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INFRARED IMAGING OF INTERACTING PAIRS

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RESUMEN

Se describen los primeros resultados de un estudio en el cercano infrarrojo de la estructura espiral a gran escala en galaxias tipo M51. Las imágenes en la banda K' son utilizadas para determinar la geometría y el tamaño del bulbo estelar.

ABSTRACT

First results on a study of the grand-design spiral structure in M51-type galaxies in the near-IR are described. K'-band images are used to study the inner structure and to determine the geometry and sizes of the stellar bulge and the presence of inner bars.

Key words: **GALAXIES: INTERACTIONS — GALAXIES: NUCLEI — GALAXIES: STRUCTURE — INFRARED: GALAXIES**

1. INTRODUCTION

An ongoing study of the Grand-Design spiral structure in M51-type galaxies is described in this paper. A sample of 40 pairs for imaging in the NIR at different resolutions was selected to study the inner and outer spiral structures. In this paper we discuss the central regions of 7 galaxies in our sample. Broad- and narrow-band NIR images are a fundamental tool since they can be used for the following purposes: 1) To estimate arm to interarm contrasts and mass distributions of galaxies, crucial in distinguishing between different dynamical models tracing the orbital histories. 2) Investigate the innermost spiral structure. 3) Study the interaction related stellar populations. 4) Together with optical images to trace the extinction. 5) Identify and trace the regions of star formation.

2. OBSERVATIONS AND DATA REDUCTION

The observations have been obtained in March 1996 at the 2.1-m telescope of the OAN/SPM with the Infrared Camera/Spectrograph CAMILA (Cruz-González et al. 1994) which uses a NICMOS 3 array sensitive in the 1-2.5 μm region. Each pair in the sample will be first studied at JHK' with the two resolutions of CAMILA: 0.3″/pixel and 0.85″/pixel to select a subsample for narrow-band imaging. We present in this contribution K'-band images of the central regions of the following galaxies: M51, KPG 302a, KPG 404b, NGC 3226/3227, NGC 4303 and NGC 5033. The galaxy observations presented in Table 1, were done using the f/13.5 camera of CAMILA which has a plate scale and field of 0.3″/pixel and 1.2′×1.2′, respectively. The pair NGC 3226/NGC 3227 was observed also at a plate scale of 0.85″/pixel which covers a field of 3.6′×3.6′. The images were obtained in a "z-cross" sequence: object, sky N, object, sky S, object, sky E, object, sky W, object, with a small dithering from the object original position; the exposure times in each position are the same. We were careful not to saturate the nucleus, and in cases where it was bright we increased the integration time with addups. The reduction process was the following: Each object image was bias subtracted, linearized, sky subtracted (median of at least 3 sky frames), and flattened (sky flats). A final image is obtained by combining all the available frames using a program developed by Salas (1995). Further analysis is done with IRAF and IDL. We are now in the process of calibrating the images, studying the surface brightness profiles, removing the

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bulge component to enhance the spiral structure, constructing true color images with JHK, and studying the arm-interarm contrast.

3. RESULTS

From the infrared images of the inner spiral structure of the M51-type pairs presented (see Fig. 1) we can draw some conclusions:

1. The inner structure of most galaxies studied shows spiral patterns. When the bulges are removed, this spiral structure will be studied in detail. We are interested in studying the arm-interarm contrast at different wavelengths.

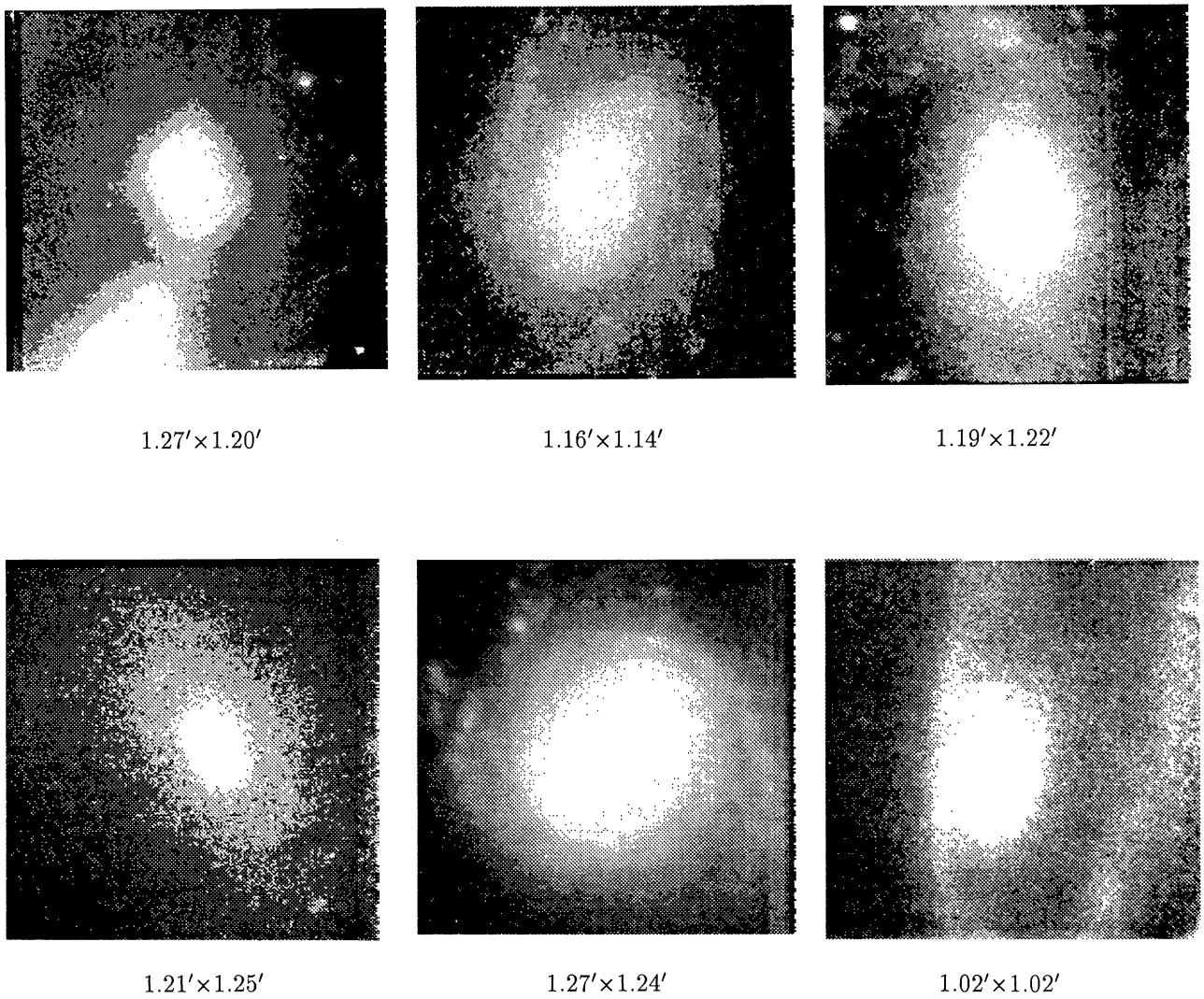

Fig. 1. K'-band images of NGC 3226, KPG 302a, NGC 4303, NGC 5033, M51, and KPG 404b (from top left to bottom right). North is up and East to the right.

2. The K' images allow us to obtain the bulge geometry (oval or circular) and sizes: NGC 3226 ($13''\times9''\rightarrow$ 1.4 kpc × 1 kpc), KPG 302a ($14''\times12''\rightarrow$ 1.3 kpc × 1.1 kpc), NGC 4303 ($19''\times13''\rightarrow$ 2.9 kpc × 2 kpc), NGC 5033 ($6''\times4''\rightarrow$ 500 pc× 350 pc), M51 ($9''\times8''\rightarrow$ 400 pc × 350 pc) and KPG 404b ($7''\times6''\rightarrow$ 2 kpc × 2.4 kpc).

3. The nucleus and bulge observed in M51, indicates that the IR bulge is smaller than the optical bulge found with *HST* by Panagia et al. (1995) ($26''\times16''$) and more circular. Our 0.3 ″/pix images are consistent with the oval component found by Zaritsky et al. (1993) at K with a resolution of 0.6″/pix. With our higher resolution the inner spiral structure could be better modeled once the bulge is removed. An inner bar is observed at PA = 135° and the inner spiral structure emanates from the edges of the bar at about 10″ from the nucleus.

4. Inner bars are obvious in three galaxies: NGC 4033, NGC 5033 and M51, once the bulge component is removed, the details of these inner bars will show more clearly.

TABLE 1

K'-BAND OBSERVATIONS OF GALAXY PAIRS

Source	Coordinates (1950)		Type	cz (km/s)	T_{int} (min)
NGC 3227	$10^h20^m47^s.$	20°07′00″	SAB(s)pec	1157	5
NGC 3226	10 20 44	20 09 07	E2pec	1322	39
KPG 302a	11 46 01	48 59 20	SAB(rs)bc	944	66
NGC 4303	12 19 21	04 44 58	SAB(rs)bc	1566	51
NGC 5033	13 11 10	36 51 33	SA(s)c	899	54
M51	13 27 46	47 27 22	SA(s)bc pec	463	36
KPG 404b	13 56 30	37 40 05	SAB(rs)c:	3493	51

4. FUTURE WORK

The K-band structure of the inner regions of the grand-design galaxies presented here are a valuable tool for modeling M51-type galaxies. There are two main approaches to explain the Grand-Design spiral structure: 1) with a quasi-stationary density-wave hypothesis (Lin 1966), suggesting that the spiral arms are of intrinsic origin, and 2) by tidally producing the spiral arms due to the passage of the satellite galaxy (Toomre 1969).

Because the spiral properties of galaxies are strongly dependent on the initial galaxy model, detailed 3D N-body simulations that incorporate modelling of many M51-type galaxies are needed to resolve which is the primary mechanism to induce and maintain spiral structure in these systems, and the number of companion passages needed. We will use Salo & Laurikainen (1996) 3D multiple spherical-polar grid code, where both components of the interacting pair are described with self-gravitating star+gas disks embedded in rigid analytical halo potentials and the gas is described with dissipatively colliding particles, to search for one that reproduces the observed morphology and kinematics.

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