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NEW NARROW AND BROAD BAND IMAGES OF THE RINGED SEYFERT 2 GALAXY MARK 620

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Abstract. We present new flux calibrated narrow and broad band images of the circumnuclear region of Seyfert 2 galaxy Mark 620 = NGC 2273 in the light of [O III] λ4959 Å , [O I] λ6364 + [Fe X] λ 6374 Å Å and [N II] λ6548 Å emission lines and two continuum images at λ6300 Å and λ 4260 Å , and in broad band *Gunn r* continuum.

The color map $F_\lambda(6300Å)/F_\lambda(4260Å)$ reveals a dusty ringlike structure around the nucleus of Mark 620.

Based on the color map $F_\lambda(6300Å)/F_\lambda(4260Å)$ we have estimated an extinction of $A_V = 1^m.04$ which yields $10^5 \times M_\odot$ for the mass of the dust in the ring.

1. Introduction

In recent years, several arguments have been advanced to indicate that galaxy interactions and/or orbital resonances can lead to the enhanced fueling of various kinds of nuclear activity, especially the Seyfert and Starburst phenomena (Heckman 1990, 1991; Dultzin-Hacyan, 1997).

In the theory of AGNs the luminous ($L_{IR} > 10^{10} L_\odot$) IRAS galaxies play an important role. Studies of dust and gas distribution in the circumnuclear regions of luminous IRAS AGNs galaxies with rings and bars provide an information both about the link between the AGN and star formation events and about the matter transport to the active nucleus.

NGC 2273 (Mark 620) was discovered by Huchra et al.(1982) to be a type 2 Seyfert galaxy and classified by de Vaucouleurs et al., 1991 [RC3] as a morfological type SB(r)a:. The heliocentric recession velocity is $cz = 1875$ km sec^{-1} [RC3].

NGC 2273 has been detected by IRAS (Lonsdale, Lonsdale & Smith, 1992 hereafter LLS92) with strong far infrared emission (FIR) $L_{FIR} \sim 10^{10} L_\odot$.

The continuum measurements by Krugel et al. (1988) at 1300 μm and the spectral index between 100 and 1300 μm clearly indicate that the emission must be thermal reradiation from dust.

The mid-infrared emission of Mark 620 at 10 μm measured by Devereux (1987) in small aperture ($\sim$5 arcsec) is due to thermal dust reradiation of the *UV*/optical emission of the central source (Giuricin et al.,1995).

CCD interference-band images isolating the emission lines of Hα + [N II] and [O III] λ5007 were obtained by Pogge (1989) and Mulchaey, Wilson and Tsvetanov (1996) (hereafter MWT96) to search for spatially extended circumnuclear emission regions.

We present the results of new narrow and broad-band imaging to study gas and dust distribution in the circumnuclear region of the ringed Seyfert 2 galaxy Mark 620.

2. Observations and data reduction

2. 1. OBSERVATIONS

Mark 620 has been observed with the 2m Ritchey-Chretien-Coudé (2-m RCC) reflector of the Bulgarian National Astronomical Observatory (BNAO) at Mount St. Spirit near Rozhen, Rodopa mountains. The observations were carried out on December 12, 1992.

The narrow-band images were taken with the Focal Reducer of the Max-Planck-Institute for Aeronomy (MPAe). The technical data and the capabilities of the MPAe Focal Reducer are described by Jockers (1992).

The telescope/reducer configuration and the CCD's square 22 μm pixels provide an image scale of $0''.8$ px^{-1}.

Images through interference filters centered near the wavelengths of [N II] λ6548 [O III] λ4959 and [O I] λ6364 + [Fe X] λ 6374 ("on-line") and on the emission free continuum windows at λ4260 and λ6300 ("off-line") were obtained. The "off-line" images were used to subtruct the continuum contribution contained in the "on-line" images. Moreover, the "off-line" images were used to form the color map.

A broad band image was obtained with *Gunn r* interference filter.

Table 1. M 620 - observing log and related data.

image frame	interference filter, $\lambda_c/\Delta\lambda$ (Å)/(Å)	exposure time (s)	final FWHM resolution (arcsec)
[N II] λ6548	6567/30	1 × 300	4.4
[O I] λ6364 + [Fe X] λ 6374	6420/30	2 × 300	3.2
red continuum	6300/34	2 × 300	3.2
[O III] λ4959	5003/40	2 × 300	2.7
blue continuum	4260/34	2 × 300	3.1
Gunn r	6550 /900	2 × 300	4.3

The observing log is presented in Table 1 where the central wavelengths λ_c and the effective width $\Delta\lambda$ of the interference filters, and the spatial resolution of the images in terms of the point-spread function (PSF) are listed.

2. 2. DATA REDUCTION

The images were reduced following the usual reduction steps for narrow-band imaging (Haniff, Wilson & Ward 1988 ; Perez-Fournon & Wilson 1990 ; Tsvetanov & Walsh 1992).

After flat-fielding the frames were aligned by rebinning to a common origin. The final alignment of all the images was estimated to be better than 0″.1. As an unwanted by-product of the rebinning procedure a small decrease of the resolution ($\sim$ 0″.15) was noticeable. The two images taken through the same filter were averaged and the cosmic-ray signatures were removed.

Unfortunately, small tracking errors of the 2-m RCC telescope caused residual ellipticities in the PSFs of our frames. Therefore, a convolution procedure was performed in order to match the PSFs of each line – continuum pair. The same procedure has been applied to those images which later were used in the mapping of continuum emission ratios. This degraded the final resolution to a mean value of $\sim 3''.3$.

3. Results

3. 1. BROAD AND NARROW - BAND CONTINUUM IMAGES

Contour map of the broad band r continuum is presented in Fig.1. Several morphological features are clearly seen : the outermost pseudoring structure at radius of 7.3 kpc ($\approx$ 60 arcsec); an ovally distorted disk with a radius of about 30 arcsec. The innermost visible structure is a bar with P.A.$\approx$ 114° . Weak spiral arms originate from the bar and form an inner pseudoring with radius $\approx$ 2.4 kpc ($\approx$ 20 arcsec). Similar features have been noted and discussed by Gallagher & Wirth (1980) and van Driel & Buta (1991).

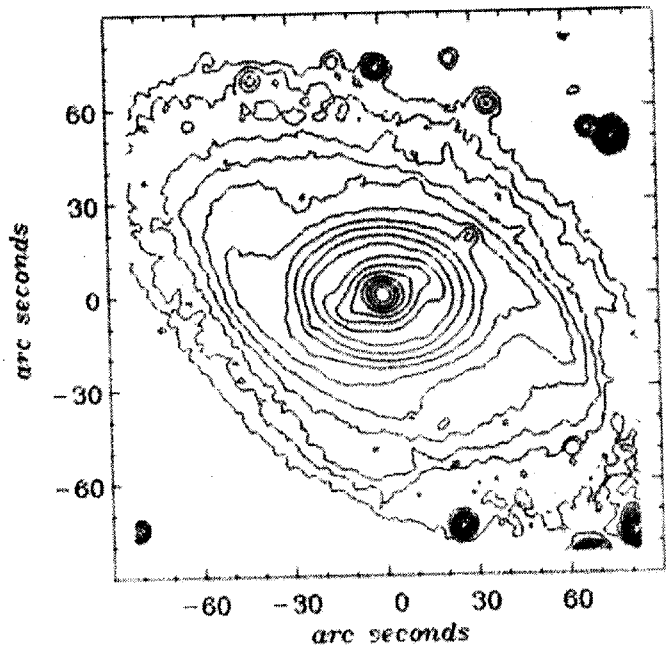

Fig. 1. CCD *Gunn r* contour plot. First contour is at 2σ from the background (1σ background noise level is 3×10^{-18} ergs cm^{-2} s^{-1}arcsec^{-2}Å^{-1}). The other contours increase as a power series of 2.

It should be noted, the *Gunn r* continuum contour map (Fig.1) shows an isophotal twist in the innermost region of Mark 620. Similar isophotal twists are observed in early type spirals and could be associated with inner Lindblad resonances (ILR) (Elmegreen et al.,1996).

The continua images obtained at λ 4260 Å and λ 6300 Å were used to create the narrow-band color map, presented in Fig. 2, where "black" means excess of light while "white" means absorption.

The color map (Fig. 2) reveals an inner redder structure reminding of dusty ring around the AGN nucleus of Mark 620. This ringlike structure has a diameter of about 14 arcsec corresponding to $\approx$ 1700 pc. Its mean projected thickness is about 500 pc.

A second dusty ring is clearly seen on the color map. Its radius is $\approx$ 20 arcsec (2.4 kpc) and is approximately placed on the inward side of the ovally distorted disk. Gallagher & Wirth (1980) have also shown the presence of outer rather red ring.

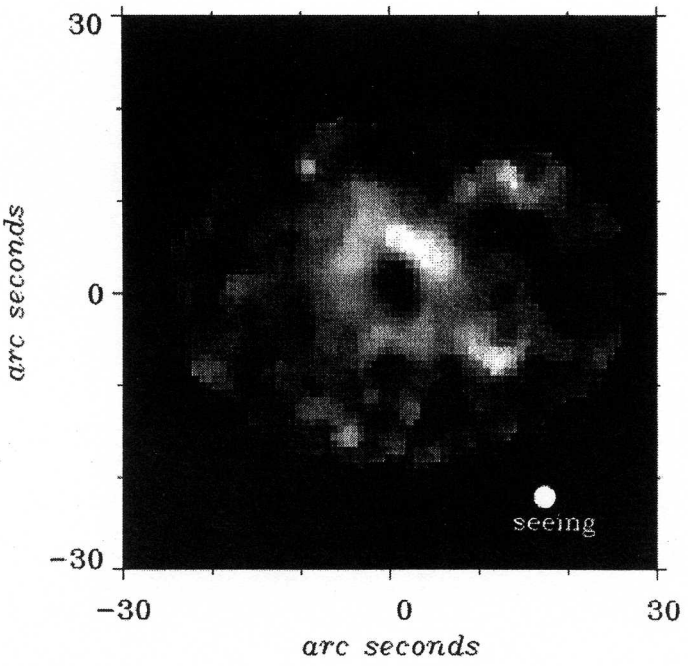

Fig. 2. Red/blue narrow-band color map of Mark 620.

3. 2. NARROW - BAND EMISSION LINE IMAGES

The emission line contours of [O III] λ4959 and [N II] λ6548 , [O I] λ6364 + [Fe X] λ 6374 superimposed on the F_λ(6300Å)/ F_λ(4260Å) color map are presented in Fig.3 and Fig.4.

The corresponding 1σ background noise levels in the emission line images are presented in Table 2. The lowest isophotal level is at 3σ above the sky subtraction level and the following contours are multiplied with $\sqrt{2}$.