High Energy Astrophysics

Katsuaki Asano
Members (2012–)

**Present Members**

**Staff:** K. Asano, K. Kawaguchi  
**PD:** A. Harada  
**Students:** S. To, K. Nishiwaki

**Former Members**

**Staff:** T. Terasawa  
**PD:** S. Kisaka, Y. Akaike, S. J. Tanaka, T. Kinugawa  
**Students:** R. Mikami, R. Takeishi, K. Sasaki, N. Hiroshima, W. Ishizaki

*Note: Due to lack of a staff associated with the graduate school, we did not accept students in 2015–2018. Now we can accept students from 2019.*
• Theoretical study in high-energy astrophysics (Asano, Kawaguchi, many PDs).
  - Gamma-ray burst, Blazar, Pulsar wind nebula, Compact binary merger etc.
  - Jet formation, Emission mechanism, Particle acceleration etc.

• Data Analysis (Terasawa, Akaike...)
  - Radio observation of giant radio pulses
  - CALET (Akaike)
Non-thermal phenomena

Some of astrophysical objects show very hard photon spectra, which seems inconsistent with the standard shock acceleration theory. We are working on an alternative mechanism: turbulence acceleration.

Evolution of electron energy distribution in a blazar with turbulence acceleration model.

Photon spectrum of Mrk 421 reproduced by our model. (Asano & Hayashida 2018)
Interaction with large-scale compressible MHD waves via transit-time damping leads to the hard-sphere acceleration, in which the acceleration timescale is independent of the particle energy.
Ultra-high energy cosmic rays and neutrinos

Gamma-ray burst
Asano & Meszaros 2013
Asano & Meszaros 2014
Asano & Meszaros 2016

GRB shock acceleration model.

GRB turbulence acceleration model

GRBs are still candidate of UHECR sources. Non-detection of neutrinos is consistent.
Other non-thermal phenomena

SSC emission in gamma-ray burst afterglow

\[ E(\gamma) \text{ [erg cm}^{-2} \text{s}^{-1}] \]

<table>
<thead>
<tr>
<th>Energy</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 GeV</td>
<td>[\times10]</td>
</tr>
<tr>
<td>0.1 TeV</td>
<td>[\times100]</td>
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</tbody>
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\[ E(\nu) = \nu \times 10^{-9} \text{ erg cm}^{-2} \text{s}^{-1} \]

\[ E(\nu) = \nu \times 10^{-11} \text{ erg cm}^{-2} \text{s}^{-1} \]

\[ E(\nu) = \nu \times 10^{-13} \text{ erg cm}^{-2} \text{s}^{-1} \]

6.8 GHz \[\times10\]

1 keV

\[ E(\nu) = \nu \times 10^{-15} \text{ erg cm}^{-2} \text{s}^{-1} \]

Fukushima et al. 2017

SSC emission is naturally expected in TeV range. Consistent with the recent MAGIC result.

Spatial profile of pulsar wind nebula.

Ishizaki et al. 2018

Our diffusion model explains both the spectrum and the spatial profile.
Pop III GW event rate

Kinugawa et al. 2017

NS–BH merger rate in each redshift.

We also estimate GRB rate with binary merger model (Kinugawa & Asano 2017)
GW170817 Kilonova: multi-component model


- We perform a radiative transfer simulation to interpret the optical/near-infrared electromagnetic counterparts to GW170817.

- We showed that the observation can be reproduced by a kilonova model of which ejecta profile is consistent with the prediction of numerical-relativity simulations, and the importance of the photon interplay between multiple ejecta components are demonstrated.
Our multi-component kilonova models are applied to explain the excess in optical/near-infrared wavelengths found in the observation of the afterglow of GRB160821B.

Ejecta masses estimated from the lightcurve comparison are consistent with the prediction of the numerical simulations, while they are relatively small compared to those estimated in GW170817. This indicates the diversity of kilonovae and could offer some clue to understand short GRBs as well as merger dynamics.
Collaboration with other groups

With CTA members

Asano & Hayashida 2015
Ackermann et al. 2016
Asano & Hayashida 2018

3C 279 flare with our model.

M87 with our model

Extremely hard blazar with our model
Collaboration with observational cosmology group

Kinugawa, Harikane, Asano 2019

Pop II Star formation history obtained by Harikane et al. 2018

GRB detection rate at high redshift

Assuming Lobster-eye optics
Data analysis: giant radio pulse from Crab pulsar

Prof. Terasawa coordinated multi-frequency simultaneous observations.

Iitate 325MHz  Kashima 1.7GHz  Usuda 2.3/8.4GHz  Takahagi 6.7GHz

Most of pulses are consistent with single power-law spectra. Softer, brighter. Hint for FRB.

Recently simultaneous observations with NICER have been done. Correlation with X-ray activity.

Mikami et al. 2016
Dr. Akaike is a very active member of CALET.

Electron+positron spectrum

We are planning to interpret the CALET results.

Gamma-ray upper limit for a GW event
Workshops etc.

We hold domestic workshops every year.

Most of talks are 1 hour or 2 hour talks.

Educational seminars for students in ICRR
one with CTA group
one with GW group

Published a textbook on GRB in 2019
Active researchers.
Our group have provided a career path for young scientists in high-energy astrophysics.