Detection of a Strong Soft X-ray Transient Near the Nucleus of Centaurus A

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Introduction

The elliptical galaxy NCG 5128 is the stellar body of the giant double radio source Centaurus A (Cen A). It is one example of the family of elliptical galaxies that have an absorbing band of gas and dust projected across their stellar body, obscuring the nucleus at optical wavelengths. The dust lane is thought to be the remnant of a recent (10^7 – 10^8 years ago) merger of a giant elliptical galaxy with a smaller spiral galaxy (Thomson 1992).
Its proximity of $<$ 4 Mpc (Hui et al. 1993) makes Cen A uniquely observable among such objects, even though its bolometric luminosity is not large by AGN standards. Therefore, NGC 5128 is a very well studied and frequently observed galaxy in all wavelength bands. Its emission is detected from radio to high-energy gamma-rays (Johnson et al. 1997; Israel 1998).
Variability of Centaurus A is reported in many wavelength regimes. In hard and in soft X-rays, observations of the Cen A region have revealed intensity variability greater than an order of magnitude (Bond et al. 1996; Baity et al. 1981; Turner et al. 1997). Many of the observations referred to in the above publications, however, were made by instruments with a spatial resolution much less than required to resolve the inner parts of Cen A.
We here report the detection of a strong source only 2.'5 off from the nucleus of Cen A in ROSAT High Resolution Imager (HRI) X-ray data.

Observations

In July 1995 a multiwavelength campaign took place to observe Cen A (NGC 5128) from radio to gamma-rays. Over a time interval of 14 days simultaneous measurements with various instruments were made (Steinle et al. 1999). The soft X-ray regime (0.1–2.4 keV) was observed five times with the ROSAT HRI during this time interval. The exposure times were in the order of 5 000 s each.
During the ROSAT HRI observations in 1995, spanning a time of 10 days, in each observation a bright X-ray source was detected 2.'5 south-west of the nucleus of NGC 5128 at the outer regions of the elliptical galaxy.
The coordinates derived from the ROSAT images are:
R.A. = $13^h\ 25^m\ 19.^s8$, Dec = $-43^o\ 03'\ 12''$
(J2000; uncertainty 5").
The source has been assigned the ROSAT catalogue name 1RXH J132519.8-430312. However, we will refer to the transient as hcs113 as it is number 113 in a list of ROSAT HRI / Chandra sources which will be published in a future paper.
In all five observations hcs113 was the brightest point source in the HRI field-of-view with an average count rate of (0.033 ± 0.003) counts sec^{-1}, which is about a factor of 4 brighter than any other point source and about 30 % of the flux of the combined Cen A nucleus and jet sources. In Fig. 2 we show the sum of all five 1995 observations where hcs113 and the object H13 are marked. H13 is a source from Turner et al. (1997) which we used for comparison, as it is a constant source in all ROSAT observations at a count rate of (0.008 ± 0.002) counts sec^{-1}. H13 is probably a 14^{th} mag M star (Feigelson et al. 1981) or a distant early type galaxy (Wagner et al. 1996).
As the ROSAT observations in July 1995 were part of an extensive multiwavelength campaign to observe Cen A from radio to gamma-rays, simultaneous observations at other wavelengths exist (Steinle et al. 1999). However, only the optical monitoring with the ESO 2.2 m telescope at La Silla (Chile), had the position of hcs113 in the field-of-view and had enough spatial resolution. No candidate object in the ROSAT error box down to a limiting magnitude of $\sim$ 18 mag is visible in the B and V exposures which were obtined during the same time interval in 1995 (see for example Fig. 4).

Variability

The measured flux from hcs113 is constant over the 10-day observation period in 1995. The only significant deviation occurs in the observation of July 22, where the flux drops by 30 %.
Before and after these 1995 observations, four other observations of Cen A had been made with ROSAT (three with the HRI and one with the Position Sensitive Proportional Counter (PSPC)). All these observations from the years 1990, 1992, 1994, and 1998 which had substantially longer exposure times than the 1995 observations, show no trace of a source at the position of hcs113, even if combined. In Fig. 1, which is the sum of all ROSAT HRI observations without the 1995 multiwavelength data and has a total exposure of 101 862 s, the cuts are set as low as possible to detect any object at the transients position, but no object is detected. The derived (2 σ) upper limit for a detection at the position in question is 0.0003 counts sec^{-1}.
Turner et al. (1997), who analyzed the 1990 ROSAT HRI observation in detail, did not detect any source at the transient's position, nor did they find any object in the ASCA and EINSTEIN data they used for comparison, which would be consistent with the position of hcs113.
The BATSE instrument on board CGRO has monitored Cen A continuously since its launch in April 1991 in the energy band 20–100 keV, with a very coarse (few degrees) spatial resolution (Wheaton et al. 1996) giving a long baseline for monitoring flux variations. Around the time of the 1995 observations, an increase of the flux is present in the data, but such variations are very common for this source (see Fig. 1 in Steinle et al. (1999)), and similar flux increases occurred during some of the other ROSAT observations, when hcs113 was not detected.
Recently released public images of one of the first Chandra observations, which was imaging the Cen A region with unprecedented arc-second resolution in the energy range 0.1–10 keV, show a weak source at the position of hcs113 (see Fig. 3). This is very probably the transient source either in its quiescent state or in a new outburst phase. However, hcs113 is not one of the highly variable or transient sources listed in the paper by Kraft et al. (2000).

Spectral Information

As the ROSAT HRI has no energy resolution, no spectral information is available from those observations. Unfortunately the only PSPC observation and the data from the ROSAT All-Sky Survey, which would have had spectral information, were made when the transient was not active. Therefore only limited indirect information can be derived from the simultaneous measurements with the BATSE and OSSE instruments onboard CGRO which observed Cen A in the adjacent higher energy bands.
From the BATSE Cen A monitoring data, no strong enhancement in the 20–100 keV flux is probable (see above). The spectral photon index derived from the data during the 1995 campaign is between -1.5 and -1.7. A consistent spectral index of -1.6 is derived from the OSSE data between 10 keV and 100 keV. These spectral index values are in agreement with the index of -1.5 measured by Baity et al. (1981). The conclusion is that the emission of the transient is mainly at soft X-rays.

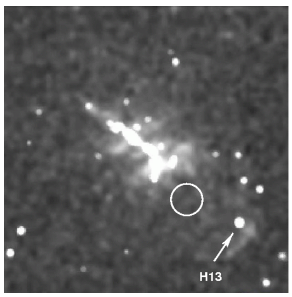

Fig. 1: X-ray (ROSAT) image
of the central region of Cen A

Combined ROSAT HRI observations from 1990, 1994, and 1998 which show no source at the position of the transient which is indicated by the circle.
(Image size: 12' x 12'; total exposure 101862 s)

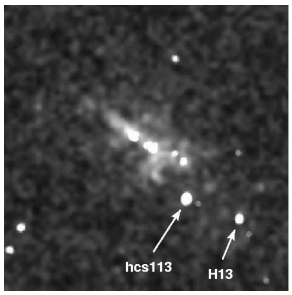

Fig. 2: X-ray (ROSAT) image
of the central region of Cen A

Combined 5 ROSAT HRI observations from the 1995 multiwavelength campaign which show the strong transient (maked hcs113).
(Image size: 12' x 12'; total exposure 24400 s)

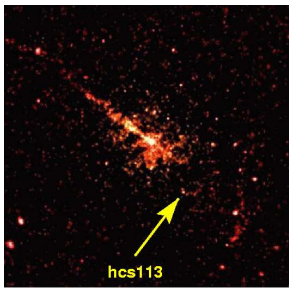

Fig. 3: X-ray (Chandra) image
of the central region of Cen A

Chandra image of Cen A from September 1999. At the position of the transient, which is marked as hcs113, a weak source is visible.
(Image size: 12' x 12'; exposure 23000 s)
(Credit: NASA/CXC/SAO - image modified)

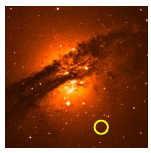

Fig. 4: Optical image
of the central region of Cen A

Simultaneous optical (B) image of Cen A taken during the 1995 campaign at the ESO La Silla 2.2m telecope. No object at the the position of the transient is visible.
(Same scale as Figs. 1 - 3, but image size: 7' x 7'; exposure 40 s)

Summary and Conclusions

During five ROSAT HRI observations in July 1995, a bright X-ray transient source 1RXH J132519.8-430312 (= hcs113) was detected 2.'5 south-west of the nucleus of NGC 5128. When compared with all other ROSAT observations of Cen A made in 1990, 1992, 1994, and 1998 it turns out, that the source is only present during the 10 day period of the 1995 observations and no trace of it can be detected down to 1 % of the 1995 flux level in the other (deep) observations. Chandra observations of Cen A made in September 1999, however, show a source at the ROSAT position, which may be either the persistent conterpart of hcs113, or the transient at a recent active state.
If at 3.0 Mpc (the distance of Cen A), the luminosity of hcs113 in the energy band 0.1–2.4 keV is $3 \cdot 10^{39}$ erg s^{-1}, assuming a power-law spectrum with photon index -1.5, $N_H = 8 \cdot 10^{20}$ cm^{-2} , and no additional intrinsic absorption in NGC 5128. This is above the Eddington luminosity of most X-ray binaries, but still within the observed range of luminosities for such objects. Therefore it cannot be ruled out that the transient is located in NGC 5128. On the other hand, if hcs113 is a Galactic object, then its soft X-ray luminosity would be less than $3 \cdot 10^{34}$ erg s^{-1} (assumed maximum distance 10 kpc). This is low for a typical neutron star transient, but is high for a typical cataclysmic variable. If it is closer than 10 kpc, its luminosity may be consistent with that of typical cataclysmic variables, whose optical counterparts are usually brighter than 19 or 20 mag, which then should be detectable in (deep) optical images. As the emission of the object seems to be mainly in the soft X-ray range, a distant AGN or Blazar is ruled out. A search for counterparts of hcs113 has been carried out using the NED (NASA/IPAC Extragalactic Database), the GSC (Hubble Guide Star Catalogue) and SIMBAD without any obvious object being found.
If hcs113 is indeed an X-ray binary or other variable object, it would be very probable that the observed outburst was not a single event. Therefore, all Cen A observations in the past with low resolution X-ray instruments sensitive in soft X-rays (several keV), may have attributed a variation in the X-ray flux of the transient source to a variation in the flux from the nucleus (and/or jet) of Cen A.
Regardless of the nature and distance of the object, the fact that it is separated only 2.'5 from the nucleus of Cen A, poses a strong problem for all spatially unresolved (on this scale) soft X-ray observations. Further observations and the interpretation of previous results (like the Cen A light-curves shown e.g. by Bond et al. (1996) and Turner et al. (1997)) as well as the interpretation of the results of current Cen A monitoring programs in X-rays have to take the existence of the transient into account.

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For more information on Centaurus A see: http://www.mpe.mpg.de/Cen-A/