Supplement to J. Astrophys. Astr. (1995) **16**, 273–274

Radio Recombination Lines from External Galaxies

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Abstract. Using the Very Large Array[1] and the Australia Telescope we have searched for the H92α recombination line from 14 external galaxies and detected the line in 9 of them. All the detected galaxies have starburst nuclei and the line emission is only from the nuclear region. No line was detected in two well known Seyfert II galaxies that were searched to similar sensitivity levels.

Key words: Galaxies; starburst, Seyfert II—Radio recombination lines.

1. Introduction

For almost 14 years after the first detection of recombination lines (RRLs) from two external galaxies (M 82 and NGC 253) beyond the Magellanic clouds (Shaver, Churchwell & Rots 1977; Bell & Seaquist 1978), there were no further detections of RRLs inspite of several searches using large single dish telescopes. The next detection came in 1991 from the galaxy NGC 2146 (Puxley *et al.* 1991). Taking advantage of the high sensitivity (noise level $\sim 100\,\mu$Jy) and spectral dynamic range (better than 1:5000) achievable with modern synthesis telescopes such as the VLA and AT, we have begun a renewed search for RRLs from external galaxies.

2. Observations and results

Observations were made during October 1990 and again in February 1992 when the VLA was in the C configuration, which gives an angular resolution of $\sim 2''.5$ at 8.4 GHz. More recently (July 1993) we observed a few southern galaxies using the AT compact array in its 750D configuration which gives a resolution of $\sim 10''$. The recombination line was detected at the level of 0.25–3.5 mJy from the nuclear region of 9 galaxies. The line widths are in the range 200–400 km s^{-1} (FWHM). Line emission extends over a region of up to 10″ which corresponds to linear dimensions of a few hundred parsecs. The detected galaxies are NGC 3628, IC 694, NGC 3690, NGC 1365,

[1] VLA is a part of NRAO which is operated by Associated Univ. Inc., under a cooperative agreement with the NSF.

Arp 220, M 83, NGC 2146, NGC 4945, and the Circinus Galaxy. The strongest line is towards NGC 4945 and the weakest is from NGC 3690 (a companion of IC 694). The line was not detected in five other galaxies (NGC 262, NGC 1068, NGC 1808, NGC 6240 and NGC 3079) that were observed to a similar sensitivity level.

3. Nature of the ionized gas

The ionized gas that produces the observed H92α line must satisfy an important constraint. In all the galaxies detected with the H92α line, the radio continuum in the nuclear region has a non-thermal spectrum. The dominant non-thermal flux density in the nuclei implies that the thermal emission from the ionized region must only be a small fraction of the observed continuum flux density. This constraint rules out models with a uniform slab of ionized gas in front of the non-thermal source. However a collection of dense HII regions within the central few hundred parsecs of the galaxy can explain the observed lines. Such a model appears reasonable for a starburst nuclear region, where the HII regions could be created by the young stars born during one or more episodes of starburst and the non-thermal radiation originates in a large number of supernova remnants. Several hundred HII regions of a few parsecs in size and density of $5-10 \times 10^3\,\mathrm{cm}^{-3}$, with a total mass of a few times $10^5\,M_\odot$ are required to account for the observed line flux density. The rate of production of Lyman continuum photons required to maintain the ionization is a few times $10^{54}\,\mathrm{s}^{-1}$. Much of the line emission comes from internal stimulated emission due to the continuum generated within the HII regions which account for 5–30% of the observed total continuum at 5 GHz. Results for three of the detected galaxies and model calculations are presented in Anantharamaiah *et al.* (1993).

References

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