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/S1743921304002601

Millimetric radio continuum investigations of active galaxies with the BIMA array

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Abstract. In this paper we present some preliminary results of a 3-mm (86 GHz) radio continuum survey of selected Seyfert galaxies made with the Berkley-Maryland Illinois Millimeter Array (BIMA) in D configuration. The images shown here have spatial resolutions of about two arcminutes after gaussian tapering. At this observing wavelength, we expect to have a negligible non-thermal emission as the spectra is certainly dominated by free-free radio emission. We have measured flux densities and 3 mm luminosities which agree with a thermal blackbody spectra expected from data obtained with the IRAS satellite at wavelengths shorter than 80 μm. Data is presented for NGC3982, NGC5597, NGC5253, NGC1667, and NGC2997 and the main astrophysical consequences of such studies are discussed in this poster. We also argue that radio continuum at millimeter wavelengths is a better observational tool to study the star-formation in active galaxies than conventional infrared photometry.

1. Introduction

Recent molecular line observations of Seyfert galaxies include those from single-dish millimetre observations of CO and HCN lines at 3 and 1 mm wavelength (Curran 1998). In fact, Seyfert 2 galaxies show higher L_{CO}/L_B ratios than Seyfert 1 galaxies, reaching about three times the values found for non-active galaxies (Heckman et al. 1989). In addition, millimetre line observations are useful to study the Seyfert phenomena, since molecular rings do exist in Seyfert galaxies (Myers & Scoville 1987; Irwin & Sofue 1998; Bergman et al. 1992; Miyoshi et al. 1995). Previous BIMA observations show the molecular gas, i.e. HCN and CO emission, concentrated around the active nucleus (Helfer & Blitz 1997; Helfer & Blitz 1995; Helfer & Blitz 1993) and that the molecular ring is mostly aligned with the galactic disk seen in H_α plates (Mcleod & Rieke 1995; Maiolino & Rieke 1995), which is particularly true for the powerful Seyfert 2 galaxy NGC4945 (Ott et al. 2001). The molecular gas content is also related to other important observational properties of Seyfert galaxies (Reichert et al. 2004).

In this work, we observed selected Seyfert galaxies and the archetypical starburst NGC5253 to look for relationships among the millimetre and infrared radio continuum properties, to look for alternatives to the standard infrared photometric method to probe star-formation in AGNs.

2. The BIMA Observations

The BIMA observations have been made with the shortest baseline configuration (D-array) with maximum baseline length of 8900 kλ. The on-source observing time was about 6 hours, carried out in a single track, on 25th July 1999.

The primary amplitude and bandpass calibrators were Mars and 3C273, the latter with a flux density of 22.5 Jy at 3.5 mm. 3C454.3 was also used as a control amplitude calibrator with a derived flux density of 7.2 Jy. An 830-MHz wide continuum channel has

also been recorded to produce the 3 mm image , which was strong enough to be used to self-calibrate de visibilities. The atmospheric absorption was strong for southern galaxies with T_{sys} reaching 380 K, but the data could be self-calibrated even in such conditions.

Data calibration (amplitude, phase and bandpass) were performed using standard procedures with the ATNF Miriad software. The calibrated data has been transported to the NRAO AIPS package for self-calibration and imaging. A uniform weighting scheme has been used with a gaussian taper of 400 $k\lambda$, to produce the final images with a circular restoring beam of $200''$ so that they can be compared with available images obtained with the HST and various large optical telescope.

3. Discussion and conclusions

Our BIMA images and the IRAS spectral data for individual objects are available upon request. We see that the 3-mm luminosities are lower, since the non-thermal contribution from the active nucleus and the interstellar matter vanishes at such short wavelength, and the thermal gas plus dust is actually detected. Hence, at millimetre radio window, we expect to have a negligible non-thermal emission as the spectra is certainly dominated by free-free radio emission with a contribution from the warm dust heated by stellar clusters.

A clear trend among the galaxies in which the 21-cm and far-infrared luminosities do correlate (Condon et al. 1991 see also Bohrer-Adornes & Lüdke 2004 for recent ATCA observations of Seyfert galaxies). The data also suggests a positive correlation between L_{3mm} and L_{IR} quantities. Therefore we present the preliminary result that the L_{3mm} luminosity is a better indicator of the star formation than the available infrared data. Of course, further observations must be carried out to pursue better statistics.

Finally, we conclude that radio continuum imaging at millimeter wavelengths is a better observational tool to study the star-formation in active galaxies than conventional infrared photometry, since modern radioastronomical techniques provide spatial resolutions of about $100''$ or less, allowing to probe the inner 100 pc field around the active nuclei in Seyfert galaxies.

Acknowledgements

The BIMA radio observatory is a consortium among University of Maryland, University of Illinois and UCLA on behalf of NSF, USA.

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