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Ionized Gas in Bright Barred Spiral Galaxies: Hα Images

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Abstract. In this paper we present the spatial distribution of ionized hydrogen gas, Hα, in a set of 52 bright barred Shapley-Ames spiral galaxies. In summary we were able to detect Hα line emission from distinct regions in the galaxies as from compact nuclei, from circumnuclear rings, from the bar, from ends of bars, from inner rings, from spiral arms, from outer rings and from places or structures perpendicular either to the bar or to the spiral arms.

1. Introduction

Recent observations of radio continuum emission from bright barred galaxies suggested that galaxies with flat spectral indices have $T_d \geq 30$ K (Garcia-Barreto et al. 1993) confirming previous statistical work by Hawarden et al. (1986) who suggested that barred spiral galaxies presented higher fluxes of far-infrared and radio continuum emissions from their central regions. Detailed studies of barred spiral galaxies like NGC 613, NGC 1097 (Hummel et al. 1987a, b), NGC 1326 and NGC 4314 (Garcia-Barreto et al. 1991a, b) have revealed the existence of circumnuclear structures, commonly referred to as nuclear rings. These are places of density enhancement undergoing vigorous star formation as a by-product. We have chosen Hα line emission as a tracer of ionizing photons in order to detect more examples of such nuclear rings or in general, symmetric structures in barred spiral galaxies. The most likely origin of symmetric structures, like nuclear, inner, and outer rings, is galactic dynamics in the presence of a non-axisymmetric gravitational potential such as a bar (Lindblad 1958, Contopoulos 1980, Schwarz 1981, 1984, Athanassoula 1984, Contopoulos & Grösbol 1989).

2. Data Set and Observations

Our data set consists of 52 barred spiral galaxies selected with the following selection criteria: a) they are bright galaxies from the Shapley Ames catalog; b)

they have IRAS colors indicative of star formation ($\log f(60\mu)/f(100\mu) \geq -0.3$ and $\log f(12\mu)/f(25\mu) \leq -0.2$) and or having dust temperature $T_d \geq 25$ K; c) with declination in the range $-41° \leq \delta \leq 65°$; d) different Hubble types.

The observations were done at the San Pedro Martir Observatory in Baja California, Mexico using the 2.12 m f/7.5 optical telescope with a CCD detector 1024 × 1024 pixels under good seeing conditions in 1992 June and in 1993 December. We took images with broadband filters I ($\lambda_c \simeq 8040$Å) and R ($\lambda_c \simeq 6340$Å) and with narrow band filters around Hα: ($\lambda_{l+c} \simeq 6607$Å) and ($\lambda_c \simeq 6459$Å). The final images were bias-subtracted and flat-fielded with the NOAO-IRAF software at our institute at UNAM. The Hα line+continuum and Hα continuum emission images were 300 sec of exposure time. The final Hα images were obtained by subtracting the continuum. The subtraction was done after the position of field stars were determined. After the subtraction, the field stars disappeared almost completely. The image scale was 1:1 for the subtraction. No amplitude calibration was performed in any of the images. The images were deconvolved with an algorithm based on a polynomial transform in order to have better signal to noise ratio (Escalante-Ramirez & Martens 1992).

3. Results and Discussion

Our main goal was to determine the spatial distribution of the ionized gas in the galaxies. Our results, dependent upon the individual signal-to-noise ratio of each Hα image, can be summarized as follows:

- 32 galaxies presented Hα emission from the compact nucleus, for which we mean within the inner 5″; 5 are SBa, 1 SBab, 7 SBb, 8 SBbc, 9 SBc and 1 SB (late). Twelve out of the 32 have Hα along their bars and 8 are X ray emitters and have $T_d \geq 30$ K,
- 10 galaxies showed Hα emission from circumnuclear structures or nuclear rings; 3 are SBa, 6 SBb and 1 SBbc,
- 18 galaxies presented Hα along their bars, 13 of which are SBbc, SBc or SB (late),
- 18 galaxies presented Hα emission from regions at the ends of bars,
- 9 galaxies presented Hα emission from regions just around the stellar bar, possibly from the so called inner-rings,
- 26 galaxies showed Hα emission from normal spiral arms or HII regions in the disk,
- 3 galaxies showed Hα emission from probably outer rings; they are SBa, SBb and SBc Hubble types,
- 9 galaxies presented Hα emission from regions or structures that were, on the plane of the sky, perpendicular to either normal spiral arms or the stellar bar.

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Is there any correlation between Hα distribution, Hubble type, galactic dynamics, and/or environment? We found that galaxies presenting circumnuclear rings were all early types. This result could be considered normal since early type galaxies have a higher central density concentration and possibly favor the development of x_2 orbits (Athanassoula 1992). Eleven galaxies are SBa but in none of them was Hα detected along their bars, that is, either gas is not present or it was already transferred to the inner regions. Thirty two galaxies of early and late Hubble types presented Hα from their compact nuclei, that is, gas transfer is highly efficient in these cases either by galactic dynamics alone, by an external mechanism (tidal and/or ram pressure) or by a combination of mechanisms since 8 of them are X-ray emitters. In this respect, for example, NGC 4314, an SBa with a circumnuclear ring, has been found to have an extreme deficiency in HI, possibly as a result of interaction of the galaxy with an intragroup medium (Garcia-Barreto, Downes, & Huchtmeier 1994). Last but not least, most of the circumnuclear rings were found to be misaligned with respect to the stellar bar with ΔP.A.$\geq$60°.

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References

Athanassoula, E. 1984, Phys. Rep., 114, 319

Athanassoula, E. 1992, MNRAS, 259, 328

Contopoulos, G. 1980, A&A, 81, 198

Contopoulos, G. & Grösbol, P. 1989, A&AR, 1, 261

Escalante-Ramirez, B. & Martens, J-B. 1992, Journ. Visual Comm. & Image Repres., 3, 272

Garcia-Barreto, J. A., Carrillo, R., Klein, U., & Dahlem, M. 1993, Rev. Mex. Astron. Astrof., 25, 31

Garcia-Barreto, J. A., Dettmar, R.-J., Combes, F., Gerin, M., & Koribalski, B. 1991a, Rev. Mex. Astron. Astrof., 22, 197

Garcia-Barreto, J. A., Downes, D., Combes, F., Gerin, M., Magri, C., Carrasco, L., & Cruz-Gonzalez, I. 1991b, A&A, 244, 257

Garcia-Barreto, J. A., Downes, D., & Huchtmeier, W. K. 1994, A&A, 288, 705

Hawarden, T. G., Mountain, C. M., Leggett, S. K., & Puxley, P. J. 1986, MNRAS, 221, 41

Hummel,E., Jörsäter, S., Lindblad, P. O., & Sandquist, A. 1987a, A&A, 172, 32

Hummel, E., van der Hulst, J. M., & Keel, W. C. 1987b, A&A, 172, 32

Lindblad, B. 1958, Stockholm Annaler, 20, 6

Schwarz, M. P. 1981, ApJ, 247, 77

Schwarz, M. P. 1984, MNRAS, 209, 93

Discussion

B. Elmegreen: Are nuclear ring starbursts usually patchy with just a few hot spots? What fraction have a smooth distribution of star formation?

J. Garcia-Barreto: Eight out of 10 circumnuclear structures seem to be formed by a few hot spots. Possibly only NGC 5728 and NGC 5430 have either smooth central Hα or very small hot spots.

A. Barth: Did any galaxies show nuclear rings in continuum filters but not in Hα?

J. Garcia-Barreto: We obtained images with broadband I and R filters but we did not obtain any IR images. So I cannot tell you an answer. Certainly if we obtain an IR image for a galaxy with a circumnuclear Hα ring, there probably would appear a similar structure. The answer is we only identified circumnuclear structures from our Hα images.

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