Exploring the Gamma-ray Skies with the Fermi Gamma-ray Space telescope and the Fermi Asian Network (FAN)

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What is Fermi?

Two Instruments:

**Large Area Telescope (LAT)**
- PI: P. Michelson (Stanford University)
- 20 MeV - 300 GeV
- >2.5 sr FoV

**Gamma-Ray Burst Monitor (GBM)**
- PI: W. Paciesas (NASA/MSFC)
- Co-PI: J. Greiner (MPE)
- 8 keV – 40 MeV
- 9 sr FoV

**Launch:** June 11 2008
**Lifetime:** 5 years (req)
          10 years (goal)
About 2000 gamma-ray sources have been discovered.
Fermi two-year all-sky map

Credit: NASA/DOE/Fermi/LAT Collaboration
The Era of Fermi

- The Fermi Gamma-ray Space Telescope was launched on 2008 June 11. Nominal observations start in 2008 August.

- After 2009 summer, all data are in public domain immediately.

- Analysis tools and manuals are provided by NASA.

- Archival data are proven to be very important in astrophysics.

- Why don’t we make use of Fermi data to do some interesting science?
What is FAN?

- FAN is Fermi Asian Network
- FAN’s members: Taiwan (NTHU +CMU+NCU), Hong Kong (HKU), and Korea (Chungnam). ~15 academic staffs and students
- We aim to promote Fermi science in Asia (e.g. helping Purple Mountain Observatory (紫金山天文台) to organize a course in 2012 June)
- We also have collaboration with Japan
FAN Publications

- Largest number of Fermi papers (18 Astrophysical Journal + 5 ATels + 3 GCN in 2010-2013) outside the NASA-led Fermi collaboration
- Globular clusters: Kong+ 2010; Cheng+ 2010; Hui+ 2011; Tam+ 2011; J. Wu+ 2013
- Pulsars: Lin+ 2010; Tam+ 2010; Tam+ 2011; J. Wu+ 2012; Huang+ 2012; E. Wu+ 2012
- Unidentified Fermi objects: Hui+ 2011; Kong+ 2012
- Gamma-ray bursts: Tam & Kong 2011; Tam, Kong & Fan 2012; Tam+ 2013
- Supernova remnants: J. Wu+ 2011; J. Wu+ 2012
- We published some of the results faster than the Fermi collaboration
- For comparison: Fermi collaboration published ~130 papers from 2008
First Gamma-ray detection from a globular cluster (47 Tuc)
Abdo et al. 2009, Science

Stellar density: ~100 stars/light year$^3$
Fermi 17-month Observations of Terzan 5

Kong et al. 2010
Questions and followup works

- What is the emission mechanisms? See Cheng+ 2010; Hui+ 2011
- Can we detect GeV emission from other GCs? Abdo+ 2009; Kong+ 2010; Abdo+ 2010; Tam+ 2011
- We now have more than 15 detections including 2 with pulsations (e.g., Wu+ 2013)
- What is the relationship among different physical parameters? Hui+ 2011
A Gamma-ray outburst of a gamma-ray binary

Pulsar B1259 – 63
- Mass: About twice the sun’s mass
- Diameter: 12 miles (20 km)

Nov./Dec. 2010 disk passage
- Fermi observes faint gamma-ray emission

Pulsar closest approach
- Dec. 15, 2010

Jan./Feb. 2011 disk passage
- Fermi sees intense gamma-ray emission

LS 2883
- Type: Be star
- Mass: 24 solar masses
- Diameter: 9 suns

Gas disk

Pulsar orbit
- Period: 3.4 years
Gamma-ray binary
PSR B1259-63, Tam+2011
In the news
Unidentified Fermi object (UFO) as a ``radio-dim’’ gamma-ray emitting millisecond pulsar in

- ``Radio-dim’’ millisecond pulsars have not been identified yet
- It is not consistent with theories
- Traditionally, pulsars are discovered mainly from radio timing observations
- No radio => Need X-ray/gamma-ray data
- Also requires optical data to support
Unidentified Fermi object (UFO) as a "radio-dim" gamma-ray emitting millisecond pulsar in optical/X-ray @4.6hr

Kong+ 2012
主星：中性子星 → X線・ガンマ線（半径10km, 1.4太陽質量）

伴星：小型の恒星 → 可視光（半径 ~10万km, 0.1太陽質量）

吹き飛ばされたガス → 赤外線

軌道半径 100万km
周期4.63時間

パルサーからのプラズマ風 → X線・ガンマ線
Gamma-ray pulsation of a millisecond (3.05 ms)pulsar in the globular cluster M28

- So far only 1 globular cluster known to have gamma-ray pulsation (based on Fermi observations; Preire+ 2011, Science)
- M28 is the second one and is the fastest one
FAN Workshops

• 1st workshop: 2010 June 21-25 @HKU
• 2nd workshop: 2011 Aug 1-5 @NTHU
• 3rd workshop: 2012 June 20-24 @Korea
• 4th workshop: 2013 July 8-12 @HKU
• 5th workshop: 2014 July @Taiwan

Science talks + hand-on sessions + discussion

We publish while practising......

The workshop has evolved into many interesting projects. Since then, a few graduate students and post-doc have been working together.