Search for an Infrared Counterpart of IGR J16358–4756

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Abstract. We report here on near infrared observations of the field around IGR J16358–4726. The source belongs to the new class of highly absorbed X-ray binaries discovered by IBIS/INTEGRAL. Our primary goal was to identify the infrared counterpart of the source, previously suggested to be a LMXB and then further reclassified as a HMXB. We have made use of Chandra observations of the source in order to better constrain the number of possible counterparts. Using the differential photometry technique, in observations spanning a timescale of 1 month, we found no long term variability in our observations. This is compatible, and we suggest here, that the source is a HMXB.

Keywords: Infrared imaging, Near infrared observations, X-ray binaries

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INTRODUCTION

Not only, with the advent of the “International Gamma-ray Astrophysics Laboratory”, (INTEGRAL) [1] mission, has the number of known X-ray binaries increased as well a new category of sources was unveiled by the power of ISGRI/IBIS [2] telescope onboard INTEGRAL. The sources belonging to this new category are the so-called highly absorbed hard X-ray sources, with column densities higher than $10^{23}$ cm$^{-2}$ [3]. The recently discovered (2003 March 19) IGR J16358–4726 source [4] is one within this new category.

After its INTEGRAL discovery source was observed by Chandra ACIS-2 [5] significantly 9.7 off-axis imaging spectrometer. Chandra has, however, provided a position for the very soft (i.e., $\lesssim 10$ keV) X-ray counterpart with an $0''$.6 error radius [6]. Strong pulsations were also found with a period of $\sim 100$ min. After this study the source was classified as being a low mass X-ray binary (LMXB).

Triggered by the Chandra study, IBIS/INTEGRAL data up to revolution 114 were analyzed [7]. Those authors found the same Chandra 1.6 hours flux modulation in the 18–60 keV band. Source was classified, in this work (as usual for the highly absorbed sources), as a high mass X-ray binary (HMXB). Pulsed fraction is high ($\sim 70\%$) both in Chandra [5] and INTEGRAL [7] data.

Despite of the good quality of the available X-ray data, no counterpart was found yet (infrared, radio, etc.). The identification of infrared counterpart of recently identified INTEGRAL sources is the primary goal of an ongoing project by our group. Here we report preliminary results for IGR J16358–4726. In the next few sections we describe the ob-
servations, carried out in the near infrared with the available Brazilian instrumentation, then we show both data and data analysis, then our results and finally our conclusions will be presented.

OBSERVATIONS AND DATA ANALYSIS

We observed IGR J16358−4726 for 6 nights in 2004 June 22–24 and July 26–28 at Laboratório Nacional de Astrofísica (LNA/MCT, Brazil) using a 1.6 m telescope with the CamIV infrared camera (details in [8]). We did H band photometry for sources inside a 5” circular region centered in Chandra position. In our observations seeing conditions were always under 1”, images were taken with 60 s integration time in a field of view of 4’ × 4’. In our nearly 450 images, the magnitude limit is 19.5. Image reduction was done using specific tasks for CamIV integrated (and designed) for use within IRAF following standard procedures (like flat-fields, bad pixel mapping, background subtraction and the differential photometry itself). Figure (1) shows a slice 1.3 × 1’ of the CamIV field.

Immediately after the Chandra observations an infrared counterpart was suggested based in 2MASS archive [6]. The source is refereed as 2MASS J16355369-4725398, very close to the Chandra position at α = 16h35m53s.8 and δ = −47°25’41''.1 (J2000). Off-axis images of Chandra are known to be inaccurate in terms of centroid positions (see [9] and [10]) by amounts always less than 2”. In this sense our search box is exaggerated.

As usual, since our images are deeper than 2MASS ones, we discovered a new source, located in the very vicinity of the Chandra counterpart. We’re aware of the danger in doing circular aperture differential photometry rather than point spread function (PSF) extraction for such a source very close to other star, but we decided to take this approach in this preliminary study, and the results have shown that the technique performed quite well.

RESULTS AND DISCUSSION

Our results are shown in Fig. (2), where we display for each image the corrected magnitude and also averaged magnitudes for each of our 6 nights of observation on 2004 (June 22–24, July 26–28).

Possible photometric variability of the sources close to the X-ray error box was quantified in two ways: first, a simple χ² test, χ² = Σ_{i=1}^{N} (y_i − ӯ_i)²/σ_i, in which the null hypothesis is the constancy of ӯ. Here y_1,...,y_N (N=6) are the photometric measurements and σ_1,...,σ_N the corresponding errors. Notice that since σ_i are obtained from many differential magnitudes with respect to a well-exposed reference star, these quantities are quite robust, including the contributions of photon noise, scintillation and systematic effects. We obtained χ² = 0.70, 2.07, and 3.47 respectively for stars #1, #2, and #3 which corresponds to 98%, 84%, and 63% probability of constancy of the measurements.

The second way of testing for photometric variability is a little more elaborated, following [11]. The variance of the 6 nights of data is modeled as σ²_{total} = σ²_{noise} + σ²_{intrinsic}; that is, the data are supposed to be characterized by the noise σ_{noise} and
FIGURE 1. A ∼ 1′ × 1′ slice of the entire CamIV field including the 2MASS suggested counterpart of IGR J16358−4726 (labeled as 1). We can see clearly the presence of a source in the vicinity of 1 (labeled as 3), not previously known in the 2MASS archive. Around the source #1, our search box of 5″ is also showed. Other sources used in the differential photometry are marked with small circles. North is on top, East is on right.

some intrinsic variations $\sigma_{\text{intrinsic}}$. Maximum likelihood estimates produce $\sigma_{\text{intrinsic}} = 0.00$, 0.02, and 0.06 mag respectively. These small values, together with the $\chi^2$ results above indicate that the stars do not present any photometric variability, given the data available. It is interesting to note that, if the system is a HMXB, the light of the system must be dominated by the companion, consistent with our results shown here, and confirming the suggestion of [7].

CONCLUSIONS

We have presented here our infrared photometric measurements of IGR J16358−4726 inside a search box of 5″. The source belongs to a new class of highly photo-absorbed hard X-ray sources. Using a Chandra X-ray counterpart, we search for an infrared counterpart to IGR J16358−4726 inside a 5″ error search box. Upper limits to any variability for objects #1, #2, and #3 are 0.00, 0.02, and 0.06 respectively. If the system is a LMXB, as previously suggested by some authors, then we would expect to see
FIGURE 2.  (A) The corrected magnitudes for each of the ∼ 450 images for the 3 objects (labeled as #1, #2 and #3, as in Fig.[1] inside our search box of 5′′. We also plot the results for the sum of fluxes of several comparison stars (labeled as comp and made dimmer by 2 mags only for plotting reasons). (B) As in (A), but with the computed average magnitude for each night for each object. Horizontal lines are averaged values for the 6 nights. Error bars are also plotted individually (some can’t be seen due to its small values).

larger variations, otherwise we are forced to conclude that the infrared counterpart of IGR J16358−4726 is still unidentified. If the system belongs to the class of HMXB, also as previously suggested by some authors, then the light of the system must be dominated by the companion, and no photometric variations are expected: our data, that span a timescale of 1 month, seem to support that interpretation. We suggest that IGR J16358−4726 is a system belonging to the class of HMXB.

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