Two Space High Energy Astrophysics Missions of China: POLAR & HXMT

Shuang-Nan Zhang (张双南)

Institute of High Energy Physics
National Astronomical Observatories of China
Chinese Academy of Sciences
2016-02-11, LIGO team announced the shocking news: The gravitational wave predicted 100 yrs ago has been detected!

We did it!

Courtesy https://www.ligo.caltech.edu/video/ligo20160211v1
A gamma-ray burst with GW150914?

Fermi GBM Observations of LIGO Gravitational Wave event GW150914


(Submitted on 11 Feb 2016 (v1), last revised 16 Feb 2016 (this version, v3))

With an instantaneous view of 70% of the sky, the Fermi Gamma-ray Burst Monitor (GBM) is an excellent partner in the search for electromagnetic counterparts to gravitational wave (GW) events. GBM observations at the time of the Laser Interferometer Gravitational-wave Observatory (LIGO)event GW150914 reveal the presence of a weak transient source above 50 keV, 0.4 s after the GW event was detected, with a false alarm probability of 0.0022. This weak transient lasting 1 s does not appear connected with other previously known astrophysical, solar, terrestrial, or magnetospheric activity. Its localization is ill-constrained but consistent with the direction of GW150914. The duration and spectrum of the transient are consistent with a gamma-ray burst.
What is a gamma-ray burst?

Still not understood well!
INTEGRAL UPPER LIMITS ON GAMMA-RAY EMISSION ASSOCIATED WITH THE GRAVITATIONAL WAVE EVENT GW150914

V. Savchenko\textsuperscript{1}, C. Ferrigno\textsuperscript{2}, S. Mererghetti\textsuperscript{3}, L. Natalucci\textsuperscript{4}, A. Bazzano\textsuperscript{4}, E. Bozzo\textsuperscript{2}, S. Brandt\textsuperscript{5}, T. J.-L. Courvoisier\textsuperscript{2}, R. Diehl\textsuperscript{6}, L. Hanlon\textsuperscript{7}, A. von Kienlin\textsuperscript{6}, E. Kuulkers\textsuperscript{8}, P. Laurent\textsuperscript{9,10}, F. Lebrun\textsuperscript{9}, I. B. Neronov\textsuperscript{11}, D. Vigan\textsuperscript{4}, G. Wiedenmoeller\textsuperscript{6,12}

However INTEGRAL did not see anything!

The event had a magnetospheric origin. Eventually, considering that the false alarm probability of the GBM association relatively high (0.2%;\textsuperscript{8} Connaughton et al. 2016) and SPI-ACS does not detect it, it is likely that the GBM excess is a random background fluctuation.

\textsuperscript{1}DSM/Irfu/Service d’Astrophysique, Bat. 709 Orme des Merisiers CEA Saclay, 91191 Gif-sur-Yvette Cedex, France
\textsuperscript{2}Université Toulouse; UPS-OMP; CNRS; IRAP; 9 Av. Roche, BP 44346, F-31028 Toulouse, France
\textsuperscript{3}European XFEL GmbH, Albert-Einstein-Ring 19, 22761, Hamburg, Germany

Draft version March 8, 2016

ABSTRACT

Therefore with full and self-consistent general relativity calculation, we find that the in-falling matter will not accumulate outside the event horizon, and thus the quantum radiation and Gamma Ray bursts predicted in [2] and [3] are not likely to be generated. We predict that only gravitational wave radiation can be produced in the final stage of the merging process of two coalescing black holes. Future simultaneous observations by X-ray telescopes and gravitational wave telescopes shall be able to verify our prediction.
Two Space High Energy Astrophysics Missions of China: POLAR and HXMT

Shuang-Nan Zhang,
Institute of High Energy Physics & National astronomical Observatories of China, Chinese Academy of Sciences

Gamma-ray burst polarization: POLAR

China-Europe collaboration
Science goal: understanding GRB jet with polarimetry
Energy Range: 50~600 keV
Launch time: 2016-9-15

Polarization sensitive to relativistic jet properties
POLAR is a little bee on TG-2

POLAR detected GRBs

**GBM 160928825**
2016-09-28 19:48:03 UT  
maxSNR=15.7816 maxSN_timestart=-0.55s maxSN_duration=4.35s

**GBM 161009651**
2016-10-09 15:38:07 UT  
POLAR maxSNR=7.94619 maxSN_timestart=-12s maxSN_duration=40s

POLAR detected solar flares

POLAR detected solar flares

POLAR also detected the Crab pulsar.
China’s 1st X-ray astronomy satellite
Selected in 2011
Total weight ~2500 kg
Cir. Orbit 550 km, incl. 43°
Pointed, scanning and GRB modes
Designed lifetime 4 yrs
Launch in 1st half of 2017

Welcome international cooperation, especially radio and optical observations on ground and from the southern hemisphere.
**HXMT Payloads**

**High Energy (HE):**
- Normal Mode
  - NaI, 20-250 keV, ~5000 cm²
  - CsI, 50-700 keV, ~5000 cm²
- GRB Mode
  - NaI, 100-300 keV, 5000 cm²
  - CsI, 250-3000 keV, 5000 cm²

**Low Energy (LE):**
- SCD, 1-15 keV, 384 cm²

**Medium (ME):**
- Si-PIN, 5-30 keV, 952 cm²

---

Scanning survey of the Milky Way: new sources and activities of known sources

Most bright X-ray sources in the Milky Way are variable: black holes and neutron stars.

ESA’s Integral satellite

A black hole/neutron stars engulfs matter from its companion and generates bright and variable X-rays.

A rapidly spinning neutron star with the strongest magnetic field in nature generates bright X-rays.

1\textsuperscript{st} yr observation program: July, 2017

Most HXMT sources are visible from SA, but not from China!
HXMT scanning survey of the Milky Way

- Repeatedly scanning the whole Milky Way, to discover new variable black holes and neutron stars, and monitor activities of the known X-ray sources.
The Milky Way is highly variable in X-ray eyes!

HXMT scan mode

The Center of the Milky Way viewed by NASA RXTE satellite

HXMT’s new capability: GRBs

The most sensitive in soft gamma-rays (MeV), 10X larger than GBM on-board Fermi satellite.

Comparison of the two GRB detectors

<table>
<thead>
<tr>
<th></th>
<th>HXMT satellite</th>
<th>TG-2 POLAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>launch</td>
<td>2017</td>
<td>2016.09</td>
</tr>
<tr>
<td>Field of View</td>
<td>~2/3 sky</td>
<td>~1/2 sky</td>
</tr>
<tr>
<td>Energy: keV</td>
<td>100-2000</td>
<td>50-500</td>
</tr>
<tr>
<td>Location</td>
<td>~10 deg</td>
<td>~5 deg</td>
</tr>
<tr>
<td>GRB Parameters</td>
<td>Energy Spectra</td>
<td>Polarization</td>
</tr>
<tr>
<td>Advantage</td>
<td>γ-ray area</td>
<td>γ-ray pol.</td>
</tr>
<tr>
<td>No. of GRBs</td>
<td>200/year</td>
<td>50/year</td>
</tr>
</tbody>
</table>

Unique advantages of HXMT&POLAR in detecting GRBs possibly associated with Gravitational wave bursts!

We are very lucky in this exciting era!

POLAR&HXMT need helps of MeerKAT&SALT!

Many thanks for your attention!