The Nature of the XMM-Newton Sources Discovered in the Galactic Plane

The XMM-Newton SSC Galactic Plane Survey

C. Motch and the SSC collaboration
Goals and Strategy for the Galactic Plane Survey

• Identify all EPIC sources in fields selected at various positions in the galactic plane (Fx > few $10^{-15}$ erg/cm$^2$/s, XID (0.5-4.5 keV band)
  – Characterize the low latitude populations
  – Use as calibration for statistical identification

• Identify X-ray/optical selected sources to search for rare and weird cases
Observations

• AXIS program
  – WHT/INT/NOT (imaging and spectroscopy)
• CFHT (CFH12k imaging, Hα)
• ESO:
  – WFI, 3.6m+EFOSC2, UT4+FORS2, VIMOS
• OHP:
  – 2m + CARELEC ($R_{\text{lim}} \sim 17$) -> bright stellar population only
Field selection

\[ R_{\text{lim}} \sim 21 \]

\[ R_{\text{lim}} \sim 17 \]
### Identification Statistics
(deep fields only)

<table>
<thead>
<tr>
<th>Fields</th>
<th>Nbr of Sources</th>
<th>% Stars</th>
<th>% EG</th>
<th>% Accreting</th>
<th>% Unidentified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low $b$ (~0°)</td>
<td>278</td>
<td>37%</td>
<td>~1%</td>
<td>~1%</td>
<td>60%</td>
</tr>
<tr>
<td>Mid $b$ (~3° 12°)</td>
<td>138</td>
<td>29%</td>
<td>~15%</td>
<td>~1%</td>
<td>54%</td>
</tr>
</tbody>
</table>

On going project ....
The stellar population

- XMM-Newton probes the young stellar population (age < 2Gyr) up to ~ 1kpc
- Main science issues:
  - Scale height increase with age
  - X-ray luminosity decrease with age
  - Recent stellar formation rate
  - IMF
- Means:
  - Comparison of observations with predictions of X-ray stellar populations models (Guillout et al. 2003)
Accreting components

- Rather scarce identified population
- Preferentially found in X-ray selected samples
- 7 new massive Be/X-ray binaries
  - Easiest to identify (optically luminous)
  - Hard X-ray spectra with sometimes heavy absorption
  - Balmer emission similar to other Be/X-ray systems
  - Several have low X-ray luminosities ($L_x \sim 10^{32-33} \text{ erg/s}$). A new population of $\gamma$-Cas like systems?
- 4 Cataclysmic Variables
  - Often need a VLT at XMM-Newton sensitivity
  - Mixture of AM Her and DN systems
XGSP –3 (Hands et al. 2004)

\[ V=20.5; R=16.2 \]
\[ EW(Ha)=101 \text{ A} \]
\[ F_x=4 \times 10^{-12} \text{ erg/s/cm}^2 \]
\[ \Gamma=1.03\pm0.27 \]
\[ N_h\sim2\times10^{22}\text{ cm}^{-2} \]
XGPS – 9 (Hands et al. 2004)

- EW (Hα) = 52 Å
- EW (HeII) = 35 Å
- V = 23.3, variable
- Fx = 8 \times 10^{-13} \text{ erg/s/cm}^2
- \Gamma = 1.38 \pm 0.24
- N_h \approx 4 \times 10^{21} \text{ cm}^{-2}
LogN-LogS curves at mid latitudes

AGN dominate X-ray counts at low energies
LogN-LogS curves at mid latitudes

AGN dominate X-ray counts at all energies

Unidentified + AGN

EG LogN-LogS

4.5–7.5 keV $|b| = 12.1 + 16.7$

$I = 100-230^\circ$

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LogN-LogS curves at low latitudes

Stars dominate number counts in the soft band

Stellar models $l=0-20^\circ$

Unidentified

All stars

$R<17$

Flux (ergs/cm$^2$/s)

N$>$S (per square degree)
Most hard X-ray sources remain optically unidentified. They are apparently not dominated by background AGN nor by stars.
Conclusions (1)

• Low to mid $b$ ($b \sim 5-20^\circ; l = 100-230^\circ$)
  – Extragalactic population dominates source counts at all energies
  – Stellar population models are in good agreement with observations

• Very low $b$ ($b = 0; l \sim 0-20^\circ$)
  – Stellar population dominates in the soft (0.5-2 keV) band
  – ISM patchiness makes comparison with stellar population models difficult. General agreement remains good.

• Will allow to efficiently constrain $z$, SFR and IMF
Conclusions (2)

• Very low \( b (b = 0; l \sim 0-20^\circ) \) ....
  – Strong evidence for the existence of an optically unidentified hard X-ray galactic population dominating at \( F_x \sim 10^{-13} - 10^{-14} \) erg/cm\(^2\)/s with a density of \( \sim 50/\text{deg}^2 \) (at \( F_x = 2 \times 10^{-14} \) erg/cm\(^2\)/s or \( L_x \sim 10^{32} \) erg/s at 7 kpc)
  - \( R_s \) Cvn ?, Be-X ?, CVs ?, wind accreting NS ?
  => need more optical Ids in the IR!
  – Consistent with results found by Hands et al. (2004) for the XGPS (\( l=20^\circ \)) and possibly more pronounced in our sample
  – Perhaps related to the population seen by Wang et al. (2001) and Muno et al. (2003) near the galactic center.