

Search for MWL Pulsed emission in accretion driven WD and LMXB systems

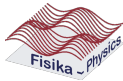
V1223 Sagittarii

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Overview

1 Introduction & Context

2 Tess analysis

3 Fermi Analysis

- TS-Gated Likelihood Analysis with Fermipy
- Tempo Preliminary Timing Analysis

4 Current Status & Future work

Introduction to V1223 Sagittarii

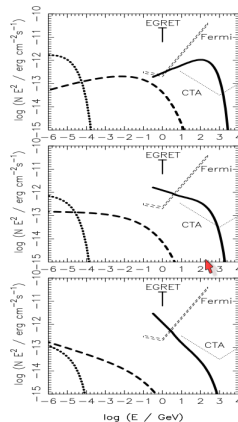
- **Location:** Sagittarius
- **Distance:** 573 pc
- **Coordinates (J2000):**
 - ▶ RA: $18^{\text{h}}55^{\text{m}}13.7^{\text{s}}$
 - ▶ Dec: $-31^{\circ}09'50''$
- **System:** Intermediate Polar (magnetic CV)
- **Orbital period:** $P_{\text{orb}} \simeq 3.37 \text{ hr}$
- **Spin period:** $P_{\text{spin}} \simeq 12.4 \text{ min}$
- **Beat period:** $P_{\text{beat}} \simeq 13.2 \text{ min}$
- **Spitzer Observtions**
 - ▶ Mid-infrared flare detected from V1223 Sgr
 - ▶ Flux decreased by a factor of ~ 13 in $\sim 30 \text{ min}$
 - ▶ Flare interpreted as transient **synchrotron emission**



(Harrison et al., 2010, *ApJ*, 710)

Theoretical Prediction of High-Energy Emission

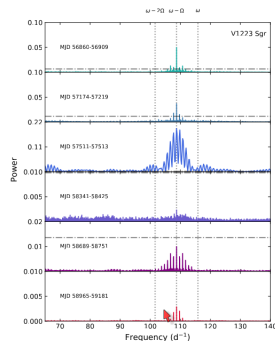
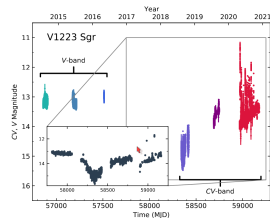
- Particle acceleration at the **disc-magnetosphere boundary** was proposed as a mechanism for high-energy emission from V1223 Sgr.
- The model predicts **GeV–TeV γ -ray emission**.
- Accelerated particles produce non-thermal emission:
 - ▶ **Primary electrons** $\rightarrow$ synchrotron and inverse-Compton emission $\rightarrow$ hard X-rays
 - ▶ **Protons** $\rightarrow$ hadronic interactions $\rightarrow \pi^0$ decay $\rightarrow$ γ -rays above **300 MeV**
 - ▶ **Charged pions ($\pi^\pm$)** $\rightarrow$ secondary leptons ($e^\pm$) $\rightarrow$ synchrotron emission $\rightarrow$ hard X-rays to soft γ -rays



(Bednarek and Pabich, 2011, *MNRAS*, 411)

V1223 Sagittarii – Optical Low State

- Long-term optical photometry from AAVSO covering normal and low-flux states were investigated.
- No evidence for a change in **accretion geometry** was found.
- The spin frequency ω was **not detected** in the periodograms.
- Variability was commonly dominated by the **orbital sideband** $\omega - \Omega$ rather than ω .
- V1223 Sgr entered a **lowest state** in **2018–2019**.
- At the lowest flux levels, optical variability was **almost completely quenched**.



(Covington et al., 2022, *ApJ*, 928)

Fermi LAT data analysis

1. Initial selection

- Event selection: front + back
- $\text{ROI} = 10^\circ$, $z_{\text{max}} = 90^\circ$
- Apply GTI
- Build counts maps, counts cube, livetime cubes

2. Generate Model

3. Likelihood Analysis

- Optimise the model
- Perform time-binned likelihood analysis
- Fit spectral models using Fermipy

4. TS gating

- Select intervals with $TS > 0$
- Retain events from selected intervals
- Fit spectral models to gated dataset
- Calculate weighted significance

Gating significance

$$\sigma_w \approx \alpha \sqrt{\sum_{0.1 \text{ GeV}}^{300 \text{ GeV}} [TS_{\text{gated}}(E) - TS_{\text{ungated}}(E)]}$$

Detailed Discussion

For a detailed discussion of the **Fermi-LAT analysis and TS-gating procedure**, see Madzime (2026).

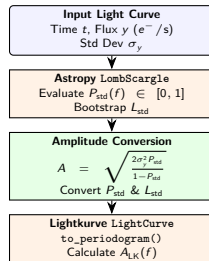
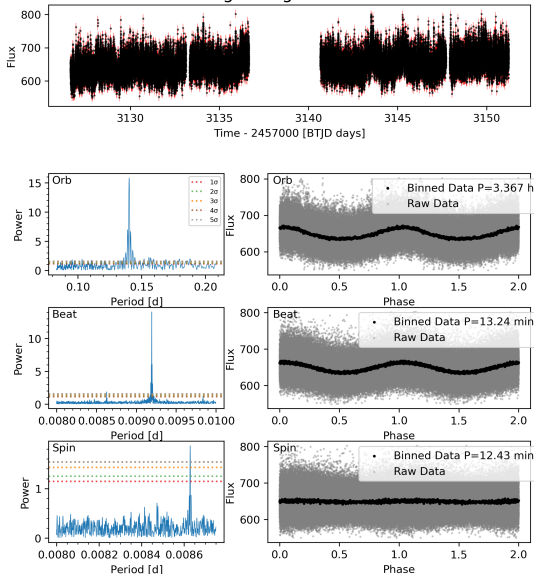
(Madzime and Meintjes, 2023, PoS(HEASA2022) and (Madzime, 2026, PhD thesis)

TESS timing analysis

- **TESS (Transiting Exoplanet Survey Satellite)** is a NASA space telescope launched in **2018**, primarily designed to detect transiting exoplanets.
- TESS performs wide-field, high-precision **optical photometry** across large regions of the sky.
- TESS provides light curves at different observing cadences, including **long-cadence and short-/high-cadence observations**, enabling studies on different timescales.
- The high-cadence data are particularly useful for resolving **short-period variability** in systems such as V1223 Sgr.
- Data analysis were done using the python **lightkurve** package.

Period analysis-TESS

TESS LC for V1223 Sgr using fast sector 67 observations



- Periods Corresponds by two decimal places to the periods found by Bruch 2025

(Bruch, 2025, *ApJS*, 279)

Intervals from the entire dataset

Offset = 0.0295

A: PowerLaw

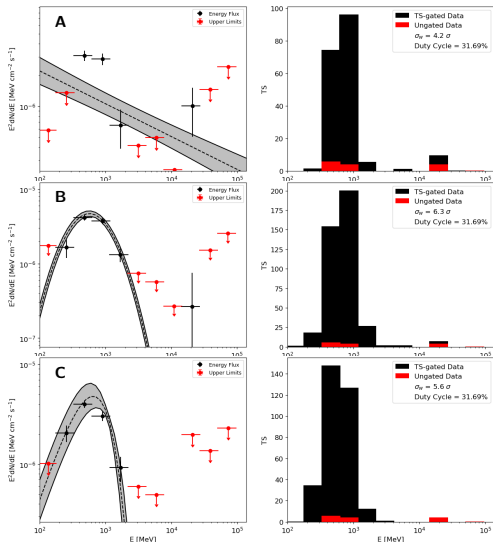
- NPred = 1608.3970
- TS = 77.1175
- EFlux = $(6.36 \pm 1.73) \times 10^{-6} \text{ MeVcm}^{-2}\text{s}^{-1}$
- Index = -2.3181 ± 0.0759

B: LogParabola

- NPred = 2427.1685
- TS = 407.6314
- EFlux = $(8.28 \pm 0.311) \times 10^{-6} \text{ MeVcm}^{-2}\text{s}^{-1}$
- alpha = 3.1085 ± 0.6870
- beta = 1.0000 ± 0.0000

C: PLSuperExpCutoff2

- NPred = 2273.1155
- TS = 358.9393
- EFlux = $(7.41 \pm 2.34) \times 10^{-6} \text{ MeVcm}^{-2}\text{s}^{-1}$
- Index₁ = -0.0000 ± 0.0029
- Index₂ = 1.3902 ± 0.0159



No Energy Above the 50 GeV threshold

Intervals between 2014-2021

Offset = 0.0295

A: PowerLaw

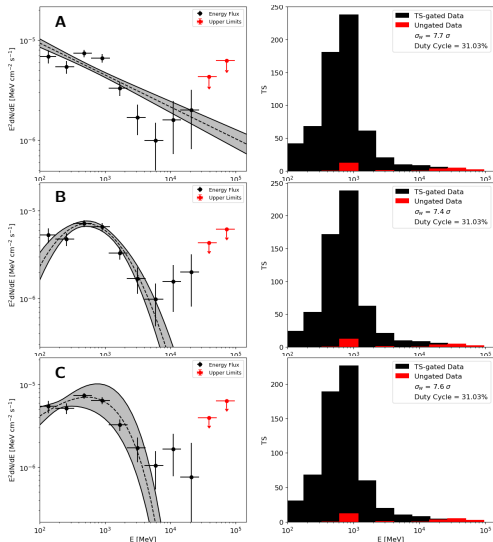
- NPred = 2351.9445
- TS = 532.7265
- EFlux = $(2.71 \pm 0.167) \times 10^{-5} \text{ MeVcm}^{-2}\text{s}^{-1}$
- Index = -2.3200 ± 0.0458

B: LogParabola

- NPred = 1859.9698
- TS = 549.5687
- EFlux = $(1.84 \pm 0.821) \times 10^{-5} \text{ MeVcm}^{-2}\text{s}^{-1}$
- alpha = 2.5327 ± 0.6324
- beta = 0.4054 ± 0.3037

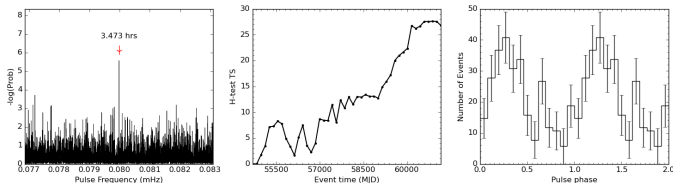
C: PLSuperExpCutoff2

- NPred = 2029.8319
- TS = 560.6179
- EFlux = $(1.9 \pm 0.655) \times 10^{-5} \text{ MeVcm}^{-2}\text{s}^{-1}$
- Index₁ = -1.2998 ± 0.3918
- Index₂ = 0.8087 ± 0.0180

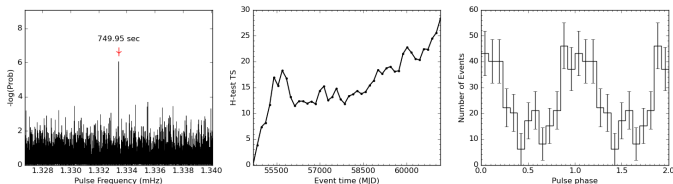


No Energy Above the 50 GeV threshold

Timing Analysis



Orbital: $P_{\text{mean}} = 3.4729 \pm 0 \text{ hr}$ ($1.6 - 20 \text{ GeV}$, $p = 2.6883 \times 10^{-6}$)



Spin: $P_{\text{mean}} = 749.63 \pm 0.90 \text{ s}$ ($1.4 - 20 \text{ GeV}$, $p = 8.56 \times 10^{-7}$)

Current Status & Future work

- Ongoing off-source likelihood analysis, explored via two complementary approaches:
 - ▶ Standard observational off-source data evaluation.
 - ▶ Monte Carlo noise simulation using `gtobssim`.
- Optical timing analysis to determine an updated ephemeris for V1223 Sagittarii. Using BOOTES and other archival data.
- Redo the tempo analysis using the updated ephemeris

Future Work

- Analyse archival multi-wavelength data, including observations from *XMM-Newton*, to investigate the source behavior across different energy bands.
- Apply the same analysis to other intermediate polars (IPs).
- Extend the study to low-mass X-ray binary (LMXB) systems.
- Investigate whether similar characteristics are observed across different accretion-powered systems.

Thank You

Questions?

References I

- [1] Bednarek, W. and J. Pabich (Mar. 2011). “{X-Rays and γ -Rays From Cataclysmic Variables: The Example Case of Intermediate Polar V1223 Sgr}”. In: *MNRAS* 411.3, pp. 1701–1706.
- [2] Bruch, Albert (Aug. 2025). “{TESS Light Curves of Cataclysmic Variables. VI. Intermediate Polars}”. In: *ApJS* 279.2, p. 48.
- [3] Covington, Ava E. et al. (Apr. 2022). “Investigating the Low-flux States in Six Intermediate Polars”. In: *ApJ* 928.2, 164, p. 164.
- [4] Harrison, Thomas E. et al. (Feb. 2010). “Additional Spitzer IRS Spectroscopy of Three Intermediate Polars: The Detection of a Mid-Infrared Synchrotron Flare From V1223 Sagittarii”. In: *ApJ* 710.1, pp. 325–331.
- [5] Madzime, Spencer T. and Petrus Meintjes (Dec. 2023). “A Search for gamma-ray Emission from a Sample of Highly Magnetised White Dwarfs Using Fermi-LAT Data”. In: *PoS(HEASA2022)*, p. 55.

References II

- [6] Madzime, Spencer Tendai (Feb. 2026). “The search for gamma-ray emission from highly magnetized white dwarfs using Fermi-LAT data.”. PHD thesis.