Multi-wavelength observations of the new TeV binary HESS J0632+057

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Abstract: The TeV source HESS J0632+057 was discovered during pointed observations of the Monoceros Loop/Rosette Nebula region with HESS. The point-like nature of the source and the positional association with the massive B0-type star MWC 148 make HESS J0632+057 a likely candidate for a gamma-ray binary system. Point-like, variable X-ray and radio counterparts have since been detected strengthening this association. Long term monitoring with Swift has revealed periodic emission with a period of around 320 days. Here the full picture of HESS J0632+057 is discussed in the context of a gamma-ray binary system including new and archival radio, optical, X-ray and GeV data.

Keywords:

1 Introduction

The TeV source HESS J0632+057 was discovered during pointed observations of the Monoceros Loop SNR/Rosette Nebula region with H.E.S.S. [1]. HESS J0632+057 appears point-like to H.E.S.S. with an upper limit on the source size of $2'$. The association with this star, and the point-like nature of the TeV emission prompted the suggestion that HESS J0632+057 may belong to the rare class of γ-ray binaries. A multi-wavelength campaign was set up to elucidate the relationship between the TeV emission and the massive star.

2 TeV observations

HESS J0632+057 was observed with the VERITAS array of Cherenkov telescopes in 2008–2009. No emission was detected from the source and upper limits were derived and combined with the published HESS flux points to show evidence of variability in the TeV emission. Yearly observations of the source with HESS from 2004–2009 and new VERITAS observations from 2009–2011 and will be presented at the conference (Abstract ID 268).

3 GeV observations

The Fermi LAT operates in all-sky mode and thus has observed HESS J0632+057 continuously since the launch in June 2008. No source is listed at this location in the Fermi 1 year catalogue. A full analysis of the Fermi data in this region will be presented at the conference.

4 X-ray observations

HESS J0632+057 has been observed with XMM (26 ks; September 2007), Suzaku (50 ks; April 2008 and 100 ks; April 2009) and Swift ($\sim$120 observations, each of 3–4 ks duration; Jan 2009 – June 2011). A point-like X-ray source is detected in all observations at the location of HD 259440. Recently significant periodicity was detected in the Swift data (see figure 1). The best estimate for the period of the system is 320 ± 5 days [3].

Energy spectra have been extracted from each X-ray data set and there is some evidence for spectral variability in the X-ray domain, see table 1.

5 Radio observations

The first dedicated radio observations of the region were performed in 2008 with the VLA (5- and 8 GHz) and GMRT (1.28 GHz) and are described in [5]. A faint point-like source was detected at the location of HD 259440. Significant variability was detected in the 5 GHz emission. New data from both the VLA and GMRT in 2009 show further evidence for variability in the radio emission. There appears to be some flux correlation between the X-ray and radio emission (see figure 2) although further observations are required to confirm this.

A dedicated search for a pulsar companion with the GBT revealed no detection of pulsed emission from the region. The observations consited of six individual pointings spread over a 4 month period. The phase corresponding to this observation is marked onto figure 2.

6 Summary

Since the publication of the HESS discovery paper a large observational data set has been accumulated including over 100 hours of dedicated radio observations, over 400 ks dedicated X-ray observations, over 100 hours TeV observations with HESS and VERITAS, a dedicated search for radio pulsations from an unseen pulsar companion to MWC 148, dedicated observations with various optical telescopes and $\sim$3 years coverage with the Fermi-LAT. These observations have lead to the discovery of the X-ray and radio counterparts and the 320 day orbital period and have given some insight into the complex variability of the system. A discussion of these results in the context of a new binary system will be presented at the conference.

References

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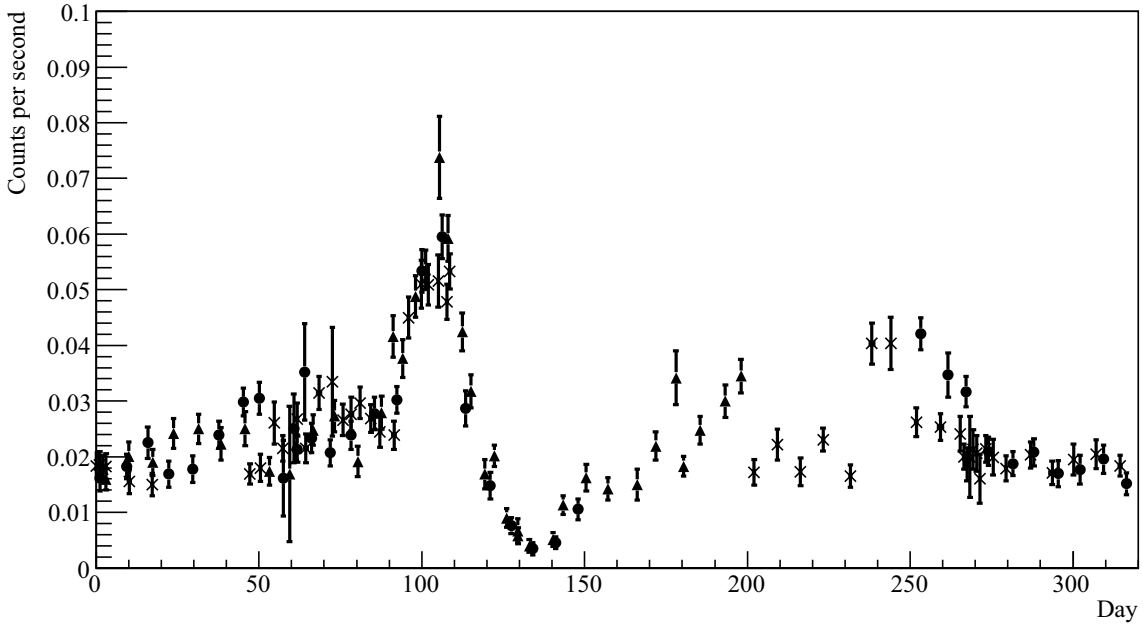

Figure 1: X-ray count-rate (0.3-10 keV) as a function of time of MWC 148 as measured by Swift. Errors are shown at the 1σ level. The lightcurve has been folded with a period of 320 days and has been set up so that the first Swift observation on MJD 54857 is at "day zero" on this plot. The three periods covered by the Swift observations are denoted by crosses, filled circles and filled triangles respectively.

Instrument	N_H (10^{22} cm^{-2})	Γ	Flux (1–5 keV) (erg cm^{-2} s^{-1})	χ^2/dof
XMM	0.28±0.03	1.24±0.05	2.3±0.2	101.80/104
Swift	0.31±0.02	1.58±0.04	8.5±0.7	57.73/55
Suzaku (2008)	0.31±0.04	1.55±0.05	9.4±0.3	33.63/28
Suzaku (2009)	0.26±0.03	1.38±0.03	8.8±0.2	72.45/63

Table 1: Best fit spectral parameters for the X-ray emission from MWC 148 measured by XMM-Newton [4], Swift and Suzaku. Errors are given at the 1σ level.

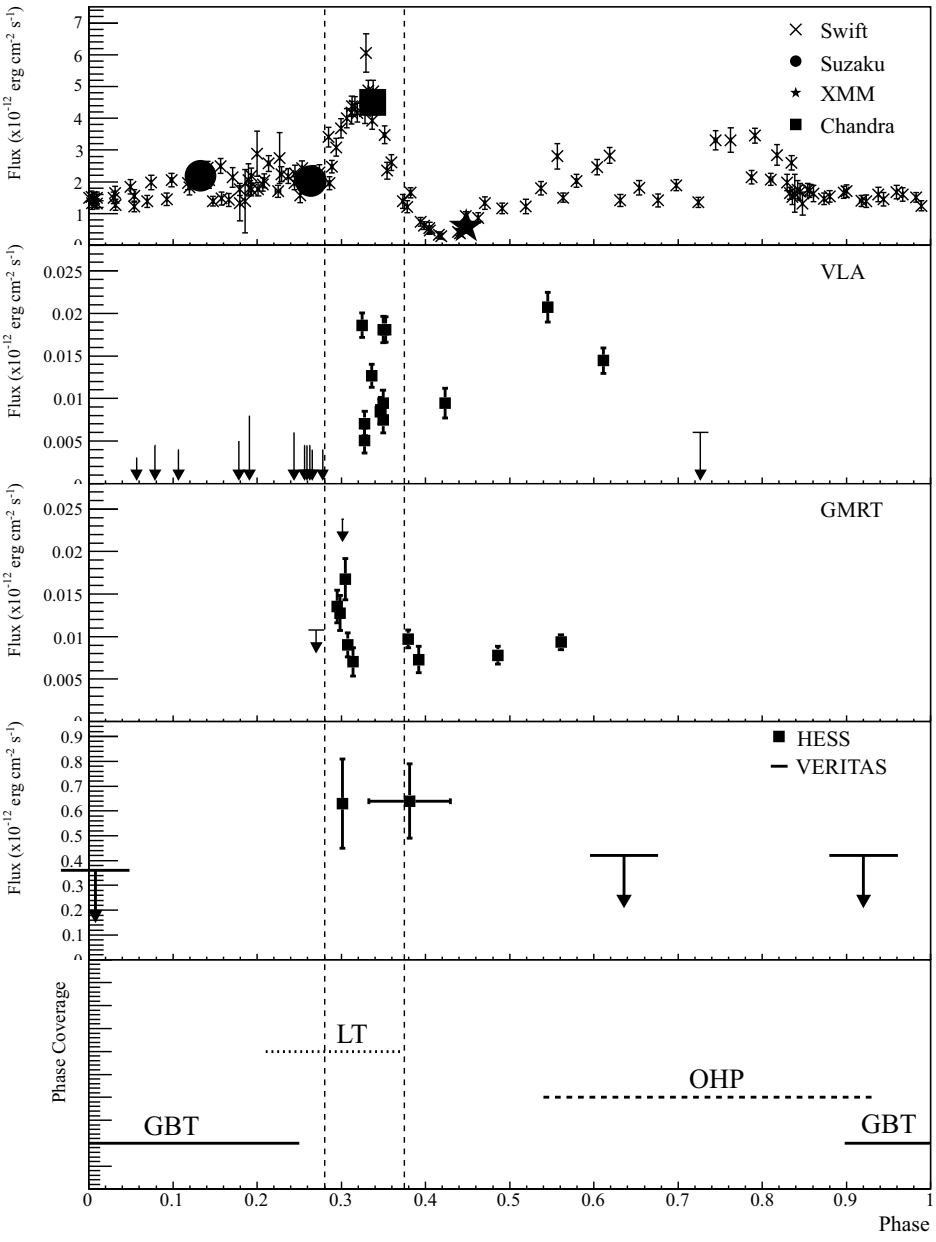

Figure 2: Multi-wavelength lightcurve of MWC 148 folded with the 320 day period found in the Swift XRT data. All errors are shown at the 1σ level. The vertical dashed lines highlight the phase range of the large X-ray flare. *Top panel:* Swift XRT, (cross markers), Suzaku (circular markers), XMM (star marker) and Chandra (square marker) fluxes (0.3 – 10 keV), binned per observation. *Second panel:* VLA 5 GHz flux points and upper limits drawn at the 3σ level, *Third panel:* GMRT 1.28 GHz flux points and upper limits drawn at the 3σ level, *Fourth panel:* HESS flux points from [1] (square markers) and VERITAS upper limits from [2] drawn at the 99% confidence level. *Bottom panel:* Phase coverage of various observations of MWC 148; Green Bank Telescope (GBT, see section 5), the Liverpool Telescope (LT, [6]) and the Observatoire Haut Provence (OHP, see [7])