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THE PHOTOMETRIC BEHAVIOR OF A SYMBIOTIC STAR V919 SGR

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ABSTRACT. We collected photometric observations of the symbiotic star V919 Sgr from the AAVSO and ASAS-SN databases, as well as UBVRI observations obtained at the Astronomical Institute of the Slovak Academy of Sciences. This symbiotic binary star belongs to the Z And type. Observers paid little attention to it until the latest outbursts that began in the 2000s The first observed outburst was described in 1991. In total, we found six outbursts of V919 Sgr. In particular, the star has recently shown significant activity, including a new active phase starting in 2022 and a re-brightening in 2023 that exceeded the previous year's outburst by about 0.4 magnitudes (in V passband).

To analyze the activity of V919 Sgr on short timescales, we used a "pattern scaling analysis" with a weighted "running parabola" (RP) approximation and additional "bi-square" weights. An optimal window half-width of 63 days minimized the rms statistical errors, and the B–V, V–R, and R–I color indices were determined. The B–V color index ranged from 0.53 at brightness maxima (10.15-10.76 in V) to 1.20 at magnitude 13.8. A periodogram analysis was also performed. However, due to the limited number of observations between outbursts, the period estimates are highly uncertain.

Keywords: stars; variable stars; symbiotic stars; photometry.

АНОТАЦІЯ. Ми зібрали дані спостереження симбіотичної зорі V919 Sgr з баз даних AAVSO і ASAS-SN, а також використали UBVRI спостереження, отримані в Астрономічному інституті Словацької академії наук. Ця симбіотична подвійна зоря належить до типу Z And. Спостерігачами приділяли їй мало уваги до спалахів, що почалися у 2000х. Перший спалах, що спостерігався, описаний в 1991 році. Загалом ми виявили сім спалахів V919 Sgr. Зокрема, нещодавно зоря продемонструвала значну активність, включаючи нову активну фазу, що почалася в 2022 році, і повторне поярчання в 2023 році, яке перевищило спалах попереднього року приблизно на 0,4 зоряної величини у фільтрі V.

Щоб проаналізувати активність V919 Sgr на коротких масштабах часу, ми використали шкалограмний аналіз зі зваженою апроксимацією «ковзаючими параболами» (RP) і додатковими «бі-квадратними» вагами. Оптимальна напівширина вікна в 63 дні мінімізувала середньоквадратичні статистичні похибки, також були визначені індекси кольору B–V, V–R і R–I. Індекс кольору B–V коливався від 0,53 при максимумах блиску (10,15–10,76 у B) до 1,20 при величині 13,8. Також був проведений періодограмний аналіз. Однак, через обмежену кількість спостережень між спалахами, оцінки періоду є дуже приблизними.

Ключові слова: зорі, змінні зорі, симбіотичні зорі; фотометрія.

1. Introduction

V919 Sgr (=EM* AS 337=VSX 28619) is a poorly understood symbiotic variable star of Z And type. Symbiotic variables of this type are close binary systems consisting of a hot star, a late-type star, and an expanding envelope excited by the radiation of the hot star. The total brightness shows uneven variations with an amplitude of usually up to 4 stellar magnitudes in the V band. This is a very heterogeneous group of objects.

The GCVS contains 46 Z And – type stars, with another 20 objects uncertainly classified as Z And (and V919 Sgr is among them) and three objects labeled as Z And+E, Z And+M, Z And+SR.

The classical representation of the symbiotic system model is considered to be the following structure: a giant star of spectral class M (less often G or K), with a radius of about 100 solar radii and a hot sub-dwarf or white dwarf (less usually a main sequence star) with radius <0.5 solar radii and temperature 10^5 K. The distances between the components are from 1 to 5 AU, the orbital periods are from 1 year to several years. Both components are surrounded by a common gas shell (or several shells) or disks. The red giant gives up its mat-

ter through stellar wind or pulsations. The gas shell can be both thin and very dense. Sometimes the system can look like a planetary nebula with two nuclei (Sokoloski, 2003).

Symbiotic variables are classified into several groups. The type of Z And is included in the group characterized by luminosity caused by a stable hydrogen layer of the white dwarf. The variability in brightness is caused by variations in the rate of fall of matter onto the hot component (Hoffmeister, 1984).

2. Symbiotic Star V919 Sgr Research

V919 Sgr is a relatively poorly studied symbiotic star despite being known since the seventies. The star has been observed in three active stages so far. The first documented outburst occurred in 1991 and was analyzed by Ivison et al. (1993). The second active phase commenced in 2007 (Munari et al., 2007) and witnessed several rebrightenings following the initial, most prominent outburst. According to the AAVSO light curve of V919 Sgr, the system returned to its quiescent brightness around 2015.

A new active stage began in 2022 (Munari et al., 2022), approximately 15 years after the onset of the previous one. Munari et al. classified the 2022 brightening as a 'cool'-type outburst based on spectroscopic data.

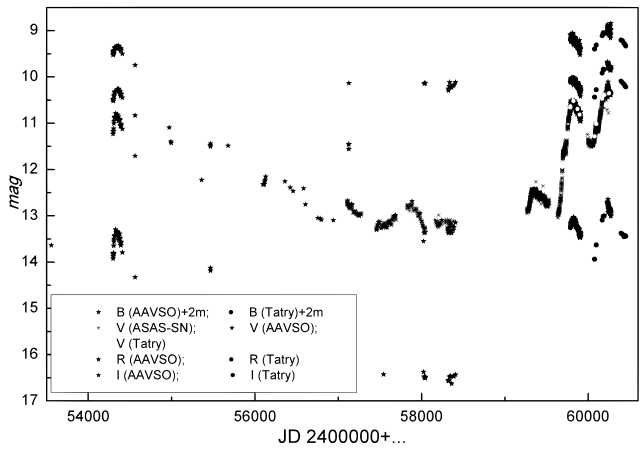

Figure 1: Light curve of V919 Sgr in 2006-2023.

Merc et al. (2023) report on the rebrightening of V919 Sgr observed in 2023. The ASAS-SN light curve well illustrates the system's brightness evolution. The peak brightness was reached in mid-October, and our BVRI photometric observations, available in the AAVSO database, show that the brightness is already decreasing. The B–V color of the system remained about the same during the maxima in 2022 and 2023, around 0.55 mag.

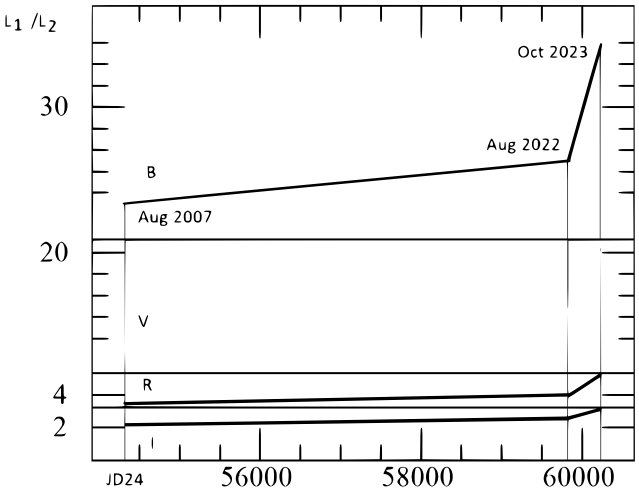

Figure 2: The luminosity of the system changed in comparison with the relatively quiet state in different bands. It can be seen that in the B-band during the last flare, the luminosity of the system increased by approximately 36 times.

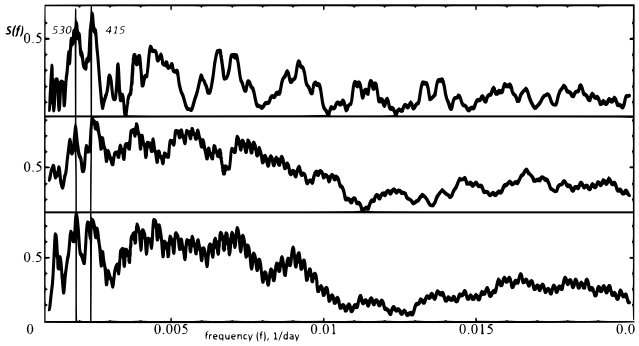

Figure 3: Periodograms for I-data calculated with the polynomial trends of orders $m = 0, 2$ and 3. The largest peaks are about 530 and 415 days.

We conduct photometric studies to analyze changes in the light curve and identify characteristic time intervals considering their evolutionary dynamics.

We used the observations of Astronomical Institute of Slovak Academy of Science (Tatry), ASAS-SN (V passband) and BVRI observations of AAVSO members. B-observations are shifted by 2^m for better visibility (Fig. 1).

The luminosity changes of the V919 Sgr in different passbands since the relatively quiet state (2007) and active state of 2022-2023 are schematically shown at Fig. 2.

The periodogram analysis was made using the completed mathematical model of a sinusoid with a polynomial trend of different order (Andronov, 1994, 2020), contrary to popular simplified methods

Table 1: Approximate times of outbursts.

data	JD	references
31.07–2.08.1991	2448470	Ivison et al., 1993
10.01.2005	2453380	Gromadzki et al., 2013
30.04.2006	2453856	Monard, 2007
12.08.2007	2454325	Munari et al., 2007
30.08.2022	2459822	Munari et al., 2022
19.10.2023	2460237	Merc et al., 2023

of preliminary detrending. Such a model was implemented in the software MCV (Multi-Column Viewer) by Andronov and Baklanov (2004). The software is available at http://uavso.org.ua/mcv/MCV.zip. The results of periodogram analysis for I-data is shown at Fig. 3.

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