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X-rays from a Peculiar Nucleus Galaxy NGC 2196

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Summary. Detection of a new X-ray source with the Einstein Observatory and its identification with the early type spiral (Sa) galaxy NGC 2196 (MCG 4-15-14), a member of Sersic's list of peculiar nuclei galaxies is reported. The X-ray luminosity of the galaxy is found to be $\sim 2\ 10^{40}$ erg s^{-1} which is an order of magnitude higher compared to that of the normal spiral galaxies but comparable to that observed from weakly-active galaxies. The optical and X-ray characteristics of the galaxy are discussed and compared with those of the other normal and weakly-active galaxies.

Key words: X-rays – galaxies – peculiar galaxies

1. Introduction

Active galaxies like the Seyferts and narrow-emission line galaxies have been known to be powerful X-ray emitters for quite some time now. However, no normal spiral galaxy, with the exception of M 31, was detected in X-rays till recently. The main reason for this is that the normal galaxies like our own and M 31 are rather weak X-ray emitters with X-ray luminosity (L_x) of $\sim(2–3)\ 10^{39}$ erg s^{-1} compared to active galaxies for which L_x is in the range of 10^{41}–10^{44} erg s^{-1}. The vastly superior sensitivity of the Einstein Observatory has now made it possible to detect and study very weak X-ray sources. As a result several normal spiral galaxies like M 33 and M 100 and weakly active spirals like NGC 7590 have already been detected in X-rays (Long et al., 1981; Maccacaro et al., 1981). In this paper we report detection of X-rays from the early type spiral (Sa) galaxy NGC 2196 (MCG 4-15-14). This galaxy is included in the list of galaxies with peculiar nuclei compiled by Sersic (1973) and is suspected to have an amorphous nucleus.

2. X-ray Observations

X-ray emission from NGC 2196 was detected in a deep exposure of a square degree of the sky with the Imaging Proportional Counter (IPC) of the Einstein Observatory (EO). For a detailed description of the EO and IPC, refer to Giacconi et al. (1979). The IPC field of view was centered on a flare star Gliese 229. The X-ray observations were made between OO: 11 UT and 06:24 UT on March 1, 1981 and data from 11759 seconds of exposure were used to construct X-ray image of the IPC field. Besides the flare star G 229, six other serendipitous X-ray sources were detected in the IPC field. Position of one of these sources at R.A. (1950) $06^h10^m02^s.8$ and Dec. (1950) $= -21°47'26''$ coincided with the position of NGC 2196. (Coordinates in the 1950 epoch: R.A. $= 06^h10^m2^s.98$, Decl. $= -21°46'59''.9$.) The X-ray position lies within 30″ of the centre of the nucleus of the galaxy NGC 2196 which has a size of about 1′.5. In Fig. 1 we show the best fit X-ray position along with 99 % confidence error circle of diameter 1′.3 superposed on a blue Palomar plate image of the galaxy NGC 2196. However, systematic uncertainties in the aspect determination could result in an error circle of as large as 2′ diameter. We estimate the probability of a galaxy brighter than 13th magnituie falling within the X-ray error circle of 2′ diameter by chance to be only $1.7\ 10^{-4}$. In view of this, identification of the X-ray source with NGC 2196 is secure.

The effective exposure time on NGC 2196 is 7604 seconds, which includes the corrections due to the vignetting, scattering and dead time effects. The source was detected only in the hard channel (0.5–4.5 keV) of IPC with a count rate of $(3.1 \pm 0.5)\ 10^{-3}$ counts s^{-1}. Due to a limited number of counts no meaningful information can be obtained on the X-ray spectrum of the source. Using a conversion factor of $2.8\ 10^{-11}$ erg cm^{-2} s^{-1} per IPC count s^{-1} appropriate for a thermal bremstrahlung spectrum with $kT = 1$ keV and an absorbing hydrogen column density $N_H = 10^{21}$ cm^{-2} in our galaxy towards NGC 2196 (Daltabuit and Meyer, 1972), the source flux is estimated to be $(8.7 \pm 1.4)\ 10^{-14}$ erg cm^{-2} s^{-1}. The use of a power law spectrum with photon index of -2 and $N_H = 10^{21}$ cm^{-2} yields a source flux of $(14.1 \pm 2.3)\ 10^{-14}$ erg cm^{-2} s^{-1}. Assuming a Hubble constant of 50 km s^{-1} Mpc^{-1} and the red shift of NGC 2196 given by Sandage (1978) corresponding values of the X-ray luminosity (L_x) are found to be $(17 \pm 2.8)\ 10^{39}$ erg s^{-1} and $(27 \pm 4.5)\ 10^{39}$ erg s^{-1} respectively. Due to uncertainties in the spectral parameters and the spatial dependence of the IPC gain the derived L_x values can change by a factor of upto 2.

3. Optical Characteristics

NGC 2196 is an early spiral (Sa) galaxy with a bright diffuse nucleus in a smooth bulge with faint smooth arcs forming hexagonal pseudo outer ring (1′.5 × 1′.4) which is slightly asymmetrical (de Vaucouleurs et al., 1976). The apparent magnitude of the galaxy is 12.5 and its corrected colours are: $B-V = 0.72$ and $U-B = 0.16$ which appear to be normal. The axial ratio i.e. the ratio of its minor diameter to major diameter is 0.80, so that the galaxy is almost face-on. Sersic (1973) has included this galaxy in a list of

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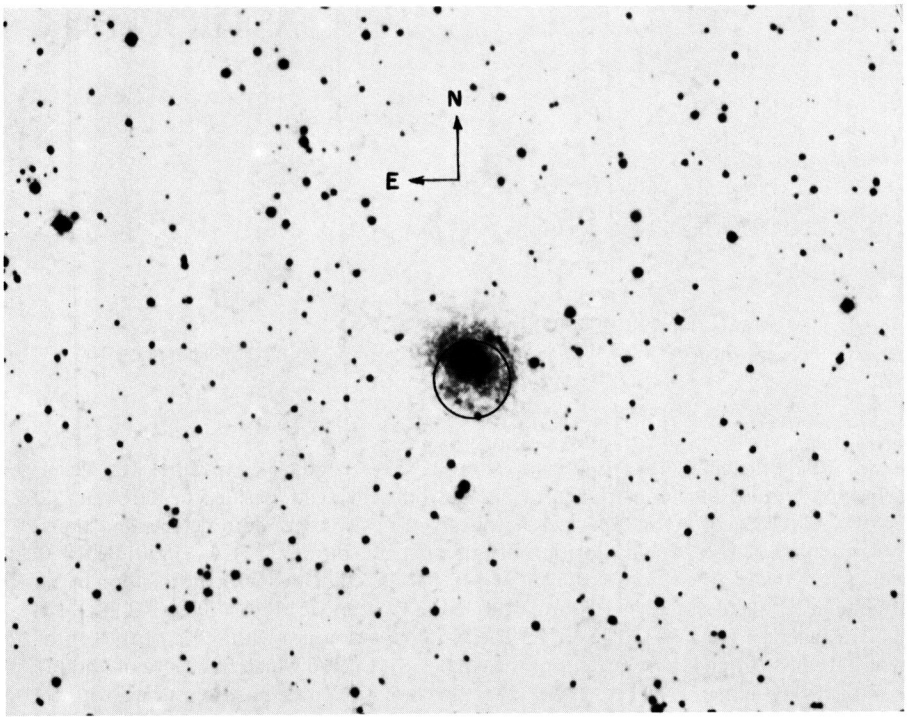

Fig. 1. IPC error circle (diameter $\simeq 1'.3$) of the X-ray source superposed on a blue Palomar sky field centered on the galaxy NGC 2196

Table 1

Galaxy	Type	L_x(0.5–4.5 keV) 10^{39} erg s^{-1}	L_x/L_{opt}	Comments	Ref.
NGC 2196	Sa	17 ± 2.8	$5.5\ 10^{-4}$	For thermal spectrum	Present work
		27.4 ± 4.6	$8.8\ 10^{-4}$	For power-law spectrum. A member of peculiar galaxies listed by Sersic (1973)	
M31	Sb	2.7	$8.3\ 10^{-5}$	Population I, inner bulge and globular cluster X-ray sources	1
M33	Sc	2.0	$4.3\ 10^{-4}$	70 % of X-ray emission is from the nucleus	2
M81	Sb	2.0	$1.4\ 10^{-4}$	X-ray source is in the nucleus	3
M100	Sc	15.0	$6.7\ 10^{-5}$	X-ray source is in the nucleus	3
NGC 4459	SO	11.5 ± 2.4	$3.75\ 10^{-4}$	Member of the Virgo cluster	4
NGC 7590	Sbc	32.0	$1.08\ 10^{-3}$	Weak emission line galaxy. Member of the Grus Quartet	5
NGC 1672	SBb	30.0	$5.72\ 10^{-4}$	A meber of peculiar galaxies listed ty Sersic and Pastoriza (1967)	6

References: 1. Van Speybroeck et al. (1979). 2. Long et al. (1981). 3. Van Speybroeck and Bechtold (1981). 4. Forman et al. (1979). 5. Maccacaro et al. (1981). 6. Griffiths (1980)

galaxies with peculiar nuclei and suggested that it may have amorphous nucleus.

Prabhu (1980) has carried out a detailed morphological study of NGC 2196 and describes it as having a bright nucleus and a bright perinuclear region with elliptical boundary and smooth intensity distribution. Spectroscopic observations by Prabhu (1980) showed no Hα emission from NGC 2196 and four other Sersic-Pastoriza galaxies having similar morphology.

4. Discussion

A number of normal and peculiar galaxies have recently been observed with the Einstein and found to be X-ray emitters with L_x in the range of 10^{39}–10^{42} erg s^{-1} (Long and Ku, 1979; Fabbiano et al., 1979). In Table 1 we have summarized published L_x and L_x/L_{opt} values for the normal and weakly active galaxies. It will be noticed from the table that the value of L_x for NGC 2196 is about an order

of magnitude higher compared to that for the normal spirals like M31 and M33 but falls in the range of L_x values observed for weakly active galaxy NGC 7590 and Sersic-Pastoriza galaxy NGC 1672. The ratio L_x/L_{opt} for NGC 2196 is also larger compared to that observed for the four normal spiral galaxies listed in Table 1.

Most of the active galactic nuclei have L_x in the range of 10^{41}–10^{44} erg s^{-1} (Kriss et al., 1980). The observed L_x for NGC 2196 is at least an order of magnitude lower than that of the active galactic nuclei. The lower L_x of NGC 2196 is most likely to be intrinsic and not due to any obscuration of an active nucleus in it due to its low gas and dust content (Prabhu, 1980) and high axial ratio. It is however likely that NGC 2196 is a weakly active galaxy similar to NGC 7590 and Sersic-Pastoriza galaxy NGC 1672. Detailed spectroscopic observations should be carried out to search for weak emission lines from this galaxy.

From the IPC observations we are unable to say whether X-rays from NGC 2196 come from a single dominant source in its nucleus, as seen in M33 and M81 (Long et al., 1981; Van Speybroeck and Bechthold, 1981), or from a large number of discrete sources like those observed in our galaxy and M31 (Van Speybroeck et al., 1979). If bright binary sources like those seen in the Milky Way are mainly responsible for the X-rays from NGC 2196, then its observed L_x suggests that number of such binary sources in this galaxy are an order of magnitude higher than that in the Milky Way and M31. This in turn implies that OB stars are about ten times more abundant in NGC 2196 compared to that in the Milky Way.

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