Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY LETTERS

Mon. Not. R. Astron. Soc. **417,** L26–L30 (2011) doi:10.1111/j.1745-3933.2011.01113.x

Discovery of the infrared counterpart of CXOU J174437.3−323222 in the field of IGR J17448−3232: a blazar candidate viewed through the Galactic Centre?[⋆]

P. A. Curran,[1]† S. Chaty,[1] J. A. Zurita Heras,[2] J. A. Tomsick[3] and T. J. Maccarone[4]

[1]*Laboratoire AIM, CEA/IRFU-Université Paris Diderot-CNRS/INSU, CEA DSM/IRFU/SAp, Centre de Saclay, F-91191 Gif-sur-Yvette, France*
[2]*François Arago Centre, APC, Université Paris Diderot, CNRS/IN2P3, CEA/DSM, Observatoire de Paris, 13 rue Watt, 75205 Paris Cedex 13, France*
[3]*Space Sciences Laboratory, 7 Gauss Way, University of California, Berkeley, CA 94720-7450, USA*
[4]*School of Physics and Astronomy, University of Southampton, Southampton, Hampshire SO17 1BJ*

Accepted 2011 July 7. Received 2011 June 24; in original form 2011 May 16

ABSTRACT

We present our near-infrared ESO-NTT K_S band observations of the field of IGR J17448−3232 which show no extended emission consistent with the supernova remnant (SNR), but in which we identify a new counterpart, also visible in *Spitzer* images up to 24 μm, at the position of the X-ray point source, CXOU J174437.3−323222. Multiwavelength spectral modelling shows that the data are consistent with a reddened and absorbed single power law over 5 orders of magnitude in frequency. This implies non-thermal, possibly synchrotron emission that renders the previous identification of this source as a possible pulsar, and its association to the SNR, unlikely; we instead propose that the emission may be due to a blazar viewed through the plane of the Galaxy.

Key words: radiation mechanisms: non-thermal – infrared: general – X-rays: individual: CXOU J174437.3−323222 – X-rays: individual: IGR J17448−3232.

1 INTRODUCTION

High energy (X-ray, γ-ray) emission is observed from numerous astronomical sources and is produced by various processes. Common sources of high-energy emission are Galactic sources such as black hole or neutron star systems (e.g. X-ray binaries, pulsars) and supernovae or supernova remnants (SNRs), and extragalactic sources such as active galactic nuclei (AGN) and gamma-ray bursts. At lower energies ($\lesssim$20 keV), thermal emission may make a significant contribution to the observed flux, but at higher energies, such as those observed by the *International Gamma-Ray Astrophysics Satellite* (*INTEGRAL*; 15 keV–10 MeV; Winkler et al. 2003), other emission mechanisms are required. Prominent, though certainly not the only, emission mechanisms at these energy ranges are synchrotron and inverse-Compton (IC) radiation which both produce broad-band spectra visible over many orders of magnitude in frequency.

In this Letter, we collate data of one such *INTEGRAL*-detected, high-energy object, IGR J17448−3232, from various sources including published catalogues, archived images and our own ESO-New Technology Telescope (NTT) observations (Section 2). We identify the multiwavelength counterparts of the point source and construct a spectral energy distribution (SED) in an attempt to understand its nature (Section 3).

IGR J17448−3232. The X-ray source IGR J17448−3232 was initially discovered by *INTEGRAL* and published in the Third (III) and subsequently Fourth (IV) IBIS/ISGRI Soft Gamma-Ray Survey Catalogue (Bird et al. 2007, 2010), though at slightly different positions. In an attempt to refine the position (see Table 1 for this and subsequent X-ray positions), the *Swift* X-ray Telescope (*Swift*-XRT; Burrows et al. 2005) observed the field (Landi et al. 2007). These authors identify a point source (henceforth SWIFT J174437.5−323220) at the edge of the original *INTEGRAL* III error circle as well as possible diffuse emission (which, after examination of the XRT image, we note is within that error circle). The position of the point source was further refined by Tomsick et al. (2009) through a 4.7 ks *Chandra* observation of the field. In addition to detecting the point source, CXOU J174437.3−323222, they confirmed an extended source, ∼7 times brighter, at the *INTEGRAL* III position (CXOU J174453.4−323254; see Fig. 1). At the XRT point source position, Landi et al. (2007) had also noted a USNO-B1.0 (0574−0773466, $R \sim 15.5$; Monet et al. 2003), 2MASS (J17443749−3232197, $K = 9.100 \pm 0.026$; Skrutskie et al. 2006) object, but the subarcsecond accuracy of the *Chandra* position eliminates it as a possible counterpart; though the X-ray point source is at the edge of the 2MASS point spread function (PSF).

[⋆] Based on observations collected at the European Organization for Astronomical Research in the Southern hemisphere, Chile, under ESO programme 084.D-0535 (P.I. Chaty).

†E-mail: peter.curran@cea.fr

Table 1. X-ray positions and 90 per cent uncertainties for the different X-ray sources in the field.

Source	RA	Dec.	Error
IGR J17448−3232[III]	17:44:54.96	−32:33:00	2.2 arcmin
IGR J17448−3232[IV]	17:44:47.76	−32:32:16	3.2 arcmin
SWIFT J174437.5−323220[a]	17:44:37.23	−32:32:24.3	2.4 arcsec
CXOU J174453.4−323254[b]	17:44:53	−32:32:54	
CXOU J174437.3−323222	17:44:37.34	−32:33:23.0	0.64 arcsec
2PBC J1744.8−3231	17:44:52.6	−32:31:01	4.56 arcmin

[III/IV] Position from the Third/Fourth IBIS/ISGRI Soft Gamma-Ray Survey Catalogue.

[a] Refined in this Letter from original position of 17:44:37.46 −32:32:20.2 (4 arcsec error; Landi et al. 2007).

[b] Extended source of radius $\sim$3 arcmin.

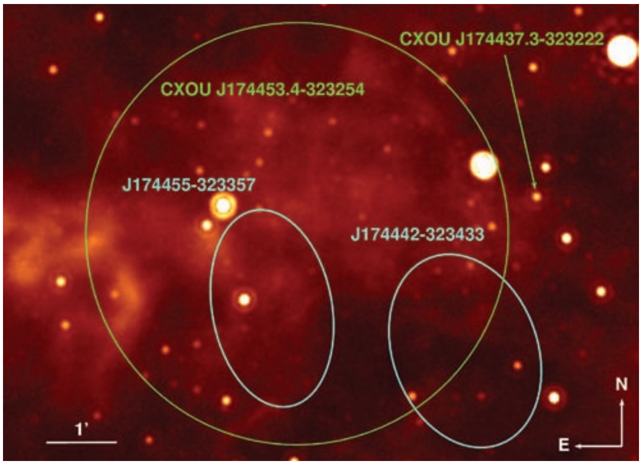

Figure 1. 24 μm MIPSGAL image of the field of IGR J17448−3232 showing the blazar candidate, CXOU J174437.3−323222, as well as the extent of the $\sim$3 arcmin extended X-ray emission from the SNR and the extended MGPS-2 radio sources.

Due to the fact that the more recent *INTEGRAL* IV position includes both the point source and extended emission within its error circle, we shall henceforth only use IGR J17448−3232 to refer to the field and, for clarity, we shall refer to the extended emission as CXOU J174453.4−323254. Given the positional coincidence and point source nature of SWIFT J174437.5−323220 and CXOU J174437.3−323222, we shall henceforth assume they are one source which we shall refer to by the *Chandra* moniker. Based on analysis of the *Chandra* spectrum, Tomsick et al. (2009) proposed the extended emission as an SNR, though they did not detect evidence of a pulsar wind nebula (PWN). They also suggested a tentative association of the point source with the SNR, hypothesizing that it may be an isolated neutron star that received a kick when the supernova (SN) occurred.

2 OBSERVATIONS

2.1 Catalogue sources

In the high-energy range ($\gtrsim$10 keV), a source, 2PBC J1744.8−3231, is documented at 1.2×10^{-11} erg cm^{-2} s^{-1} in the Palermo *Swift*-BAT hard X-ray catalogue (15–150 keV; Cusumano et al. 2010). The source is therein associated with IGR J17448−3232, though its position is consistent with both the extended and point sources in the field; given the resolution of the BAT instrument, this is an unresolved measurement of the flux at that position. No source, consistent with either position, is found in the *Fermi*-LAT First Source Catalogue (100 MeV–100 GeV; Abdo et al. 2010) and no such source has been made public by *Fermi* GBM (10 keV–30 MeV) or HESS (100 GeV–100 TeV; Chaves & the HESS Collaboration 2009).

The second epoch Molonglo Galactic Plane Survey (MGPS-2) compact source catalogue (Murphy et al. 2007), which details observations at 843 MHz, documents two nearby sources, MGPS J174442-323433 and MGPS J174455-323357, which are also included in the NRAO VLA Sky Survey (1.4 GHz; NVSS; Condon et al. 1998) as NVSS J174442−323436 and NVSS J174455−323359. The extension of these sources overlaps with the extended X-ray emission of the SNR, but neither is consistent with the point-like X-ray source. From a visual inspection of the NVSS and MGPS-2 images available of the field, there is no obvious sign of any excess emission above background levels at the point source position; we use the flux density of the nearby dim, NVSS 174423−323502, as a measure of the 1.4-GHz upper limit in the field (2.8×10^{-3} Jy). No nearby sources are found in any of the nine bands (30–856 GHz) of the all-sky, *Planck* Early Release Compact Source Catalogue (Ade et al. 2011); flux density limits for the region are not well quantified but are on the order of 1 Jy for latitudes up to $\pm 10^{\circ}$ (Ade et al. 2011; fig. 5).

2.2 Near-infrared observations

On 2010 March 28, a total of nine 10 s $K_{\rm S}$ filter exposures were obtained with the Son of ISAAC (SofI) infrared spectrograph and imaging camera on the 3.58 m ESO-NTT. The NTT-SofI data were reduced using the IRAF package wherein cross-talk correction, flat-fielding, sky-subtraction and frame-addition were applied. The image was astrometrically calibrated against 2MASS (Skrutskie et al. 2006) within the GAIA package. No extended emission consistent with the diffuse X-ray emission is found in the image, but a new source is detected at the position of the *Chandra* point source (Fig. 2). The $K_{\rm S}$ counterpart is at the edge of, and has an overlapping PSF with, the aforementioned 2MASS source and hence PSF photometry is required to accurately determine the magnitude.

PSF photometry was carried out on the final image using the DAOPHOT package (Stetson 1987) within IRAF. The magnitude of the

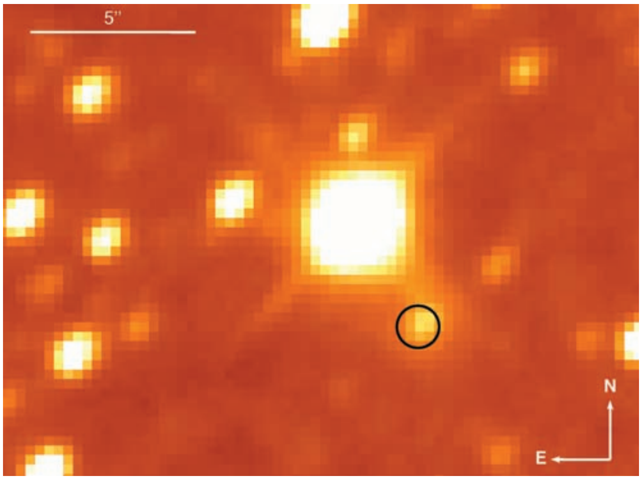

Figure 2. SofI $K_{\rm S}$ band 20 × 15 arcsec^2 image with *Chandra* 0.64 arcsec 90 per cent error circle marked.

Table 2. Observed magnitudes and flux densities, F_ν, for IR counterparts of CXOU J174437.3−323222 (1σ errors).

Band (instrument)	Magnitude	Flux density (Jy)
UV (*Swift*)	>21.82	$<1.38 \times 10^{-6}$
K_S (SofI)	14.03 ± 0.20	$(1.63 \pm 0.16) \times 10^{-3}$
3.6 µm (IRAC)	12.66 ± 0.11	$(2.42 \pm 0.27) \times 10^{-3}$
4.5 µm (IRAC)	12.00 ± 0.08	$(2.85 \pm 0.29) \times 10^{-3}$
5.8 µm (IRAC)	11.18 ± 0.06	$(3.88 \pm 0.23) \times 10^{-3}$
8.0 µm (IRAC)	10.12 ± 0.04	$(5.74 \pm 0.23) \times 10^{-3}$
24 µm (MIPS)	6.7 ± 0.3	$(1.5 \pm 0.5) \times 10^{-2}$

counterpart was then calculated relative to a number of comparison stars in the field, using the scatter as a measure of the error. The comparison stars were calibrated against a Persson photometric standard star (Persson et al. 1998) observed on the night. The resultant magnitude and 1σ error of the near-IR (NIR) source is $K_S = 14.03 \pm 0.20$, corresponding to a flux of $(1.63 \pm 0.33)\times 10^{-3}$ Jy (see also Table 2). The source appears point-like, with no evidence of extended emission. The approximate probability of a chance superposition down to the observed magnitude of the source is 3 per cent, or down to the limiting magnitude of the field ($K_S = 19.0$) is 11 per cent; these are the number densities of observed sources in the field at those magnitudes, times the area of the X-ray positional error.

2.3 *Swift* observations

We are further able to refine the *Swift*-XRT position of Landi et al. (2007), using the XRT online tool (Goad et al. 2007; Evans et al. 2009). This position (Table 1), based on a 3.6 ks exposure, is consistent with the previous XRT and *Chandra* positions as well as our newly proposed counterpart, but excludes the 2MASS source. While *Swift* was observing the field of IGR J17448−3232, it was also being observed with the Ultraviolet and Optical Telescope (UVOT; Roming et al. 2005). From the *Swift* archive, we find that 3592 s of *uw*2 image data were obtained. Using FTOOLS we summed the image data and, since no source was found at the position, derived a limiting magnitude of 21.82 (UVOT photometric system; Poole et al. 2008), equivalent to 1.38×10^{-6} Jy at 1.477×10^{15} Hz.

2.4 *Spitzer* observations

We utilize data from the *Spitzer Space Telescope*'s (Werner et al. 2004) Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE) and MIPSGAL surveys. The GLIMPSE (Benjamin et al. 2003) was carried out by the IRAC instrument (Fazio et al. 2004) aboard *Spitzer*. GLIMPSE spans 65° either side of the Galactic Centre up to ±2–4° in latitude, and includes mosaic images and catalogue entries at 3.6, 4.5, 5.8 and 8.0 µm. At the X-ray point source position there, is a GLIMPSE catalogued source, G356.8134−01.6971, as well as one coincident with the nearby 2MASS source. Two consistent magnitudes are given at each wavelength, so we calculate a weighted averaged and error for each (Table 2). MIPSGAL (Carey et al. 2009) is a survey of the inner Galactic plane using the MIPS instrument (Rieke et al. 2004) aboard *Spitzer*. It covers approximately the same longitudes as GLIMPSE, up to latitudes of ±1°, at 24 and 70 µm, though at the moment only the 24 µm mosaic product (Fig. 1) has been released and no catalogue is available. A source coinciding with the X-ray point source is visible in this image though the 2MASS source, visible at shorter wavelengths, is not. We have derived the flux and magnitude of this source by aperture photometry in IRAF and the photometric information in the image header (Table 2). There is no sign of any diffuse emission corresponding to the extended X-ray emission in any of the GLIMPSE or MIPSGAL mosaic images available.

3 MULTIWAVELENGTH SED

The infrared (IR) flux densities in Jansky (Jy), F_ν, at frequency ν (Table 2) were first converted to flux per filter, $F_{\rm filter}$, in units of photons cm^{-2} s^{-1}. This is done via $F_{\rm filter} = 1509.18896 F_\nu\ (\Delta\lambda/\lambda)$, where λ and $\Delta\lambda$ are the effective wavelength and width of the filter in question. XSPEC compatible files are then produced using the FTOOL, FLX2XSP. Within XSPEC, the IR, *Swift* UVOT and *Chandra* X-ray (Tomsick et al. 2009) data were initially fitted by a single power law where interstellar extinction and absorption were modelled by REDDEN and PHABS, respectively. However, this model gave an unsatisfactory fit ($\chi^2_\nu = 1.82$ for 16 degrees of freedom), namely due to a clear excess of emission at energies >5 keV that could not be accounted for by any possible pile-up. Including an additional, purely phenomenological, power-law component produces an improvement ($\chi^2_\nu = 1.00$) of the fit with power-law and extinction/absorption parameters similar to those of the initial fit. The best fit (Fig. 3) gives a broad-band spectral index, α ($F_\nu \propto \nu^\alpha$), from IR to X-ray of $\alpha = -1.057 \pm 0.015$ (1σ confidence), as well as a secondary spectral index (not plotted) to account for the excess emission >5 keV which can only be constrained to be within the range $1.4 < \alpha' < 2.3$. Unabsorbed X-ray fluxes and flux densities were calculated in five energy bins: 0.3–1, 1–2, 2–3, 3–5 and 5–10 keV.

The optical extinction is fitted as $E_{(B-V)} = 0.84^{+0.3}_{-0.15}$, and the equivalent hydrogen column density as $N_{\rm H} = 2.69 \pm 0.25 \times 10^{22}$ cm^{-2}, greater than the Galactic value of $N_{\rm H\,Galactic} = 0.67 \times 10^{22}$ cm^{-2} (Kalberla et al. 2005). These should be treated with caution due to the small range over which they are calculated and, in the case of extinction, the lack of sensitivity at those wavelengths. It is also worth noting that the best-fitting optical extinction is well below that of the Galactic value, $E_{(B-V)\,\rm Galactic} = 3.761$ (Schlegel, Finkbeiner & Davis 1998), though this should be treated with caution as estimates of the extinction so close to the Galactic plane

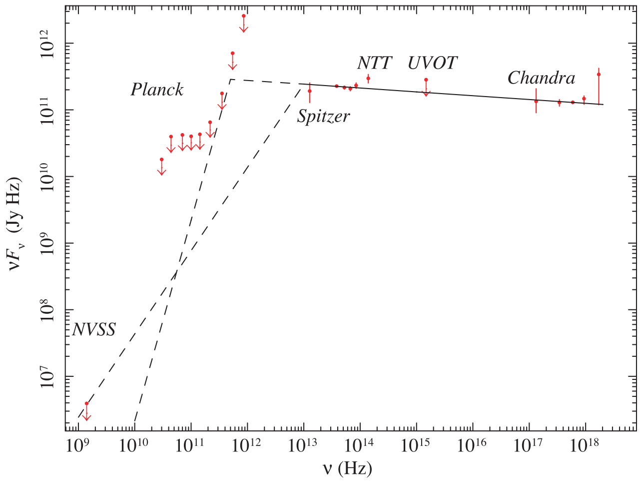

Figure 3. Unabsorbed/dereddened (Cardelli et al. 1989) SED for the point source, showing power-law fit ($\alpha = -1.057$) and two possible low-frequency spectral slopes ($\alpha = 0.25, 2.0$).

(<5°) are unreliable. The measured column density to the source implies an optical extinction (Güver & Özel 2009) of $E_{(B-V)\,\mathrm{Galactic}} = 3.9 \pm 0.4$, well in excess of the observed value, which suggests an intrinsic excess of N_{H} at the source.

The *Planck* limits imply that the spectrum breaks at a frequency, ν_{break}: $5 \times 10^{11} \lesssim \nu_{\mathrm{break}} \lesssim 1 \times 10^{13}$ Hz, i.e. between the *Planck* and *Spitzer* frequencies, though the exact value will depend on the sharpness of the break. The flattest possible spectral index, α, at low frequencies is ≈0.25. The upper limits are also consistent with a steepest possible (physical) spectral slope of $\alpha = 2$.

4 DISCUSSION

We detect an IR point source, with no evidence for extended emission, at the X-ray position of CXOU J174437.3−323222, the X-ray point source in the field of IGR J17448−3232. The probability of chance superposition, even in this crowded field, is relatively low at 11 per cent in the K_{S} band, or only 3 per cent for a source of this magnitude or brighter, and lower (1–4 per cent) in the more sparsely populated GLIMPSE fields. As X-ray flux measurements from *Swift*-XRT and *Chandra* are consistent, we can assume that the source is relatively persistent, though we cannot rule out variability. The IR to X-ray SED displays a single power law, with only a suggestion of excess emission above 5 keV (this single power-law SED derived from non-contemporaneous archive/catalogue values is another argument against a significantly variable source). There is no evidence in the SED for any thermal emission at any frequency in the observed bands. The spectral index of the power law, $\alpha \sim -1.0$, could correspond to the expected spectral slope of synchrotron emission from accelerated electrons; such electrons, accelerated to a power-law energy distribution $\mathrm{d}N \propto E^{-p}\mathrm{d}E$ with a cut-off at low energies, are expected, under standard assumptions, to emit high-energy photons with a spectral index of $\alpha = -(p-1)/2$ up to the cooling break frequency, which is due to the finite synchrotron-emitting lifetimes of the electrons, and $\alpha = -p/2$ thereafter (e.g. Longair 1994). The value of the electron energy distribution index, p, is thought to have a value of ∼2.0–2.5 (e.g. Kirk et al. 2000; Achterberg et al. 2001; Spitkovsky 2008; Curran et al. 2010), so the observed value of $\alpha \sim -1.0$ could correspond to a value of $p = 2.0$ for observations above the cooling frequency, though this is only one possible interpretation of the data.

This persistent, single power-law emission might be expected from a number of astronomical sources such as AGN, persistent X-ray binaries or magnetars; but in most of these cases, there would be a measurable thermal component, of which there is no evidence of here. Power-law emission would also be expected from an SNR or PWN, but the extended nature of these sources should be observable in either the X-ray or IR/optical, which is not the case (e.g. Gaensler & Slane 2006). As previously mentioned above, Tomsick et al. (2009) suggested a tentative association of the point source with the nearby SNR, hypothesizing that it may be an isolated neutron star that received a kick when the SN occurred. However, a pulsar would not be expected to be so bright in the NIR relative to the radio regime where a detection would be expected, but is not the case here. Noting that the source is so close to the Galactic Centre; if we assume a distance of 8 kpc, then the angular separation of 3 arcmin (corresponding to ∼8 pc) would require ∼16 000 years since the SN occurred, if a pulsar was given a kick velocity of $500\,\mathrm{km\,s^{-1}}$ [at the high end of the distributions of Brisken et al. (2003) and Hobbs et al. (2005)] . At that age, we would expect that the SN would have faded significantly, which does not seem to be the case, though of course this time can be reduced significantly by reducing the distance to the source. While we cannot rule out an association, we find it unlikely, and to confirm the point source as a pulsar, associated or not to the SNR, X-ray timing analysis is required.

One solution that can explain the emission is that the source is a blazar (e.g. Urry & Padovani 1995; Padovani 2007; Ghisellini 2011), an AGN with its jet pointing directly at us. Blazars are persistent sources, though it should be noted that they have been observed to undergo flares (e.g. Pacciani et al. 2010) and high-energy rapid variability. In this scenario, the emission in a given regime is dominated by synchrotron or IC emission from the jet which, because of its angle towards us, is much brighter than the thermal and other emission associated with the AGN. Even though the source is close to the Galactic Centre, the Galactic column density is relatively low in that direction, allowing the emission to be visible through the Galaxy. The excess column density required by the X-ray spectra suggests excess absorption which may be explained by absorption close to the source, though the apparent excess may also be an effect of spectral curvature. The measured IR and X-ray fluxes of this source, approximate radio limits and spectral slope are all broadly consistent with those of blazars in general (Fossati et al. 1998). In this framework, the apparent excess of emission at energies >5 keV, which we model, phenomenologically, with a second power law is due to the expected IC emission from blazars (e.g. Maraschi, Ghisellini & Celotti 1992); either IC emission from the interaction of the synchrotron generated photons with the electrons in the jet (synchrotron self-Compton) or from external photons interacting with jet electrons (external-radiation Compton). However, we cannot constrain this excess component from the *Chandra* spectrum alone and the source is unresolved from the SNR in the higher energy bands (i.e. *Swift*-BAT, *INTEGRAL*).

Tests of this hypothesis require an optical or IR spectrum with which to confirm the extragalactic nature of the source, though blazars are expected to have no or only very weak lines; so it may be the absence of lines, such as those that would be expected from Galactic sources, that will add weight to the blazar argument. Additionally, a high level of linear polarization might be expected if the source is a blazar, due to the synchrotron emission. However, the main test is a broader band SED spanning from radio to optical and into the high-energy X-rays, which should display the double synchrotron and IC peaks, or at least slopes, and confirm the absence of a thermal component. If this source is confirmed as a blazar, at $l, b = 356\overset{\circ}{.}81, -1\overset{\circ}{.}70$, while not the first in the Galactic plane (Vandenbroucke et al. 2010), it will be the first identified so close to the Galactic Centre (Massaro et al. 2009, 2010).

5 CONCLUSION

On the basis of positional coincidence and common spectral slope, we have identified a new IR counterpart to the X-ray point source, CXOU J174437.3−323222 in the field of IGR J17448−3232, visible from 2.2 to 24 μm. Multiwavelength spectral modelling shows that the data are consistent with a reddened and absorbed single power law over 5 orders of magnitude in frequency. This implies non-thermal, possibly synchrotron emission, that renders the previous suggestion that this source may be a pulsar, and its association to the extended SNR emission, unlikely. We propose that the emission may be due to a blazar viewed through the plane of the Galaxy, and we suggest a number of tests of this hypothesis.

ACKNOWLEDGMENTS

We thank the referee for their constructive comments. This work was supported by the Centre National d'Etudes Spatiales (CNES) and based on observations obtained with MINE: the Multiwavelength INTEGRAL NEtwork. JAT acknowledges partial support from Chandra award number GO1-12046X issued by the Chandra X-ray Observatory Center, which is operated by the Smithsonian Astrophysical Observatory for and on behalf of NASA under contract NAS8-03060.

REFERENCES

Abdo A. A. et al., 2010, ApJ, 188, 405
Achterberg A. et al., 2001, MNRAS, 328, 393
Ade et al., 2011, preprint (arXiv:1101.2041)
Benjamin R. A. et al., 2003, PASP, 115, 953
Bird A. J. et al., 2007, ApJS, 170, 175
Bird A. J. et al., 2010, ApJS, 186, 1
Brisken W. F. et al., 2003, AJ, 126, 3090
Burrows D. N. et al., 2005, Space Sci. Rev., 120, 165
Cardelli J. A., Clayton G. C., Mathis J. S., 1989, ApJ, 345, 245
Carey S. J. et al., 2009, PASP, 121, 76
Chaves R. C. G., the HESS Collaboration, 2009, preprint (arXiv:0907.0768)
Condon J. J. et al., 1998, AJ, 115, 1693
Curran P. A. et al., 2010, ApJ, 716, L135
Cusumano G. et al., 2010, A&A, 524, A64
Evans P. A. et al., 2009, MNRAS, 397, 1177
Fazio G. G. et al., 2004, ApJS, 154, 10
Fossati G. et al., 1998, MNRAS, 299, 433
Gaensler B. M., Slane P. O., 2006, ARA&A, 44, 17
Ghisellini G., 2011, preprint (arXiv:1104.0006)
Goad M. R. et al., 2007, A&A, 476, 1401
Güver T., Özel F., 2009, MNRAS, 400, 2050
Hobbs G., Lorimer D. R., Lyne A. G., Kramer M., 2005, MNRAS, 360, 974
Kalberla P. M. W. et al., 2005, A&A, 440, 775
Kirk J. G., Guthmann A. W., Gallant Y. A., Achterberg A., 2000, ApJ, 542, 235
Landi R. et al., 2007, Astron. Telegram, 1323
Longair M. S., 1994, High Energy Astrophysics, Vol. 2, 2nd edn. Cambridge Univ. Press, Cambridge
Maraschi L., Ghisellini G., Celotti A., 1992, ApJ, 397, L5
Massaro E. et al., 2009, A&A, 495, 691
Massaro E. et al., 2010, preprint (arXiv:1006.0922)
Monet D. G. et al., 2003, AJ, 125, 984
Murphy T. et al., 2007, MNRAS, 382, 382
Pacciani L. et al., 2010, ApJ, 716, L170
Padovani P., 2007, Ap&SS, 309, 63
Persson S. E. et al., 1998, AJ, 116, 2475
Poole T. S. et al., 2008, MNRAS, 383, 627
Rieke G. H. et al., 2004, ApJS, 154, 25
Roming P. W. A. et al., 2005, Space Sci. Rev., 120, 95
Schlegel D. J., Finkbeiner D. P., Davis M., 1998, ApJ, 500, 525
Skrutskie M. F. et al., 2006, AJ, 131, 1163
Spitkovsky A., 2008, ApJ, 682, L5
Stetson P. B., 1987, PASP, 99, 191
Tomsick J. A. et al., 2009, ApJ, 701, 811
Urry C. M., Padovani P., 1995, PASP, 107, 803
Vandenbroucke J. et al., 2010, ApJ, 718, L166
Werner M. W. et al., 2004, ApJS, 154, 1
Winkler C. et al., 2003, A&A, 411, L1

This paper has been typeset from a TEX/LATEX file prepared by the author.