several components, mostly a power-law continuum extending from the infrared to soft X-rays with a similar relationship holding at centimetre wavelengths (Osterbrock 1991). The ultraviolet emission can usually be explained as dissipation of thermal energy, due to an accretion disk near the massive black hole. The main parameters is the black hole mass and the mass accretion rate, which would determine the amount of radiation emitted by the central engine, namely the optical and infrared luminosities.

In this paper we investigate correlations among other integrated quantities, such as the total neutral hydrogen content, the ratio of the CO luminosity to the H_α and infrared luminosities for a large sample of Seyfert galaxies from the Markarian catalog.

2. Compilation of the data

We compiled a list of Markarian galaxies hosting Seyfert nuclei from a variety of sources. ^{12}CO(J=1-0) line emission is available for samples of distance-limited Seyfert galaxies belonging to the markarian class, mostly by Maiolino et al. (1997) and Vila-Vilaró et al. (1998), as well as 8.4, 5 and 1.4 GHz radio continuum images from the Very Large Array archives, Ulvestad & Wilson (1984) and the NRAO/NVSS survey, as well as published data with the Owens Valley Radio Observatory (Israel, Seielstad & Berge 1988). Neutral hydrogen observations were taken from published surveys made with the Arecibo radio observatory, the Effelsberg radio telescope and with the late NRAO 301-ft telescope, as well as from published surveys (Mirabel & Wilson 1984).

3. Discussion and conclusions

Bohrer-Adornes et al. (2004) found a trend among the total neutral hyrogen content and the 21-cm radio continuum emission for southern galaxies, and the 21-cm radio

continuum luminosity versus far-infrared luminosity. We investigate this result for our sample and confirm a trend with a slope similar to the one found by these authors. We also found a relationship between the total infrared emission and the HI content. From the available data on the nuclear H_α and neutral hydrogen luminosities of the Markarian galaxies, we found a clear trend among these quantities. The data also distributes well in a good trend among the CO line luminosities and the HI line luminosity, whereas a clear connection between the CO and the far-infrared emission is evident, as previously pointed out by Vila-Vilaró et al. (1998).

It is important to point out the nature of each emission mechanism: (a) The HI line emission is associated with the neutral gas envelope surrounding the optical disk and therefore is more related to the primordial gas content in the early stages of galactic disk evolution than the present-day activity, (b) The total mass of CO is associated with the amounts of interstellar matter chemistry in the warm gas, released from the cumulative stellar ejecta during the evolution of the active galaxies. In fact, some authors were able to link the dynamical properties of the inner CO disk to those of the outer HI disk in small samples of nearby spiral galaxies, using a single galaxy rotation profile. (c) The H_α luminosity, 21-cm radio continuum and the IR continuum luminosities are direct indicators of AGN activity, as they show temporal variations in a timescale of a few years. Of course we could not expect a relationship among such different quantities but the trends found in this work help to corroborate the nature of AGN activity in Markarian galaxies.

A quick analysis of selected galaxies with 5 GHz and 8.4 GHz observations, made with the Very Large Array, shows jets of radio emission with projected angular sizes of about 0.5-2.8 kpc. The jet radio emission of selected Markarian galaxies also correlates well with the HI radio emission, but the available data comprises only a dozen objects, which is too few to produce significant statistics.

We suggest that the present-day activity in active galaxies is due to the initial neutral Hydrogen mass content of early-type galaxies, which produced the modern-day AGNs. The trends discussed here help to corroborate such a scenario. In addition, star formation rates and mean supernova rates have also been estimated for individual Markarian galaxies. The SFR values of the most luminous Markarian galaxies are considerably higher than those found in compact blue dwarf galaxies and also in gas-rich, early-type spirals.

We expect that the Atacama Large Millimetre Array (ALMA), the southern VLBI array and the GEMINI telescopes to be very helpful in allowing more accurate measurements for detailed theoretical modelling.

Acknowledgements

FAPERGS, CAPES and CNPq/Brazilian Government are acknowledged for research. The IRAS Point-Source Catalog and the NASA Extragalactic Database have been used in this work. The VLA is operated by the NRAO under contract with the NSF.

References

Israel, F. P., Seielstad, G. A., & Berge, G. L. 1988, A&A, 189, 7
Maiolino, R., Ruiz, M., Rieke, G. H., & Papadoupolos, P. 1988, ApJ, 485, 552
Mirabel, I. F., & Wilson, A. S. 1984, ApJ, 277, 92
Osterbrock, D. E. 1991, Rep. Prog. Physics, 54, 579
Ulvestad, J. S., & Wilson, A. S. 1984, ApJ, 278, 544
Vila-Vilaró, B., Taniguchi, Y., & Nakai, N. 1998, AJ, 116, 1553