Investigating the nature of IGR J17454-2919 using X-ray and NIR observations

Paizis, Nowak, Rodriguez, Segreto, Chaty, Rau, Chenevez, Del Santo, Greiner, Schmidl
Chandra ToO campaign active since Chandra AO5 (2003)
“INVESTIGATING NEW INTEGRAL SOURCES WITH Chandra”

PI: A. Paizis

IAUC 8063, Courvoisier et al., Feb 2003
“detection of the first transient source observed by the ISGRI detector of the IBIS instrument”

QLA:
http://xmm.esac.esa.int/external/xmm_news/items/IGR/index.shtml
Coffee break chat with Joern Wilms and Ken Ebisawa

Idea for a Chandra proposal!

“The trigger criterion will be an IBIS (15–40 keV band) detection of at least 20mCrab”

Chandra HETGs, 20 ks

- Sub-arcsec position accuracy
- Soft band spectrum of the source

Ks band, IGR J17497–2821
(Swift, 5″.3 ; Chandra, 0″.6, error circle radii)
• About 1 trigger every ~2 years

• No giant lines as in IGR J16318-4848 :

• Sources
  IGR J00291+5934      LMXB, accretion driven msec pulsar
  IGR J17511-3057      LMXB, AMSP & burster
  IGR J17497-2821      LMXB, BHC
  IGR J17177-3656      LMXB, edge on, BHC?
  IGR J18179-1621      HMXB, obscured accreting pulsar
  IGR J17454-2919      This talk

• Chandra position in ATel to allow multi-λ

• Chandra + INTEGRAL + other X-ray mission (RXTE, Swift) + multi-λ:
  NIR/Optical, Radio
IGR J17454-2919

**JEM-X discovery**: 2014 Sept 27

Monitoring **IBIS**: above 20mCrab @Oct 22

**Chandra**: 2014 Nov 3

**Atels:**
- Chenevez et al., ATEL #6530
  JEM-X discovery
  6.5±1 mCrab (3-10 keV)
  8.2±1.7 mCrab (10-25 keV).
  No significant time variation
  Swift follow-up → position at 5"

- Tendulkar et al., ATEL #6574
  NuSTAR observation
  consistent with properties expected for an accreting black hole in the hard state (NS not excluded)

- Chenevez et al., ATEL #6602
  JEM-X monitoring: about a factor two brighter
  10±1mCrab (3-10 keV)
  15±2mCrab (10-25 keV).
The J2000.0 Chandra position
RA: 17ʰ 45ᵐ 27ˢ.689
DEC: -29° 19' 53''.83
(90% uncertainty of 0''.6)

consistent with
2MASS J17452768 - 2919534

Paizis et al., ATEL #7020

The J2000.0 *Chandra* position
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**TABLE 3**
GROND, 2MASS, UKIDSS and VVV photometry

<table>
<thead>
<tr>
<th>Band</th>
<th>GROND(^a)</th>
<th>2MASS(^b)</th>
<th>UKIDSS(^b)</th>
<th>VVV(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(J^c)</td>
<td>16.07 ± 0.08</td>
<td>&gt; 16.227</td>
<td>16.587 ± 0.015</td>
<td>16.46 ± 0.02</td>
</tr>
<tr>
<td>(H)</td>
<td>13.10 ± 0.07</td>
<td>13.038 ± 0.065</td>
<td>13.150 ± 0.003</td>
<td>13.12 ± 0.01</td>
</tr>
<tr>
<td>(K_s)</td>
<td>11.37 ± 0.06</td>
<td>11.365 ± 0.024</td>
<td>11.334 ± 0.002</td>
<td>11.37 ± 0.01</td>
</tr>
</tbody>
</table>

\(^a\): NIR during source outburst.
\(^b\): Archival NIR catalogues.


→ Slight brightening in the J band during the outburst
**Chandra spectra & variability**

\[
tbabs(Wilms+00)\times po
\]

\[
N_H = 12.1^{+0.8}_{-1.1} \times 10^{22} \text{ cm}^2
\]

\[
\Gamma = 1.6 \pm 0.2
\]

Flux = 2.0 \times 10^{-10} \text{ erg cm}^{-2} \text{ s}^{-1}

L(2-8 \text{ keV}) = 0.9 \times 10^{36} \text{ erg s}^{-1}

No evidence for bursts or pulsations on scales: 4-10000 \text{ s}
Simultaneous broad-band spectra

Chandra + BAT

XRT + BAT

$tbabs^*po$

$N_H = (10-12) \times 10^{22} \text{ cm}^{-2}$

$\Gamma = 1.6 \pm 0.2 \quad ; \quad \Gamma = 1.8 \pm 0.1$

Flux = $(7-10) \times 10^{-10} \text{ erg cm}^{-2} \text{ s}^{-1}$

$L(0.5-100 \text{ keV}) = (5-7) \times 10^{36} \text{ erg s}^{-1}$

$\rightarrow$ No spectral var, no cutoff
**Swift results (spectra)**

$P_\text{o} (15-50 \text{ keV})$

$\Gamma = 1.9 \pm 0.5$

$tbabs*po (0.6-8 \text{ keV})$

$N_H = (7.5 - 10.7) \times 10^{22} \text{ cm}^{-2}$

$\Gamma = 1.5 \pm 0.3$

No spectral variability

Even the dip is in all bands
From $N_H$ to NIR

**Absorbing material GLOBAL**

- $N_H \sim 12 \times 10^{22} \text{ cm}^{-2}$
- $N_H \rightarrow A_v, A_K, A_J$
- $m_{Ks} = 11.37 \pm 0.06$ (GROND)
- $m_J = 16.07 \pm 0.06$ (GROND)
- $M_{Ks} = -8.1$ (@8kpc)
- $\rightarrow$ M-type red giant (LMXB)

But:
- $M_J - M_{Ks} = -2.8$ out of range
  - $-0.5 < M_J - M_{Ks} < 1.5$

**Absorbing material LOCAL to c.o.**

- $N_H \sim 1.2 \times 10^{22} \text{ cm}^{-2}$
- $N_H \rightarrow A_v, A_K, A_J$
- $m_{Ks} = 11.37 \pm 0.06$ (GROND)
- $m_J = 16.07 \pm 0.06$ (GROND)
- $M_{Ks} = -3.9$ (@8kpc)
- $\rightarrow$ K/M type red giant (LMXB)
  - B-type main sequence (HMXB)

But:
- $M_J - M_{Ks} = +3.6$ out of range

Most likely, we are *somewhere in between*: some of $N_H$ local to the c.o. *and* additional contribution from accretion disk (LMXB)
IGR J17454-2919: wrapping it up …

Abs PL ($\Gamma \sim 1.6-1.8$, $N_H \sim 10^{23}$ cm$^{-2}$); no cutoff @100 keV; $L^*_{0.5-100\text{keV}} \sim 10^{37}$ erg s$^{-1}$ (8kpc)

✔ LMXB in hard state (HMXB usually have cutoff within 40 keV)

✔ $N_H$ intrinsic to source or seen at high inclination

✔ No indication on compact object (4U 1850-087 is a burster with similar properties)
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Broad asymmetric Fe line (NuSTAR)
✓ Mostly LMXB (typical of accretion disc)
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60 day outburst with double peak, dip in all bands (4-5 days):
✓ Unlikely a spectral transition
✓ Intrinsic mass transfer (Cir X-1)? or change of the absorbing medium: dips from matter, eclipse by donor or tilted/warped accretion disc?
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Slight brightening in the NIR J band, constant in K and H
- Donor dominates H, K; increasing disc contributes to bluer band (LMXB)
- Disc contributes to $M_J - M_{Ks}$ and some $N_H$ local to the c.o. (LMXB)

LMXB, no indication on the compact object
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<th>#</th>
<th>Bibcode</th>
<th>Authors</th>
<th>Score</th>
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<td>Investigating the Nature of IGR J17454-2919 Using X-Ray and Near-infrared Observations</td>
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<td>2</td>
<td>2015ATel.7020....IP</td>
<td>Paizis, A.; Nowak, M.; Chatty, S.; Chenevez, J.; Del Santo, M.; Rodriguez, J.; Segreto, A.; Wilms, J.</td>
<td>1.000</td>
<td>02/2015</td>
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<td>Chandra position of IGR J17454-2919 and discovery of a possible NIR counterpart</td>
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<td>INTEGRAL/JEM-X sees enhanced activity in the Galactic center region: SAX J1747.0-2853 and IGR J17454-2919</td>
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<td>Tendulkar, Shrirash P.; Bachetti, Matteo; Tomsick, John A.; Chenevez, Jerome; Harrison, Fiona</td>
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<td>10/2014</td>
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<td>Hard X-ray spectral and timing properties of IGR J17454-2919 consistent with a black hole in the hard state</td>
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Tendulkar et al on its way, stay tuned!
Thank You
TABLE 2  
FIT TO IGR J17454—2919 SPECTRA: tbabs*po.

<table>
<thead>
<tr>
<th>Spectra</th>
<th>$N_H$(^{(a)}) ($10^{22}$ cm(^{-2}))</th>
<th>$\Gamma$</th>
<th>Average U_Flux (^{(b)}) ($10^{-10}$ erg cm(^{-2}) s(^{-1}))</th>
<th>Average Flux (^{(c)}) ($10^{-10}$ erg cm(^{-2}) s(^{-1}))</th>
<th>Average Luminosity (^{(d)}) ($10^{36}$ erg s(^{-1}))</th>
<th>Red $\chi^2$/Dof</th>
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<tr>
<td>Chandra/HETGS</td>
<td>12.1(^{+0.8}_{-1.1})</td>
<td>1.6±0.2</td>
<td>2.0(^{(b)})</td>
<td>1.1(^{(c)})</td>
<td>0.9(^{(d)})</td>
<td>1.05/66</td>
</tr>
<tr>
<td>Swift/(XRT+BAT)</td>
<td>10.5(^{+1.2}_{-1.1})</td>
<td>1.8±0.1</td>
<td>9.7(^{(e)})</td>
<td>7.1(^{(f)})</td>
<td>5.4(^{(g)})</td>
<td>0.87/66</td>
</tr>
<tr>
<td>Chandra/HETGS + Swift/BAT</td>
<td>11.9(^{+1.1}_{-1.0})</td>
<td>1.6±0.2</td>
<td>11.7(^{(e)})</td>
<td>9.7(^{(f)})</td>
<td>7.4(^{(g)})</td>
<td>1.03/69</td>
</tr>
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</table>

Note. — Error bars are 90\% confidence level for one parameter. Chandra spectra are shown in Figure 2 and discussed in Section 3.1.1. Swift/(XRT+BAT) spectra are shown in Figure 3, upper panel, and discussed in Section 3.3.1 while Chandra – Swift/BAT spectra are shown in Figure 3, lower panel, and discussed in Section 3.3.2.

\(^{(a)}\) In the fit we have used an improved model for the absorption of X-rays in the interstellar medium by Wilms et al. (2000).

\(^{(b)}\) Unabsorbed 2–8 keV flux.

\(^{(c)}\) Absorbed 2–8 keV flux.

\(^{(d)}\) Absorbed 2–8 keV luminosity, assuming a distance of 8 kpc.

\(^{(e)}\) Unabsorbed 0.5–100 keV flux.

\(^{(f)}\) Absorbed 0.5–100 keV flux.

\(^{(g)}\) Absorbed 0.5–100 keV luminosity, assuming a distance of 8 kpc.
Hard X-ray spectral and timing properties of IGR J17454-2919 consistent with a black hole in the hard state

ATel #6574; Shriharsh P. Tendulkar (Caltech), Matteo Bachetti (INAF/OAC), John A. Tomsick (SSL/UCB), Jerome Chenevez (DTU Space, Denmark), Fiona Harrison (Caltech) on behalf of the NuSTAR binaries team

on 13 Oct 2014; 20:10 UT

Credential Certification: Shriharsh Tendulkar (spt@astro.caltech.edu)

Subjects: X-ray, Request for Observations, Black Hole, Neutron Star, Transient

Referred to by ATel #: 6602, 7020, 7096

IGR J17454-2919 is a recently discovered X-ray transient that lies 24 arcminutes away from the Galactic Center (ATel #6530). NuSTAR observed the source starting at 2014 October 10, 9.17 h UT, and obtained an exposure time of 29 ks. An inspection of the 3-79 keV light curve does not show any evidence for bursts or pulsations, but the NuSTAR count rate drops from 2.8 c/s to 2.4 c/s (rates are for one NuSTAR module with no deadtime correction). We performed spectral and timing analysis of the NuSTAR data. The energy spectrum is well described (reduced chi2 = 1.06 for 748 dof) by an absorbed power-law with an exponential cutoff and a broad, asymmetric, iron emission line. The column density is (3.3 +/- 0.6)e22 cm^-2 (using Anders & Grevesse 1989 abundances; errors on all spectral parameters are 90% confidence), the photon index is 1.46 +/- 0.06, and the e-folding energy is >100 keV (with the "cutoffpl" model in XSPEC). The unabsorbed 3-79 keV flux is 3.96e-10 erg/cm2/s with a 0.8% error. At the Galactic center distance, this corresponds to an isotropic luminosity of 3e36 erg/s. The power spectrum consists of two components: a zero-centered Lorentzian peaking near 1 Hz and a power-law at lower frequencies. The Lorentzian has a width of 2 Hz and a fractional rms of 25 +/- 3%. The hard power-law index, the high energy of the cutoff, and the level of variability all are consistent with properties expected for an accreting black hole in the hard state. While we cannot completely rule out the possibility of a low magnetic field neutron star, a black hole is more likely.