THE H II REGIONS OF M31

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Abstract. The luminosity of the brightest H II regions of M31 was determined with the NRAO 3-element interferometer at 3.7 cm and 11 cm wavelength. It is unlikely that M31 has any superbright H II regions such as W51 or W49; our Galaxy has between 10 and 20 H II regions that are more luminous than any in M31.

The great nebula in Andromeda, M31, is often thought of as a model for our own Galaxy, and even though there is evidence that the two systems are dissimilar, quantitative data on the differences is sparse. The occurrence of giant H II regions is related to spiral type, and as a rule the most luminous H II regions occur in the later spiral types, S_c and Magellanic Cloud-type irregulars. In order to provide a quantitative measure of the luminosity of the H II regions in M31 compared to those of our own Galaxy, a study was undertaken with the NRAO 3-element interferometer to determine the luminosity of the brightest H II regions of M31.

A complete synthesis was made of five fields using all available interferometer spacings, at both 3.7 cm and 11 cm wavelength. These five fields each include a known 5C3 source. In addition a 'quick look' synthesis of 29 fields was performed using tle single antenna configuration that gave spacings of 900, 1800, and 2700 m baselines. The catalog of Baade and Arp (1964) was used as a finding list of H II regions for comparison with the radio data.

The five 'complete synthesis' fields included the nuclear region, 5C3.97, 5C3.126, 5C3.141a, and a field partly displaced from 5C3.97. Only one example was found of a coincidence between a visible H II region and a radio source, the coincidence being close for Baade and Arp's Source 298, which agrees in position with a 4 mJy source at 11 cm.

For purposes of comparison with our own Galaxy, the surveys of Reifenstein *et al.* (1970) and of Wilson *et al.* (1970) can be used to estimate the appearance of the H II regions in our Milky Way Galaxy if they were at the distance of M31. The flux of W49 would be 25 mJy, and W51, M17, and M42 would exhibit fluxes of 13, 5, and 0.25 mJy, respectively.

In our own Galaxy there are at least seven H II regions whose flux would exceed 10 mJy, and more than 22 would exceed 2.1 mJy. The complete synthesis fields found only one source that might be an H II region, of the 167 H II regions in the fields, and that one is not as luminous as M17.

The 'quick look' synthesis of 29 fields was not as sensitive, but only seven sources stronger than the 3σ level were found, and none of them were found to coincide with catalogued H II regions. The 3σ sensitivity limit varied from field to field, but in most cases varied between 9.5 and 10.5 mJy. Seven fields had 16.5 mJy 3σ-limits.

F. J. Kerr and S. C. Simonson, III (eds.), Galactic Radio Astronomy, 229–231.

We conclude, therefore, that it is most unlikely that M31 has *any* superbright H II regions such as W51 or W49, and while it is possible that a few of the sources are in the M17 class, it appears probable that our Galaxy has between 10 and 20 H II regions that are more luminous than any in M31.

The lack of very bright H II regions in M31 has two important implications:

(1) It is strong evidence that our Galaxy is considerably later in spiral type (and probably considerably smaller) than M31, and

(2) The use of H II regions as distance indicators for distant galaxies is a method that may be subject to order-of-magnitude errors, if it is applied without certain knowledge of the expected H II-regions luminosity class in a given galaxy.

References

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DISCUSSION

Wielebinski: On an 11-cm continuum map made by Berkhuijsen and myself with the 100-m telescope we find that spectrum in the direction of clumps of optical H II regions is less than the spectrum elsewhere in the spiral arms. In fact, three radio sources in the direction of optically detected groups of H II regions have nearly thermal spectra. These sources are 5C3.98, 5C3.77 and 5C3.94. The conclusion of Burke that there are no giant H II regions in M31 of the type W49 or 30 Doradus is correct, since they would be seen as single strong point sources on our map.

Baldwin: What is the total flux density of the sources associated with H II regions in M33? From the spectrum of the total flux density it seems likely that the thermal component is quite small.

Habing: The flux is mostly nonthermal. The amount of thermal flux is very uncertain, but it is small.

Van Woerden: In M101, Allen, Ekers and Goss find several H II regions (or rather *complexes*) which, at the distance of M31 or M33, would have a flux of about 1000 mJy. These complexes have sizes of the order of 1000 pc and masses $\sim 10^7 \ M_\odot$.

Habing suggests that the whole radio flux from M33 could be thermal. Do none of the sources found have nonthermal spectra? One should expect to find remnants of type II supernovae.

Habing: The study of M33 by Israel and van der Kruit is based on a map at only one frequency (1415 MHz). A second map at 5 GHz is in preparation. It can be used to sort out nonthermal sources and its use could lead to identification of some supernova remnants.

Price: What is the distribution in radius of the bright H II regions with respect to the center of M33?

Habing: The largest surface density of H II regions is between 1 and 2 kpc from the center. Within 1 kpc the data are unreliable; beyond 2 kpc there is a very clear decrease in the surface density.

Greenberg: Would you be willing to conjecture that the lack of nonthermal emission in M33 could be used to imply that there is no magnetic field to produce synchrotron radiation from relativistic electrons and that – going very far indeed – the lack of continuous arms is a result of this lack of magnetic field?

Habing: You just phrased a nice speculation.

Mathewson: I would urge that Northern Hemisphere observers should, by narrow band photography, determine the ratio of S II/Hα in these H II regions to detect supernova remnants. This technique has been used successfully by Clarke and myself in the Magellanic Clouds, where we have detected 15 SNR.

Mezger: Optical observers of H II regions in external galaxies quote sizes ranging from 50 to 200 pc. Radio observations in our Galaxy never show H II complexes of such large dimensions, with the exception of the extended region in the Galactic center. Do your radio observations of H II regions in M33 yield sizes which are comparable with the optical dimensions?

Habing: In this study the dimensions the authors used were derived from the photographic plates. If the optical sizes of H II regions in other galaxies are indeed larger than in our Galaxy, as you suggest, then this is perhaps caused by blending. Complexes of H II regions are quite common in our Galaxy.

Mills: The Magellanic Clouds are other examples in which emission of giant H II regions is detected. These agree perfectly in position with the optical regions and fit smoothly on to the top-end of the galactic distributions with larger sizes and lower mean electron densities.