Multi-wavelength Observations of Galactic Microquasars

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Recent observations reveal ~ 20 microquasars with astrophysical jets in our Galaxy. However, the generation mechanism or the composition (i.e. hadronic / leptonic) of the jet is still unclear, as well as those of active galactic nuclei. Multi-wavelength observations are the key to detecting the synchrotron and inverse-Compton (as well as π^0-decay) emission from the jets. The Gamma-ray Large Area Space Telescope (GLAST) has unprecedented sensitivity, and will provide us the opportunities to study the gamma-rays from the microquasars. Through the survey observation of GLAST, there are also possibilities to reveal unidentified EGRET sources as new microquasars in our Galaxy. In this presentation, we estimated the detection sensitivity by GLAST and showed the recent progress of X-ray observations by the Suzaku satellite.

1. Microquasar

- Binary system consisting compact object (**stellar back hole/ weakly magnetized neutron star**) and normal star.
- **Relativistic jets** are sometimes observed.
  → Small scale analogues of quasars.
- 2 state : Soft vs. Hard
  → Radio jet is often observed when state changes from hard to soft.
- **γ-ray observation is frontier.**
  - **Inverse Compton** emission has not yet been observed significantly.
  - If jet consists of protons, γ-ray from **π^0 decay** may be emitted through interaction with inter stellar medium.

Released potential energy through accretion reaches ~10% of rest mass energy.

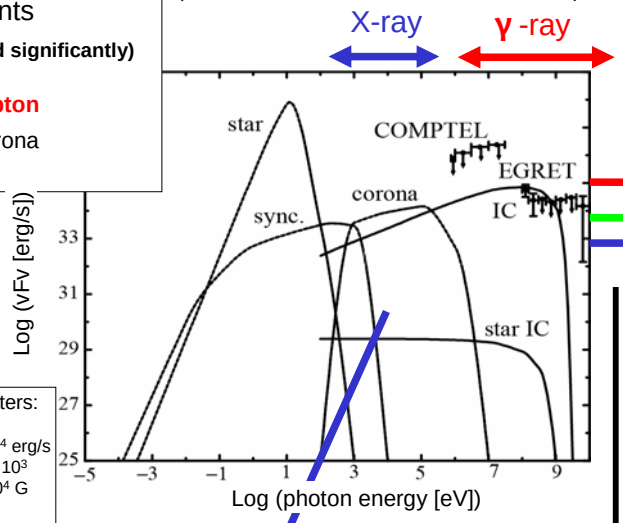
Sequences of radio observations
(Circinus X-1; Fender et al. 2004)

After X-ray flare, two bright radio spots appeared

2. Estimated SED (average luminosity)

(3EG J1735-1500; Bosch-Ramon et al. 2006)

Spectral components
- **Jet (Not yet observed significantly)**
  - **Synchrotron**
  - **inverse Compton**
- Accretion disk + corona
- Star



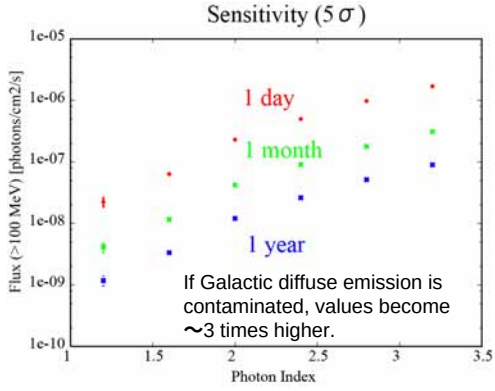
Assuming distance of several kpc

1 day
1 month
1 year

Assumed physical parameters:
Jet Lorentz factor = 1.2
Leptonic kinetic energy = 10^{34} erg/s
Maximum e^- Lorentz factor = 10^3
Maximum magnetic field = 10^4 G
e^- power-law index = 2
Angle of jet = 45 °

In the case of high-mass companion star, inverse Compton emission of star may exceed that of synchrotron.

3. GLAST sensitivity with DC2 data



- Estimated exposure to detect inverse Compton emission
  - **at average flux** → **~ 1 month**
  - **when source flares up** → **~ 1 day**

(GLAST can catch flare before source returns to faint state).

- Some of unidentified EGRET sources may be recognized as microquasars.

4. X-ray study of microquasars (**Suzaku observation of GRO J1655-40**; H. Takahashi et al. PASJ submitted)

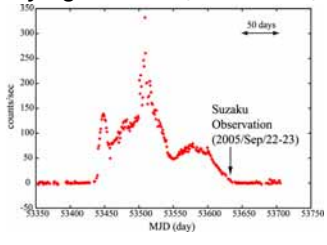
To derive information of accretion flow, simultaneous X-ray observation is very important.

Suzaku satellite

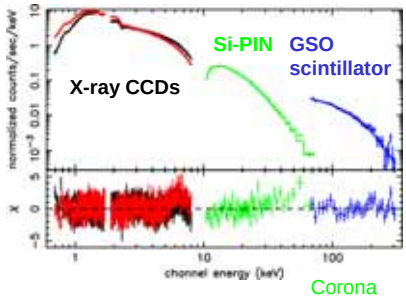
- Japanese 5th X-ray observatory
- **Wide energy band: 0.2−600 keV**
- **High sensitivity**
  → **Energy spectrum even with one-day exposure**

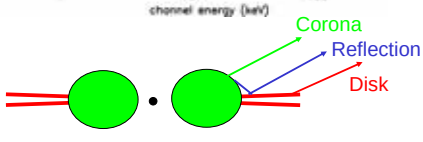
GRO J1655-40
- black hole + low-mass star
- 6 M_{solar}, 3.2 kpc
- Lx (0.7-300 keV) : 4 x 10^{36} erg/s.

X-ray light curve (2005 outburst)

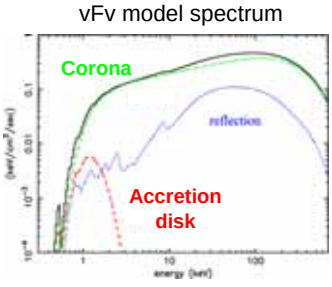


One-day average spectrum of low state (0.7-300 keV)





vFv model spectrum



- State was determined as Low state.
- Accretion disk structure
  → innermost radius
- Geometry of corona
  → e^- temperature, optical depth

5. Conclusion

To study physics of microquasars, multi-wavelength observations are essential.

- GLAST
  - Survey will detect inverse Compton emission from jet.
  - Some of EGRET sources may be revealed as microquasars.
- Simultaneous X-ray observation (by Suzaku) can determine states of microquasars and derive physical parameters of accretion flow.
- Other wavelength is also important to obtain entire shape of SED.