

# Runaway stars in Vel OB1 association

N. Azatyan<sup>\*1</sup>, L. Kaper<sup>2</sup>, D. Guo<sup>2</sup>, and E. Nikoghosyan<sup>1</sup>

<sup>1</sup>Byurakan Astrophysical Observatory, 0213, Aragatsotn prov., Armenia

<sup>2</sup>Astronomical Institute "Anton Pannekoek" and Center for High-Energy Astrophysics, University of Amsterdam, Kruislaan 4003, 1098 SJ Amsterdam, The Netherlands

## Abstract

We present the origins of two runaway stars in the VelOB1 association using *Gaia* proper motions and parallaxes. Proper motions and parallaxes show that mentioned two runaways came out from VelOB1 association: one of them, namely CD-41 4637 is the result of dynamical interaction in its host cluster and Vela X-1 high-mass X-ray binary became a runaway after supernova explosion.

**Keywords:** stars: early type stars – stars: binary stars – Open clusters and associations: Vel OB1 – stars: mass loss – individual: Vela X-1, CD-41 4637

## 1. Introduction

The two most popular scenarios to explain the existence of runaway stars and their high velocity are: (1) the supernova of the companion star in a massive binary (Blaauw, 1961) and (2) the dynamical ejection from a young cluster in the early stages of evolution (Poveda et al., 1967).

*VelOB1* is one of the largest OB associations known at a distance of 1.5-1.9 kpc (Bassino et al., 1982, Humphreys, 1978, Sahu, 1992). Humphreys (1978) derived angular extent of Vel OB1 ( $l=262^\circ$  to  $268^\circ$ ,  $b=-2.^\circ7$  to  $+1.^\circ4$ ) and 17 probable members. Reed (2000) extant the size of the association ( $l=255^\circ$  to  $275^\circ$ ,  $b=-5^\circ$  to  $+5^\circ$ ) and the probable members of VelOB1 up to 70 stars.

*Vela X-1* (also V\*GPVel, HD77581 and HIP44368) high-mass X-ray binary (HMXB) is a short-period (8.96 d; Forman et al., 1973) and low-eccentricity ( $e\approx 0.09$ ; Bildsten et al., 1997) eclipsing binary system composed of a blue supergiant star (B0.5 Ia; Hiltner et al., 1972) of mass of  $\approx 24 M_\odot$  and a neutron star of mass of  $\approx 1.9 M_\odot$  (the most massive neutron star known to date; Koenigsberger et al., 2012). The distance is estimated of 2.4 kpc from the *Gaia* second data release (DR2) (Bailer-Jones et al., 2018).

*CD-41 4637* is massive star binary with one unresolved companion and spectral type of the brightest component is O6 Ib(f)(n) (Aldoretta et al., 2015). The distance estimate by *Gaia* DR2 is 2.89 kpc (Bailer-Jones et al., 2018).

The identification of the “parent” OB association of a runaway is important because it provides unique constraints on its evolution. The purpose of this study is to understand from which part of the VelOB1 association the stars were kicked out and what was the reason.

## 2. Results and Discussions

We used the proper motions and positions of *Gaia* DR2 (Gaia Collaboration et al., 2018) for runaways and all individual members of VelOB1 association to trace back in time to determine the location of the closest encounter and the time that has passed since that event: the kinematic age. Figure 1 shows the small part of VelOB1 association in Equatorial coordinates, the current location of Vela X-1 and CD-41 4637 runaway stars and their possible origins.

\*nayatyan@bao.sci.am, Corresponding author

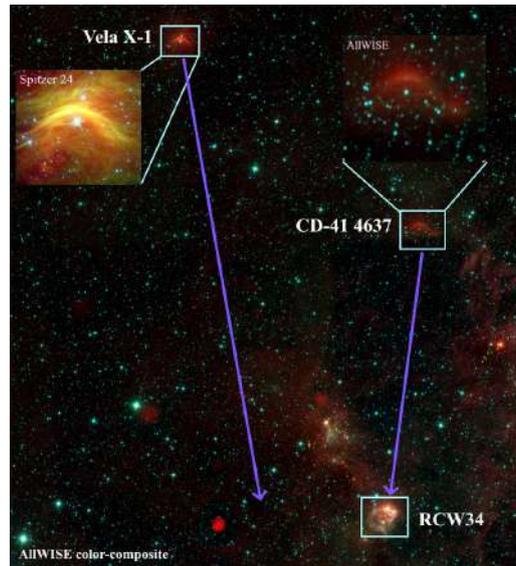


Figure 1. AllWISE color-composite image of Vel OB1 association, the current location of Vela X-1 and CD-41 4637 runaway stars and their possible origins in Equatorial coordinates.

Constructed path of Vela X-1 HMXB over 5 Myr did not provide any information about its parent star cluster although the binary system was kicked out Vel OB1 less than 3 Myr ago (van Rensbergen et al., 1996). The search for the origin of Vela X-1 runaway must be continued further.

Constructed path of CD-41 4637 over 5 Myr shows that CD-41 4637 is supposed to have come out of the RCW 34 HII region 2 Myr ago. Since the age of the RCW 34 HII region is also estimated to be 2 Myr (Bik et al., 2010), then one can supposed there was a dynamic interaction between the members of HII region and in the result CD-41 4637 left the birthplace.

### 3. Conclusions

Using the proper motions and positions of *Gaia* DR2 (Gaia Collaboration et al., 2018) for Vela X-1 and CD-41 4637 runaway stars and members of Vel OB1 association, we trace back in time to determine their origin. Constructed path of Vela X-1 HMXB confirmed that the binary system was kicked out from Vel OB1 less than 3 Myr ago although the search for the origin of Vela X-1 runaway must be continued further. According to the constructed path of CD-41 4637, we assume that it have came out of the RCW 34 HII region 2 Myr ago after dynamic interaction between the members of HII region.

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