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Optical identification of hard X-ray source IGR J18257–0707

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We present the results of the optical identification of hard X-ray source IGR J18257–0707 through the spectroscopic observations of its optical counterpart with RTT150 telescope. Accurate position of the X-ray source, determined using Chandra observations, allowed us to associate this source with the faint optical object ($m_R \approx 20.4$), which shows broad H_α emission line in its optical spectrum. Therefore we conclude that the source IGR J18257–0707 is a type 1 Seyfert galaxy at redshift $z = 0.037$.

Keywords: X-ray sources — gamma-sources — active galactic nuclei — optical observations

The hard X-ray source IGR J18257–0707 was discovered in INTEGRAL all sky survey (Krivonos et al. 2007). This source is also known in literature as IGR J18259–0706 (e.g., Stephen et al. 2006). Our group systematically observe unidentified INTEGRAL sources with the aim to determine their nature (Bikmaev et al. 2006a,b, 2008; Burenin et al. 2008; Sazonov et al. 2008; Kniazev et al. 2008). In the case of IGR J18257–0707 the association of the X-ray source with its optical counterpart was complicated, therefore we present the results of the optical identification of this source in this separate Letter.

In soft X-rays the source was found also in ROSAT All-Sky Survey (RASS) and is included in ROSAT Bright Source Catalog as 1RXS J182557.5–071021 (Voges et al. 1999). The error circle for this source is of $\approx 20''$ radius — much more accurate than the localization error of INTEGRAL hard X-ray source, which is $\approx 5'$. However, this improved accuracy is still insufficient to associate this source with some object in optical band (Fig. 1).

Position of the hard X-ray source was refined using the X-ray telescope aboard SWIFT satellite, observations were made on Feb. 12, 2007. These data give the following coordinates of the X-ray source: $\alpha, \delta = 18:25:57.12, -07:10:24.4$ (J2000). Astrometric uncertainty of this position is about $6.5''$ and is mainly systematic (Moretti et al. 2006). Corresponding error circle is shown in Fig. 1.

The object is located at low Galactic latitude, $b = 2.35^\circ$, therefore due to high stellar density in this area there are more than one optical objects in SWIFT/XRT error circle. Spectra of some of these objects were obtained with Russian-Turkish telescope (RTT150). In

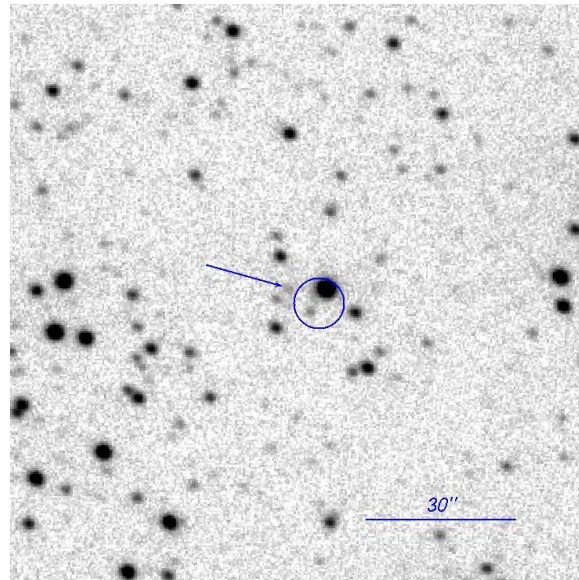


Fig. 1. The image of the field near IGR J18257–0707 in R band. The position of the source determined with SWIFT/XRT is shown with the circle. The size of the circle correspond to the SWIFT/XRT localization uncertainty ($6.5''$). Arrow denote the object which was identified as an optical counterpart of the X-ray source using Chandra observations.

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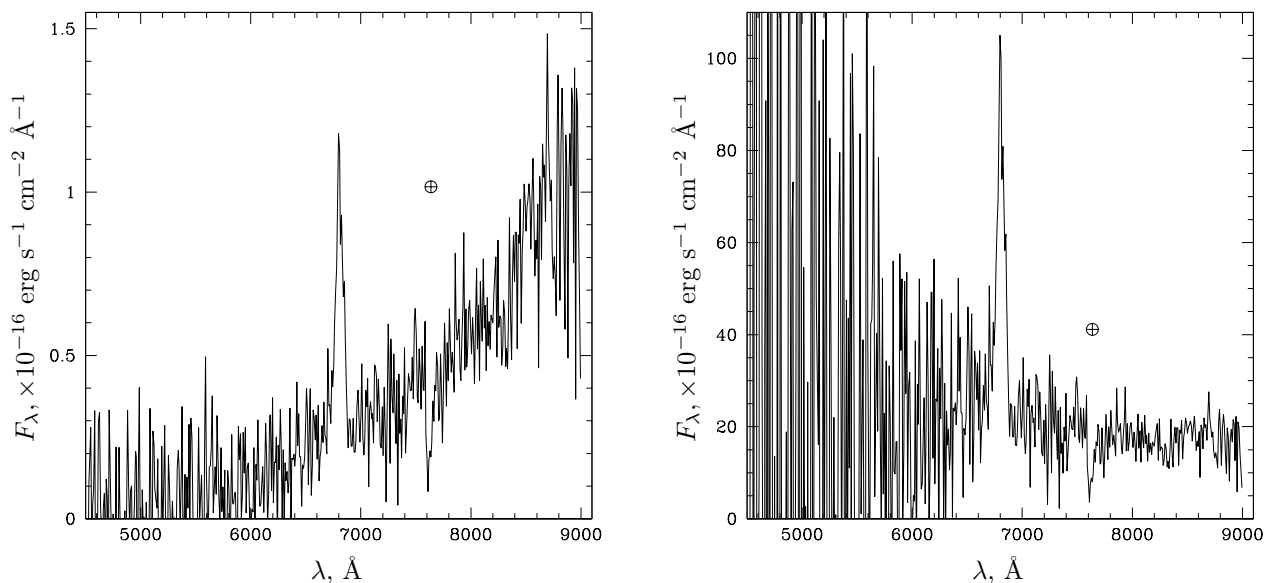


Fig. 2. Left: the spectrum of the optical object, associated with hard X-ray source IGR J18257–0707. Right: the same spectrum, corrected for the Galactic extinction $E(B - V) = 2.01$.

particular, using *TFOSC* spectrometer we obtained the spectrum of the bright ($m_R \approx 14.6$) star, located within the circle (Fig. 1). This object appeared to be an ordinary *K*-type star and there is a fair probability for such a star to be located in the SWIFT/XRT error circle by chance.

In order to obtain more accurate position of the X-ray source we used Chandra observations of this field made on Feb.14, 2008. With these data the position of the source was determined with the accuracy $0.64''$ (90% confidence): $\alpha, \delta = 18:25:57.58, -07:10:22.8$ (J2000). The detailed results of Chandra observations of the source will be presented in a separate paper (Tomsick et al. 2008).

Refined position of the source IGR J18257–0707 allowed to associate it with the optical object, shown with arrow in Fig. 1. This object is located in about $7''$ from the center of SWIFT/XRT error circle, the position of the optical object also coincides with the position of infrared source 2MASS J18255759–0710229 from 2MASS survey (Cutri et al. 2003).

The magnitude of the optical counterpart of IGR J18257–0707 is $m_R \approx 20.4$ and usually objects with similar magnitudes are considered to be too faint for spectroscopic observations with 1.5-m telescope. However, even for those faint objects, 1.5-m telescope is able to detect bright emission lines if they are present in the spectrum of the source. With the aim to search for these bright emission lines, with RTT150 telescope we obtained a number of spectra of the source with 6300 s total exposure time.

In these observations we used the $100 \mu\text{m}$ slit which

corresponds to $1.78''$ in the sky and grism #15 which provide the best optical transmission and the most wide spectral coverage (3500–9000 Å). Spectral resolution with this setup is $\approx 15 \text{ \AA}$ (FWHM). The data were reduced using standard *IRAF*¹ software. The aperture for the extraction of the object spectrum was defined using the spectrum of the nearby bright star which was also found in the slit.

The spectrum obtained in these observations is shown in Fig. 2. One can see the bright and broad emission line in the spectrum. The equivalent width of this line is -276 \AA , full width at half maximum is 3600 km s^{-1} . The lines with that large width are known only as hydrogen lines in quasars and AGNs spectra. Also, that can not be a line, where the other nearby bright lines are detected. For example, near the $H\beta$ line one should detect the bright [OIII], 4959, 5007 forbidden narrow emission lines, near the $L\alpha$ line bright NV, SiIV+OIV, CIV lines should be detected.

We conclude that this line should be identified with $H\alpha$ line at redshift $z = 0.037$. In that case the object is identified as nearby type 1 Seyfert galaxy, which constitute the main part of extragalactic objects among the optical identifications of new INTEGRAL hard X-ray sources (see, e.g. Bikmaev et al. 2006a; Burenin et al. 2008). The other emission lines which are usually observed in Seyfert 1 galaxies are not detected here for the following reasons: bright $H\beta$ and [OIII] lines are in blue part of the spectrum which is heavily absorbed in Galaxy. Other lines near $H\alpha$, like [SII] are much weaker than $H\alpha$ and are not detected due to low signal-to-noise

¹<http://iraf.noao.edu>

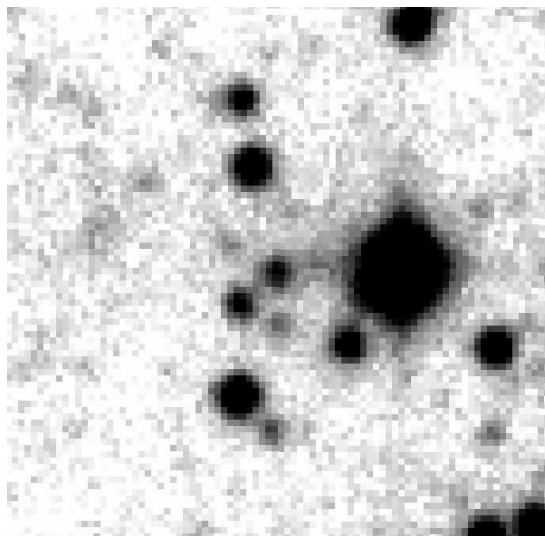


Fig. 3. The image of AGN identified with hard X-ray source IGR J18257–0707 in filter *I*.

ratio in our data.

Spectrum corrected for interstellar reddening $E(B - V) = 2.01$ (Schlegel et al. 1998) is also shown in Fig. 2. The overall shape of dereddened spectrum is consistent with the presence of nonthermal continuum which is typically observed in optical spectra of Seyfert galaxies (e.g., Elvis et al. 1994). The interstellar reddening $E(B - V) = 2.01$ approximately corresponds to $A(R) \approx 5.1$, therefore the brightness of the object corrected for Galactic absorption should be ≈ 15.3 . If the AGN host galaxy were of comparable magnitude, it would be detected in the optical images as an extended source. However, in our case we could not reliably determine the object extent, because the observations are hampered by PSF wings from the bright star in vicinity of the object. This is illustrated in Fig. 3.

The line of sight absorption column, measured in the X-ray spectrum of IGR J18257–0707 with SWIFT is approximately $n_H L = (1.4 \pm 0.4) \times 10^{22} \text{ cm}^{-2}$. From the other hand, the interstellar reddening $E(B - V) = 2.01$ with typical ratio $n_H L / E(B - V) \approx 4.8 \times 10^{21} \text{ cm}^2$ corresponds to the line of sight absorption column about $n_H L \approx 1 \times 10^{22} \text{ cm}^{-2}$. Approximately the same value $n_H L \approx 0.7 \times 10^{22} \text{ cm}^{-2}$ can be obtained from the HI map of the Galaxy (Dickey & Lockman 1990). Therefore, our data do not contradict to the suggestion that the absorption observed in X-rays originate completely in the disk of our Galaxy.

Thus, in result of our study of the hard X-ray source IGR J18257–0707 we conclude that this source is an active galactic nucleus — type 1 Seyfert galaxy at redshift $z = 0.037$.

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