Optical—Infrared Observation of Astronomical Transients with the "KANATA" 1.5-m Telescope

Uemura, M.,[1] and the KANATA team

[1] Astrophysical Science Center, Hiroshima University, Kagamiyama 1-3-1, Higashi-Hiroshima, 739-8526, Japan
E-mail(MU): uemuram@hiroshima-u.ac.jp

Abstract

In the last decade, studies of astronomical transient phenomena entered a new era, in which we can promptly receive and send the information about transients and variables. On the other hand, large ground-based telescopes can provide only few observation times for them, which is insufficient to perform dense and long monitorings of transients. Here, we introduce our new observatory and telescope, which are developed exclusively for studies of various kinds of transients. Our 1.5-m telescope "KANATA" was installed at Higashi-Hiroshima Observatory in May 2006. We can study transients in near-infrared wavelengths, with polarimetry, and with high-speed photometry. These observation modes have revealed several new features of our targets, such as gamma-ray bursts, blazars, X-ray binaries, supernovae, and cataclysmic variables.

Key words: infrared:general — polarization — telescopes

1. Introduction

Astronomical transient phenomena have received much attention since ancient times. The situation of observations of them has recently experienced a revolution led by the development of the Internet. We can now send the information of variables and transients to general public, immediately receive them, and quickly start observations. On the other hand, the revolution was, in general, applied only to observations with small, 30-cm class telescopes, since only few observation times were allowed for transients in large telescopes. Most recently, however, the situation has been changing. Due to the growing number of $>$ 3 m class telescopes, 1-m class telescopes are now regarded as "small" ones, having a plenty of flexible observation times. They have a great potential for observations of transients.

Here, we introduce our project, "Higashi-Hiroshima Observatory". We moved a 1.5-m telescope installed in Tokyo in 1995 by National Astronomical Observatory of Japan to Hiroshima, and rebuilt its driving system. In 2006 May, our new observatory opened, and the telescope was named "KANATA" (having a meaning of "far away"). KANATA is the telescope dedicated for astronomical transients. Owing to a plenty of observation times and an easy access to the observatory (20-min by car from our office), we have obtained several results for γ-ray bursts (GRBs), blazars, supernovae, X-ray binaries, cataclysmic variables, and others, which are shown below.

2. "KANATA" and Instruments

As a 1-m class telescope, KANATA is one of standard systems, having Ritchey-Chretien optics and three available focuses (one Cassegrain and two Nasmith), except for its high driving speed. The azimuth and altitude driving speeds are 5° and $2^\circ\,\mathrm{s}^{-1}$, respectively. This high motion is required to obtain very early light curves of GRBs and their afterglows.

At the Cassegrain focus, TRISPEC, developed by Nagoya University, is currently attached to KANATA (Watanabe et al. 2005). In TRISPEC, the incident light is divided into optical (0.45—0.90 μm) and two infrared lights (0.90—1.85 and 1.85—2.5 μm) by two dichroic mirrors. Each path has wheels including grisms and Wollaston prisms. As a result, TRISPEC works as a simultaneous optical and near-infrared imager, spectrograph, and polarimeter.

There are still only few observatory which can monitor variables in the near-infrared region, although it provides an important information for objects showing dust formation episodes and jets, for example, classical novae, blazars, and microquasars. Figure 1 shows the K_s-band light curve of a famous microquasar GRS 1915+105 obtained with TRISPEC/KANATA. Between JD 2454350 and 2454550, we can see a previously-unknown anticorrelation between the infrared and X-ray fluxes. During this period, the object was in its soft X-ray state. We consider that the infrared emission originated from the thermal accretion disk, which occasionally disappeared or weakened when X-ray flares occured (Arai et al. 2008, in prep)

As well as infrared observations, polarimetric observations were also desired for transients and variables, for example, showing anisotropic explosions and synchrotron jets. Figure 2 shows the light curve and the temporal evolution of polarization parameters on the Stokes $Q-U$ plane of a blazar 3C 454.3, obtained with TRISPEC/KANATA. The polarization vector experienced clockwise rotation around the maximum of the giant flare in JD 2454300—2454350, as can be see in figure 2. Between JD 2454370 and 2454500, the object experienced repetitive short flares superimposed on a gradually brightening trend. On the $Q-U$ plane, we can see that these short flares have their specific polarization vectors, and furthermore, their vector was apparently rotating anticlockwise with time. These episodes of the rotation of the polarization vector may indicate a moving of the emitting region through a helical magnetic field in a jet (Sasada et al. 2008, in prep).

At the 1st Nasmith focus of KANATA, High Speed Camera is attached, as a collaboration with the Kyoto University team. It has a frame transfer CCD chip, enabling the fastest time-resolution of 0.03 s. We use this camera for X-ray binaries and cataclysmic variables, in which the gas rapidly rotates around compact objects. Its spectroscopic mode is now under development.

For the 2nd Nasmith focus, we are now developing a new instrument, "HOWPol" (Hiroshima One-shot Widefield Polarimeter), which focuses on rapid variations of polarizations. The engineering first-light of HOWPol was performed in July 2008. A new infrared—optical camera is also under development. It will be the instrument to be replaced with TRISPEC.

3. Summary and Future Plan

KANATA can provide unique data of transients, in terms of infrared, polarimetric, and high speed observations. These observation modes, in particular, can be a great tool for studies of jet sources, as shown in figure 1 and 2. From August 2008, we are planning to perform observational campaign for blazars, collaborating with the *Fermi* satellite. Preliminary results of blazars and other transients are reported in our web site[1]

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References

Watanabe, M. et al., 2005, PASP, 117, 870

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*[1] http://kanatatmp.blogspot.com/

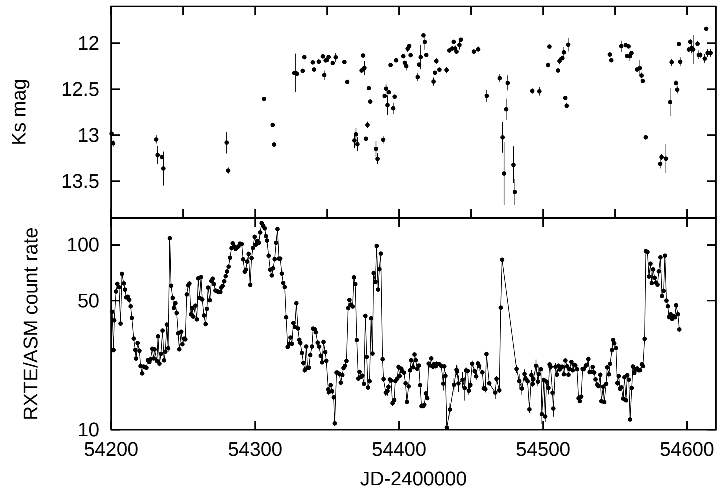

Fig. 1. K_s-band (upper panel) and X-ray (lower panel) light curves of GRS 1915+105..

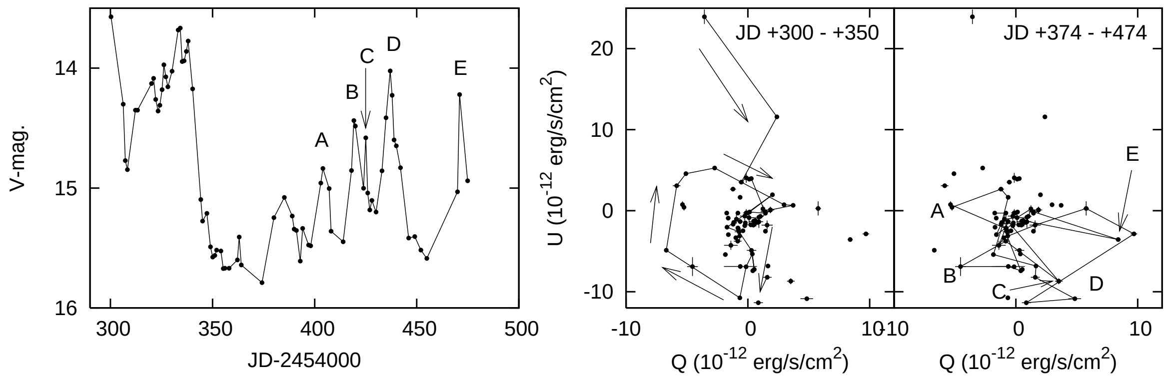

Fig. 2. (Left panel) Light curve of 3C 454.3 in 2007. (Middle and Right panels) Temporal variations of the polarization parameters on $Q-U$ plane. The directions of QU are not corrected to the standard north-east ones.