Multi-Wavelength Observations of the Microquasar SS433

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Abstract

A radio-IR-optical-X-ray observation campaigns have been performed in 2006 April and 2006 December for SS433, the unique microquasar known for the very stable continuous jet emanating at a quarter of the speed of light. The participating observatories/telescopes include Suzaku, RXTE, BTA, 150-cm Telescope at Gunma, Nayuta at Nishi-Harima, Crimean Observatory, MITSuME, VSOLJ, 1.4-m Telescope at SAAO, RATAN-600, RT-32 at IAA RAS, and Nobeyama Millimeter Array. In the April campaign, five radio flares have been detected and the source seems to be in the active state. In the December campaign, a single radio flare has been detected, and we triggered a series of observations with RXTE.

Key words: X-ray binary: SS433 — transient — multi-wavelength

1. Introduction

SS433 is the unique microquasar known for the very stable continuous jet emanating at a quarter of the speed of light. Multi-wavelength observation campaigns are very important to understand the system, in which multi-wavelength emission mechanisms are working; synchrotron radio emission from the high-energy electrons in the jet, thermal optical emission from the super-critical accretion disk, and X-ray from the inner edge of the disk and the central engine.

We have performed multi-wavelength observation campaigns for several microquasars including SS433 (Trushkin et al. 2006; Kotani et al. 2006; Kubota et al. 2008), Cyg X-3 (Tosaki et al. 2006; Tsuboi et al. 2006, 2008), and GRS 1915+105. Two campaigns performed in 2006 are reviewed in the following.

2. Campaign in 2006 April

The source has been observed with the X-ray astronomical satellite Suzaku at MJD = 53830 and 53833. An optical-IR-radio observation campaign was performed to cover the periods of the Suzaku observations. Spectra have been taken with the 6-m Telescope (Afanasiev et al. 2001) at the Special Astrophysical Observatory, Russian Academy of Science (SAO RAS), the 122-cm Telescope at the Padova-Asiago Observatory (Iijima 2002), the 150-cm Telescope at the Gunma Astronomical Observatory obayashi04, and the Nayuta (Narusawa et al. 2006) Telescope at the Nishi-Harima Astronomical Observatory. Photometric data have been obtained with the KGB-38 Telescope at the Crimean Astrophysical Observatory (Pavlenko et al. 20000, a non-filter 40-cm Telescope at the Kyoto University equiped with an SR-7 CCD camera of SBIG, MITSuME Akeno 50 cm (Kotani et al. 2005; Shimokawabe et al. 2008) at the Akeno Observatory, MITSuME OAO 50 cm (Kotani et al. 2005; Shimokawabe et al. 2008) at the Okayama Astrophysical Observatory (OAO), the 51-cm Telescope at the Osaka Kyoiku University (Yokoo et al. 1994), and telescopes in VSNET kato04 and in the Variable Star Observers League in Japan (VSOLJ) (Kato et al. 2004). Infrared photometry data have been obtained with the IRSF 1.4-m Telescope (Kandori et al. 2006) at the South African Astronomical Observatory (SAAO). The radio activity from 1.0 GHz to 21.7 GHz has been monitored with the RATAN-600 korolkov79,trushkin07 at SAO in the period covering the campaign. Radio observations at 2.3 and 8.5 GHz have been carried out simulteneously with the 32-m radio telescope (RTF-32) at the Institute of Applied Astronomy RAS (IAA RAS). The Nobeyama Millimeter Array (NMA) (Morita 1994; Tsutsumi et al. 1997) at the Nobeyama Radio Observatory have also participated in the campaign. A comprehensive observation log is presented in Kotani et al. (2006), and the X-ray data are

analyzed in Kubota et al. (2008).

The radio light curves exhibit five radio flares, suggesting that the source has been in the active state successively ejecting massive jets.

3. Campaign in 2006 December

SS433 has been monitored with RATAN-600 (Korolkov & Pariiskii 1979; Trushkin et al. 2008) and the 60-cm Maksutov telescope at the Crimean Observatory (Pavlenko et al. 2000) from 2006 November. The observation log and light curves are shown in Table 1-4 and Fig. 1.

In December, a significant radio flare has been detected (Trushkin et al. 2006). The 1-22-GHz flux densities has increased from a quiet optically thin synchrotron spectrum,

$$S_\nu/\mathrm{Jy} = 1.05 \times (\nu/\mathrm{GHz})^{-0.54},$$

on 2006 December 6.48 (MJD=54075.48) to flaring one,

$$S_\nu/\mathrm{Jy} = 2.90 \times (\nu/\mathrm{GHz})^{-0.43}$$

on 2006 Dec 8.47 (MJD=54077.47). The optical magnitude has also been increased from V=13.94 mag and Rc=12.52 mag at MJD=54075.691 to B=15.61 mag, V=13.41 mag, and Rc=11.99 mag at MJD54076.633. The last visual magnitude is one of the maximum values during last years.

We have triggered a series of RXTE TOO observations. Spectroscopic and radio follow-up observations have been performed at Gunma Astronomical Observatory (Obayashi et al. 2004) and with the Nobeyama Millimeter Array (Morita 1994; Tsutsumi et al. 1997). The optical light curves again show a rise in the last bins of the data, but no flare is detected in other bands.

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Table 1. X-Ray observation log.

Start		End		Expos.	Remark
(MJD)		(MJD)		(ks)	
Observatory: RXTE (Jahoda et al. 1996). PI: T. Kotani.					
2006/12/16 22:37	(54085.9425)	2006/12/16 23:25	(54085.9758)	2.9	
2006/12/17 23:48	(54086.9918)	2006/12/18 00:15	(54087.0105)	1.6	
2006/12/18 23:21	(54087.9730)	2006/12/18 23:50	(54087.9932)	1.7	
2006/12/19 22:54	(54088.9543)	2006/12/19 23:24	(54088.9751)	1.8	
2006/12/20 21:51	(54089.9105)	2006/12/20 22:27	(54089.9355)	2.2	
2006/12/21 23:04	(54090.9612)	2006/12/21 23:40	(54090.9862)	2.2	
2006/12/22 22:36	(54091.9418)	2006/12/22 23:13	(54091.9675)	2.2	
2006/12/23 17:40	(54092.7362)	2006/12/23 18:13	(54092.7591)	2.0	
2006/12/24 20:08	(54093.8390)	2006/12/24 20:41	(54093.8619)	2.0	
2006/12/25 21:37	(54094.9008)	2006/12/25 22:27	(54094.9355)	3.0	
2006/12/26 21:44	(54095.9057)	2006/12/26 22:07	(54095.9216)	1.4	
2006/12/27 17:29	(54096.7286)	2006/12/27 18:18	(54096.7626)	2.9	

Table 2. Spectroscopy log.

Start		Exposure	Remark
(MJD)		(s)	
Telescope: 150 cm (Obayashi et al. 2004). Observatory: Gunma. PI: K. Kinugasa.			
2006/12/11 08:55	(54080.37)	1080	
2006/12/19 08:44	(54088.36)	1080	
2006/12/20 08:33	(54089.36)	900	
2006/12/23 08:41	(54092.36)	540	
2006/12/25 08:35	(54094.36)	720	

Table 3. Photometry log.

Start (MJD)	End (MJD)	Frames	Remark
Instrument: 60-cm reflector. Observatory: Crimean (Pavlenko et al. 2000). PI: V. Goranskij.			
54071.6747	54071.6873	V:5, B:0, Rc:0, I:0	50-cm Maksutov telescope
54072.6355	54072.6600	V:5, B:3, Rc:2, I:0	
54073.6347	54073.6480	V:2, B:3, Rc:1, I:1	
54074.6385	54074.6708	V:4, B:1, Rc:1, I:0	
54075.6877	54075.6907	V:2, B:2, Rc:1, I:1	
54076.6328	—	V:1, B:1, Rc:1, I:1	
54077.6282	54077.6936	V:19, B:19, Rc:18, I:18	
54078.6326	54078.7085	V:24, B:24, Rc:24, I:23	
54079.6289	54079.7103	V:24, B:23, Rc:24, I:19	
54084.6418	—	V:1, B:1, Rc:1, I:1	
54085.6216	54085.6914	V:26, B:26, Rc:26, I:20	
54086.6510	54086.6567	V:2, B:2, Rc:1, I:0	
54091.6376	54091.6838	V:21, B:21, Rc:18, I:11	
54095.6463	54095.6678	V:7, B:6, Rc:4, I:3	

Table 4. Radio observation log.

Start		End		Remark
	(MJD)		(MJD)	
Telescope: RATAN-600 (Korolkov & Pariiskii 1979; Trushkin et al. 2008). Observatory: SAO RAS. PI: S. Trushkin.				
2006/11/03	(54042)	2007/02/16	(54148)	1.0 GHz–21.7 GHz
Telescope: Nobeyama Millimeter Array (Morita 1994; Tsutsumi et al. 1997). Observatory: Nobeyama. PI: K. Nakanishi				
2006/12/11 05:01	(54080.2090)	2006/12/11 07:30	(54080.3125)	115.271204 GHz
2006/12/27 04:15	(54096.1771)	2006/12/27 07:41	(54096.3201)	115.360478 GHz
2006/12/28 04:08	(54097.1722)	2006/12/28 09:08	(54097.3806)	115.360478 GHz
2006/12/29 04:12	(54098.1750)	2006/12/29 09:14	(54098.3847)	115.360478 GHz
2007/01/19 03:02	(54119.1264)	2007/01/19 06:29	(54119.2701)	115.271204 GHz
2007/01/21 03:08	(54121.1306)	2007/01/21 06:28	(54121.2694)	146.969049 GHz
2007/02/16 02:36	(54147.1083)	2007/02/16 04:00	(54147.1667)	109.782182 GHz
2007/02/18 23:54	(54149.9958)	2007/02/19 01:30	(54150.0625)	109.782182 GHz

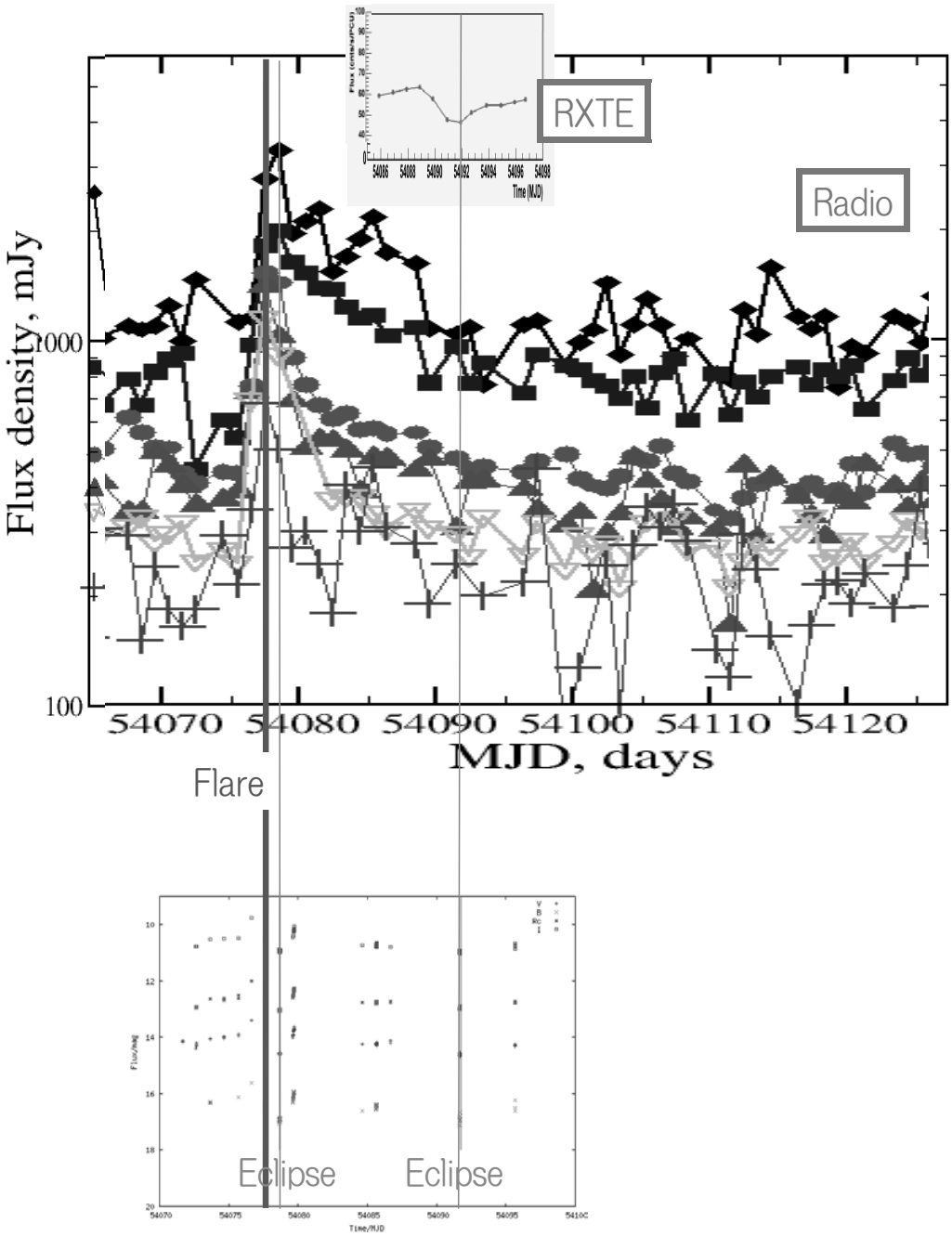

Fig. 1. Radio, optical, and X-ray light curves. A radio flare and two eclipses are indicated by vertical lines.