unveils a supernova shock break-out candidate in XMM-Newton archival data

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**EXTraS: Exploring the X-ray TRAnsient and variable Sky**

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Partners:
- **INAF**, Italy *(PI: Andrea De Luca)*
- **IUSS Pavia**, Italy
- **CNR – IMATI Genova**, Italy
- **University of Leicester** (UK)
- **MPG – MPE**, Germany
- **FAU – ECAP**, Germany

EXTraS aims at exploiting the *serendipitous* content of the **XMM-Newton** archive in the *time domain* and to make it *publicly available* to the community.


*See talk by A. De Luca tomorrow at 5 p.m.*
For each EPIC observation, **source detection** is performed on images integrated on short time intervals.

The time intervals are derived from **Bayesian Blocks** (BB) analysis (Scargle 2013).

The **transient candidates** are only the new point-like sources detected within the regions from which the specific time interval was derived.

The transient candidates must be confirmed by manual **screening**.

**122 new transients**
Duration of high confidence transients

14 additional transients from regions close to bright sources (1 ks time bins)

The SN candidate is the shortest transient (315 s)
The SN candidate: X-ray data

Entire observation (net exposure >20 ks)

The new transient is NOT visible in the whole observation
The SN candidate: X-ray data

1σ position error: 1.9"

Time interval: 315 s

The position is consistent with a blue galaxy with no redshift reported in literature
Follow-up optical observations

From CTIO* optical high resolution spectrum we derive a redshift of $z = 0.092 \pm 0.003$, corresponding to a distance of 424 Mpc.

* (COSMOS spectrograph at the Blanco Telescope of the Cerro Tololo Inter-American observatory)
X-ray light curve

47 net counts by integrating the Gaussian profile
Comparison with SN2008D

The flare energy and duration are very similar to those of the X-ray transient associated to SN2008D*, interpreted as the emission from the shock break-out of a core-collapse supernova.

<table>
<thead>
<tr>
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<th>SN 2008D</th>
<th>Transient source</th>
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<tr>
<td><strong>d</strong></td>
<td>27 Mpc ($z=0.006494$)</td>
<td>424 Mpc ($z=0.092$)</td>
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<tr>
<td><strong>Fluence</strong></td>
<td>$2.3 \times 10^{-7}$ erg cm$^{-2}$</td>
<td>$8 \times 10^{-10}$ erg cm$^{-2}$</td>
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<tr>
<td><strong>Total energy</strong></td>
<td>$2 \times 10^{46}$ erg</td>
<td>$1.7 \times 10^{46}$ erg</td>
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<tr>
<td><strong>Peak luminosity</strong></td>
<td>$6.1 \times 10^{43}$ erg s$^{-1}$</td>
<td>$4.3 \times 10^{43}$ erg s$^{-1}$</td>
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</table>

X-ray **spectrum** possibly steeper than that of SN2008D*; >3σ evidence for absorption > $N_{H,\text{Gal}}=3 \times 10^{20}$ cm$^{-2}$

* (Soderberg et al., 2008)
Supernova association

Being discovered in archival data, no follow-up optical observations to search for a supernova; no sufficiently deep archival optical observations; outside OM FoV during XMM-Newton observation

SN2008 was discovered during the observation of a SN-rich galaxy, whereas our discovery is serendipitous

http://www.nasa.gov/centers/goddard/news/topstory/2008/swift_supernova.html
From this single detection, the (preliminary) event rate is $1.3 \times 10^5 \text{ yr}^{-1} \text{ Gpc}^{-3}$, consistent with Sorderberg et al. (2008) and a factor $\sim 2$ larger than core-collapse SN rate ($\sim 6 \times 10^4 \text{ yr}^{-1} \text{ Gpc}^{-3}$).

Optical SN searches might have missed a significant fraction of core-collapse SNe.
- The EXTraS algorithm for the detection of faint and short X-ray transients could detect an analogue of the SN 2008D X-ray flare at a >15 times larger distance (~300 times smaller fluence)
- After careful evaluation of the algorithm sensitivity and the systematic screening of the full XMM-Newton archive, a robust estimate of the event rate can be derived and compared with the core-collapse supernova rate

Conclusions

Work in progress

- More simulations to evaluate sensitivity and constrain event rate
- Further analysis of optical data to better characterize galaxy properties
- Optical follow-up of a few other possible SN candidates
- Search for additional SN candidates among fainter transients, 3XMM sources with <100 counts and more recent data