Acknowledgments. We would like to thank L. Tresse, C. Lobo, S. Arnouts, A. Boselli, for their help.

References

C. Adami et al., 2000, A&A 353, 930

C. Adami et al., 1998, A&A 334, 765

G.M. Bernstein et al., 1995, AJ 110, 1507

A. Biviano et al., 1995, A&A 297, 610

Calcáneo-Roldán, C., Moore, B., Bland-Hawthorn, J., Malin, D., & Sadler, E.M. 2000, MNRAS, 314, 324

Diafero et al., 2000, iap2000 proc. in press

J.G. Godwin and J.V. Peach, 1977, MNRAS 181, 323

Gregg, M.D., & West, M.J., 1998, Nature, 396, 549

C. Lobo et al., 1997, A&A 317, 385

N. Metcalfe et al., 2000, MNRAS in press

H.J. Rood, 1969, ApJ 158, 657

J. Secker et al., 1997, ucb proc. 115S

Trentham, N., & Mobasher, B. 1998, MNRAS, 293, 53

Nuclear star formation in the hot-spot galaxy NGC 2903

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Introduction

Circumnuclear regions (CNR) of enhanced star formation (SF) in disk galaxies are usually associated with the presence of stellar bars. Since bars are believed to be one of the most effective mechanisms for transporting material into the central regions of galaxies, CNRs are excellent laboratories for the study of the effects of inflow processes on the triggering of SF (see Knapen 1999 for a review on the subject).

We have obtained high angular resolution near-infrared (NIR) adaptive optics (AO) and HST/NICMOS imaging, and NIR spectroscopy of the hot-spot galaxy NGC 2903. The presence of a bar in this galaxy has been inferred from NIR, Hα and CO observations. Early studies of this galaxy showed that there is enhanced SF within the complex hot spot morphology in its CNR (Wynn-Williams & Becklin 1985; Simons et al. 1988). These works however, lacked the necessary spatial resolution to determine whether the SF was confined to these hot spots or not. Throughout this paper we will assume that NGC 2903 is at a distance of 8.6Mpc.

Observations

A K'-band image of the central region of NGC 2903 was obtained on October 25, 1998 with the Canada France Hawaii Telescope (CFHT), equipped with the AO system PUEO and the KIR camera. The images were reduced following standard procedures. We estimate that the natural seeing of 0.6" at the time of the observations was improved to a resolution in the final image of approximately 0.25". The final field of view of the reduced image was 46" x 46". Archival *HST* / NICMOS images of NGC 2903 through the NIC2 F160W (H-band), NIC3 F160W and NIC3 F187N (Paα + continuum at 1.87μm) filters were also obtained.

Long-slit spectroscopy of the central regions of NGC 2903 was carried out using CGS4 on the United Kingdom Infrared Telescope (UKIRT). Using the PUEO K' image, the slit was placed at five different locations to obtain spectra of the nucleus, a number of hot-spots and the background stellar continuum.

Results

Early studies of NGC 2903 at a lower spatial resolution than the present work found that there was little correspondence between the optical, NIR and radio morphologies of this galaxy (Wynn-Williams & Becklin 1985; Simons et al. 1988). Although it was recognized that enhanced SF is currently occurring in this galaxy, the effects of young and old stellar populations, gas and dust were not well understood. The high resolution PUEO K' image (Fig.1, left panel) resolves the previously known NIR hot spots into a large number of individual stellar clusters or groups of these. The NICMOS Paα emission line map (not shown here, see Boeker et al. 1999 and Alonso-Herrero et al. 2000a) reveals a large number of HII regions (also known from ground-based Hα imaging, see Planesas et al. 1997), arranged in a ring-like morphology with a diameter of approximately 625pc. The bright NIR stellar clusters, although located close to the HII regions, are not coincident with them. We carefully aligned the NICMOS Paα and the radio images of Wynn-Williams & Becklin (1985) and found a good overall correspondence. The main peaks detected in their 2cm radio image are clearly identified with HII region emission in the ring of SF. This is in good agreement with the fact that a significant fraction of the radio emission in this galaxy is free-free emission from HII regions.

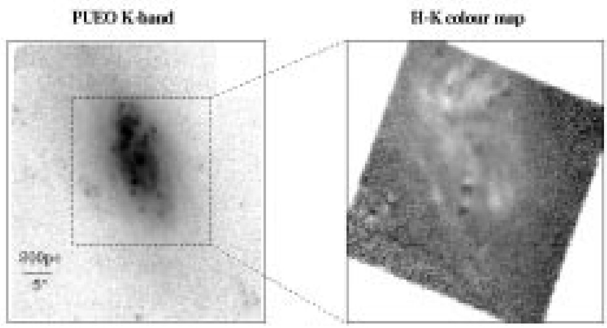

Figure 1) *Left panel:* PUEO AO K-band image of NGC 2903 on a logarithmic scale. The field of view is 46" x 46". Orientation is north up, east to the left. *Right panel:* Close-up of the central regions showing the m_{F160W} - K' (equivalent to a ground-based H-K') colour map. This colour map was constructed using the NIC2 F160W and the PUEO K-band images. Dark colours indicate regions with high extinction. The m_{F160W} - K' colour map is displayed from 0.1 to 0.8mag. The field of view of the image is 22" x 22".

The right panel of Fig.1 is a close-up (22” x 22”) of the central region showing a m_{F160W} - K’ colour map that traces mainly the extinction to the stars. Although the morphology of the obscuration appears very complex, a detailed analysis yields values of the NIR extinction (both to the stars and the gas) relatively modest (H-band extinction of up 1.6mag).

Both the spectroscopic and photometric information available for the stellar clusters are a valuable tool to constrain their SF properties. We have compared the observations with outputs from evolutionary synthesis models and found that short-lived bursts of SF produce good fits to the equivalent width of Brγ (which basically measures the number of young stars relative to the number of red giants and supergiants) and the CO index (used to determine the presence of red supergiants). From our modelling we established that the NIR stellar clusters are relatively young (4-7 million years after the peak of SF), and contribute some 7-12% of the stellar mass in the central region of NGC 2903. Recent high resolution studies have found that a large population of young stellar clusters are routinely present in galaxies with enhanced SF: interacting galaxies, and infrared luminous and ultraluminous galaxies (e.g., Whitmore et al. 1999; Scoville et al. 2000; Alonso-Herrero 2000b, 2001). We find that the stellar clusters in NGC 2903 show similar properties (luminosities and sizes) to those identified in the interacting galaxy the Antennae (Whitmore et al. 1999).

The HII regions in the star forming ring exhibit Paα luminosities approaching that of the giant HII region 30 Doradus, and they are younger (1-4 million years after the peak of SF) than the stellar clusters. From this analysis a clearer picture has emerged of the SF processes occurring in NGC 2903. The ages and masses derived for the bright stellar clusters and HII regions in the CNR of NGC 2903 suggest that the HII regions are possibly the progenitors of the bright NIR stellar clusters. This may offer an explanation for the lack of a detailed correspondence between the positions of the young stellar clusters and HII regions. A similar situation has now been found in other galaxies with enhanced SF (see Alonso-Herrero et al. 2000b, 2001).

The SF efficiency (that is, the SF rate relative to the amount of gas) in the CNR of NGC 2903 is more elevated than in normal galaxies, and similar to (although slightly lower than) those of infrared luminous galaxies.

Acknowledgments. This work is partly based on observations taken with the Canada-France-Hawaii Telescope operated by the National Research Council of Canada, the Centre National de la Recherche Scientifique de France and the University of Hawaii. This work is partly based on observations collected at UKIRT. The UKIRT is operated by the Joint Astronomy Centre on behalf of the UK Particle Physics and Astronomy Research Council. Based on observations with the NASA/ESA Hubble Space Telescope, obtained at the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc. under NASA contract No. NAS5-26555.

We thank Drs. René Doyon, Dolores Pérez-Ramírez, and Daniel Nadeau for help with the CFHT observations, and Dr. Marianne Takamiya for help with those on UKIRT. We are grateful to Dr. C. G. Wynn-Williams for providing us with the radio data.

References

Alonso-Herrero, A., Ryder, S., & Knapen, J. H. 2000a, MNRAS, submitted

Alonso-Herrero, A. et al. 2000b, ApJ, 532, 845

Alonso-Herrero, A. et al. 2001, ApJ, 546 in press (astro-ph/0008317)

Boeker, T. et al. 1999, ApJS, 124, 95

Knapen, J. H. 1999, in The Evolution of Galaxies on Cosmological Timescales, ASP Conference Series, eds. J. E. Beckman and T. J. Mahoney, Vol 187, p 72

Planesas P., Colina L., Pérez-Olea D., 1997, A&A, 325, 81

Scoville, N. Z. et al. 2000, AJ, 119, 991

Simons, D. A. et al. 1988, ApJ, 335, 126

Whitmore B. C. et al. 1999, AJ, 118, 1551

Wynn-Williams, C. G., & Becklin E. E., 1985, 290, 108

First results of the Achromatic Interfero Coronagraph at CFHT

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Introduction

Since the mid 1980's, the development of stellar coronagraphy led different groups to the detection of faint emissions very close to much brighter stars. The coupling of stellar coronagraphs with high angular resolution techniques, accessible only with adaptive optics (AO) systems for ground-based observations, helped to improve the rejection rate of such coronagraphs. However, the coronagraphs used until now were designed on the basis of the Lyot coronagraph, which principal drawback is to create a blind zone around the star where information is completely lost. New types of coronagraphs have been recently proposed to overcome this limitation (Gay & Rabbia, 1996; Roddier & Roddier, 1997; Rouan et al., 2000). Among them, only the Achromatic Interfero Coronagraph (AIC) proposed by Gay & Rabbia (1996), has been tested on the sky. We present here the first results obtained with the AIC at CFHT using the PUEO AO system, first during a technical run in June 1999 and then for scientific observations in June 2000.

Principle

The Achromatic Interfero Coronagraph, which is described in detail elsewhere (Gay & Rabbia, 1996; Baudoz et al., 2000a), is basically a modified Michelson interferometer. The beam of a single aperture is split in two arms and before recombining the beams coming from each arm, in one arm, the pupil is π-dephased and π-rotated by crossing of a focus. Because of the π-rotation of the pupil, only the wavefront perpendicular to the axis of the AIC (on-axis source) produces interferences. And because the two arms are now π-dephased, these interferences are destructive. This nulling process fully works when one accurately maintains the Optical Path Difference (OPD) between