Microquasars And Microblazars As Potential Targets Of Ground Based Cherenkov Telescopes

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Abstract

The discovery of highly relativistic jets and superluminal motion from some x-ray binaries (Microquasars) and the tentative identification of two unidentified EGRET sources with the Microquasars LS 5030 and LSI+61 303, has revitalized the interest in these sources as candidate targets for ground based gamma-ray astronomy. Here we present a possible strategy for the MAGIC telescope to search for VHE gamma-rays from these sources, and discuss prospects off detecting hypothetical Microblazars.

1. Introduction

X-ray binaries have long been suspected as sources of very high and ultra high energy gamma rays. However searches for these sources with ground-based detectors have yielded contradictory results and the detections of plerions, shell-type SNRs and blazars using Cherenkov telescopes have shifted away the interest in these sources. The analogy between Quasars and Micrquasars as scaled down versions of the same astrophysical process (accretion driven ejection of highly relativistic jets) has changed our few on these targets and makes them prime candidates for a dedicated search with the new more sensitive instruments now comming online.

2. Microquasars

The term Microquasar is used for galactic sources exhibiting relativistic radio jets [5]. All these sources can be classified as radio emitting x-ray binaries either HXMBs or LMXBs (high-/low-mass x-ray binaries). Our picture of these sources is of a compact object (either a neutron star or a black hole) accreting matter from its companion. The x-ray luminosity of these objects is explained as energy released during the accretion process. In Microquasars a significant energy fraction (the lower limit being $L_{inj} \approx (10^{-3} - 10^{-2})L_E$ [3]) may be injected into the jets which can be detected by the synchrotron emission at radio wavelength. Inverse Compton (IC) scattering of photons, from the companion

pp. 2529–2532

Table 1. List of currently known Microquasars. Sorces marked in boldface are observable at zenith angles $\leq 35°$ from the northern hemisphere. Microquasars marked in italics can be observed at high zenith angle with a higher energy threshold.

Object Name	RA (J2000.0)	Dec. (J2000.0)	Type
LS I 61°303 (V615 Cas)	$02^h\ 40^m\ 31.7^s$	+61° 13' 46"	HMXB
XTE J0421+560 (CI Cam)	$04^h\ 19^m\ 42.2^s$	+55° 59' 58"	HMXB
XTE J1118+480 (KV UMa)	$11^h\ 18^m\ 10.9^s$	+48° 02' 13"	LMXB
Circinus X-1 (BR Cir)	$15^h\ 20^m\ 40.9^s$	-57° 10' 01"	LMXB
XTE J1550-564 (V381 Nor)	$15^h\ 50^m\ 58.7^s$	-56° 28' 36"	LMXB
Scorpius X-1 (V818 Sco)	$16^h\ 19^m\ 55.1^s$	-15° 31' 15"	LMXB
GRS J1655-40 (V1033 Sco)	$16^h\ 54^m\ 00.1^s$	-39° 50' 45"	LMXB
GX 339-4 (V821 Ara)	$17^h\ 02^m\ 49.5^s$	-48° 47' 23"	LMXB
XTE J1748-288	$17^h\ 48^m\ 05.1^s$	-28° 28' 26"	LMXB
1E1740.7-2942 (Great Annihilator)	$17^h\ 44^m\ 02.7^s$	-29° 43' 25"	LMXB
GRS 1758-258	$18^h\ 01^m\ 12.3^s$	-25° 44' 36"	LMXB
V* V4641 Sgr (XTE J1819-254)	$18^h\ 19^m\ 21.6^s$	-25° 24' 25"	LMXB
LS 5039	$18^h\ 26^m\ 15.0^s$	-14° 50' 54"	HMXB
SS 433 (V1343 Agl)	$19^h\ 11^m\ 49.6^s$	+04° 58' 58"	HMXB
GRS 1915+105 (V1487 Aql)	$19^h\ 15^m\ 11.5^s$	+10° 56' 44"	LMXB
Cygnus X-1 (V1357 Cyg)	$19^h\ 58^m\ 21.7^s$	+35° 12' 06"	HMXB
Cygnus X-3 (V1521 Cyg)	$20^h\ 32^m\ 26.6^s$	+40° 57' 09"	HMXB

star, accretion disk or hot corona, off relativistic electrons inside the jet may also produce a significant gamma-ray flux. Recently, compelling evidence has been presented, that the persistent nearby (3 kpc) Microquasar LS 5039 may be associated with the EGRET gamma-ray source EG J1824-1514 [6]. If this identification is correct we can estimate its gamma-ray luminosity above 100 MeV from the measured EGRET flux of $F_\gamma(E > 100MeV) = (35.2 \pm 6.5) \times 10^{-8} cm^{-2} s^{-1}$ as $L_\gamma(> 100MeV) \sim 2.4 \times 10^{35} erg\ s^{-1}$.

Extrapolating the EGRET flux of 3EG1824-1514 to 30 GeV and using the measured spectral index $\gamma = 2.19 \pm 0.18$ we obtain a flux above 30 GeV of $F_\gamma(E > 30GeV) \sim 4 \times 10^{-10} cm^{-2} s^{-1}$.

3. Microblazars and IXOs

The above considerations did not take into account possible beaming amplifications due to the alignment of the jet with the line of sight. For small inclination angles $\Theta < 10°$ the timescales scale as $\Delta t \sim \Gamma^2$ and the flux as $F \sim \Gamma^3$. Using moderate bulk Lorentz factors of $\Gamma \sim 5$ we may obtain a flux boosted by a factor of $10^2 - 10^3$ and timescales reduced by a factor of ~ 25. Lorentz factors of 50 as deduced from some flaring events of gamma-ray emitting blazars (e.g. Mrk 501) may give flux enhancements of $\sim 10^6$ and reductions of the timescales by ~ 1000. This type of Microblazars has been postulated by Mirabel and Rodriquez[5], however the low probability of jet alignment and the low number of known galactic Microquasars could imply, that no such objects may be found in the Milky Way.

However, x-ray surveys of nearby galaxies have revealed intermediate-luminosity x-ray sources IXOs (Intermediate-luminosity X-Ray Objects) with typical x-ray luminosities of $10^{39} erg\ s^{-1} \leq L_x \leq 10^{41} erg\ s^{-1}$. These sources are of intermediate luminosity between x-ray binaries and cores of Seyfert galaxies. ROSAT observations with the High Resolution Imager (HRI) showed that these IXOs (a.k.a UltraLuminous X-ray sources ULX) are extranuclear compact objects in those nearby galaxies. The luminosities inferred for the ULXs are, however, exceed the Eddington limit for accretion onto a one solar-mass black hole. If the x-ray emission is beamed, the x-ray luminosities are well comparable to those expected from jets in Microquasars. This has motivated the interest in IXOs as possible candidates for Microblazars.

In Table 2. we selected all nearby galaxies with distances less then 10 Mpc found in the IXOs catalog derived from the ROSAT observations [2].

4. Detectability with the MAGIC telescope

The MAGIC telescope is a ground-based imaging Cherenkov telescope presently becoming operational [1]. It is located at the canary island La Palma at a northern latitude of 28°. Using a classical PMT camera (MAGIC phase 1) it will have an energy threshold of ~ 30 GeV and an integral flux sensitivity for a 50 hour observation run of roughly $10^{-10} cm^{-2} s^{-1}$ at the threshold and of $2 \times 10^{-11} cm^{-2} s^{-1}$ at 100 GeV. With such a sensitivity MAGIC should be able to detect comparable gamma-ray fluxes as that inferred from LS 5039 (assuming the EGRET identification) if the spectra of these sources extends up to 100 GeV. Sources up to 10 kpc distance, corresponding to a significant fraction of our galaxy, shall be detectable. To enhance the detection probability we will try to select these targets based on radio flaring events which have been shown to be connected with the ejection of blobs into the jets. If the jet of some of the Microquasars from this list should be pointing in the line of site a significant enhancement of the gamma-ray flux, combined with strong source variability, should be expected. This alignment may originate from the precession of the accretion disc [4].

For IXOs as possible Microblazars candidates in nearby galaxies, the detectability for MAGIC may depend strongly on the beaming and Lorentz factors. At a distance of 5 Mpc, enhancement factors of 10^6, are needed to obtain detectable fluxes. This enhancement factor may however mean very short timescales

Table 2. List of nearby galaxies containing IXOs from the catalog of Colbert and Ptak[2]. Boldface galaxies are observable from a northern observatory.

Host Galaxy Name	RA (J2000.0)	Dec. (J2000.0)	D[Mpc]	Comments
NGC 891	$02^h\ 22^m\ 32.9^s$	+42° 20' 45"	9.6	
NGC 1291	$03^h\ 17^m\ 18.3^s$	-41° 06' 25"	8.6	
NGC 1313	$03^h\ 18^m\ 15.4^s$	-66° 29' 50"	3.7	2 IXOs
IC 342	$03^h\ 46^m\ 49.1^s$	+68° 05' 47"	3.9	
Holmberg II	$08^h\ 19^m\ 03.9^s$	+70° 43' 09"	2.7	
NGC 3031 (M81)	$09^h\ 55^m\ 33.2^s$	+69° 03' 55"	3.6	
NGC 3628	$11^h\ 20^m\ 16.9^s$	+13° 35' 14"	7.7	
NGC 4395	$12^h\ 25^m\ 48.9^s$	+33° 32' 48"	2.9	
NGC 4485	$12^h\ 30^m\ 31.6^s$	+41° 41' 58"	9.3	
NGC 4559	$12^h\ 35^m\ 57.8^s$	+27° 57' 35"	9.7	2 IXOs
NGC 4631	$12^h\ 42^m\ 07.8^s$	+32° 32' 27"	6.9	
NGC 5055	$13^h\ 15^m\ 49.3^s$	+42° 01' 47"	7.2	
NGC 5128 (Cen A)	$13^h\ 25^m\ 27.6^s$	-43° 01' 09"	4.9	2 IXOs
NGC 5204	$13^h\ 29^m\ 36.5^s$	+58° 25' 13"	4.8	
NGC 5194 (M51)	$13^h\ 29^m\ 52.4^s$	+47° 11' 41"	8.4	4 IXOs
NGC 5236 (M83)	$13^h\ 37^m\ 00.8^s$	-29° 51' 59"	4.7	
NGC 5457 (M101)	$14^h\ 03^m\ 12.5^s$	+54° 20' 53"	5.4	
NGC 6946	$20^h\ 34^m\ 52.7^s$	+60° 09' 14"	5.5	

($\sim 1s$) of flux variability. To test this hypothesis we will select some of the nearby galaxies (preferably at distances ≤ 5 Mpc) containing IXOs from Table 2. for a deep observation campaign.

5. References

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