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VFTS682: a confirmed dynamical ejection?

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ABSTRACT

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1. Introduction

How do stars form is one longstanding question in astrophysics ■ **[ref?]** ■. Answering it for massive stars is particularly difficult, since these are intrinsically rare (e.g., **???**), evolve fast, and remain enshrouded in their parent cloud during the whole formation process. Moreover, observations of young massive stars reveal a complicated multiplicity structure which requires explanation.

Understanding massive star formation, possibly as a function of metallicity, is a key question given the present and upcoming transient survey (e.g., LSST, BlackGem, LIGO/Virgo O3) which will reveal transients associated to their evolution and death.

■ **[short summary of formation scenarios goes here]** ■.

The second data release (DR2) from the Gaia satellite (**??**) allows us to test these hypothesis using one particular star, VFTS682. This star is a very massive ($\sim 150\,M_\odot$) WNh5 star in the 30 Doradus region of the Large Magellanic Cloud, and it is presently observed at a projected distance of ~29 pc from the nearest cluster of massive stars R136 (**?**). Based on the extremely high mass of this star and its present day apparent isolation, **?** proposed it might be a candidate for isolated star formation, if it has not been ejected from R136 in the past.

In this study, we combine the radial velocity measurements from the VFTS survey (**?**) with the proper motion from Gaia DR2 to reconstruct the three-dimensional velocity of VFTS682, and test the null hypothesis that this star was ejected from R136. ■ **[check the following]** ■ Our results indicate that R136 is the likely origin of this star, and therefore isolated star formation is *not* required to explain it. However, we find a discrepancy between the apparent age of VFTS682, it's kinematic age, and the age estimates for R136.

In Sec. 2 we describe how we select stars in R136 and in the surroundings of VFTS682 itself to remove the mean motion of the region. Sec. **??** presents our main findings. We conclude by discussing the implications for theories of star formation, N-body interactions, and binary evolution in Sec. **??**.

Parameter	Value	Source
RA [degree]	84.73 ± 0.036	Gaia DR2
DE [degree]	-69.07 ± 0.05	
$\mu_{\rm RA}$ [mas yr^{-1}]	1.84 ± 0.07	
$\mu_{\rm DE}$ [mas yr^{-1}]	0.78 ± 0.08	
$\delta v_{\rm rad}$ [km s^{-1}]	-45 ± 25	**?**

Table 1. Astrometric parameters for VFTS682

2. Gaia DR2 data selection

VFTS682 is labeled in the Gaia DR2 catalog[1] with the source id 4657685637907503744. For this star, we retrieve from the Gaia catalog its position in right ascension (RA) and declination (DE) in the IGCS frame(**?**)■ **[some 2016 Gaia paper?]** ■, its proper motion components ($\mu_{\rm RA}$, and $\mu_{\rm DE}$, respectively). For the radial velocity of VFTS16 and of the 30 Doradus region as a whole, we instead use the VFTS data as quoted in **?**. Our main conclusions do not depend on the detailed value of the radial velocity.■ **[improve phrasing]** ■ The values of all these quantities that we use are listed in Table 1.

To compare the astrometry of VFTS682 and derive its peculiar motion, we then select data from the Gaia DR2 catalog for two regions: the "surroundings" of VFTS 682, and the "R136 cluster". The surrounding region is defined by all the stars within 10 arcminutes from VFTS682. This includes the subset of stars which we consider to be part of R136. We include all the stars for which a value of the proper motion components and the corresponding errors are available. The "R136 cluster" is effectively defined by taking all the stars within 25 arcseconds from R136a, one of the most massive members of the cluster itself (**?**).

Throughout this study, we assume the same distance of 50 kpc to the star, and to the 30 Doradus region as a whole, since the parallax for VFTS682 listed in the Gaia DR2 catalog is negative.

3. The kinematics of VFTS682

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[1] https://gea.esac.esa.int/archive/

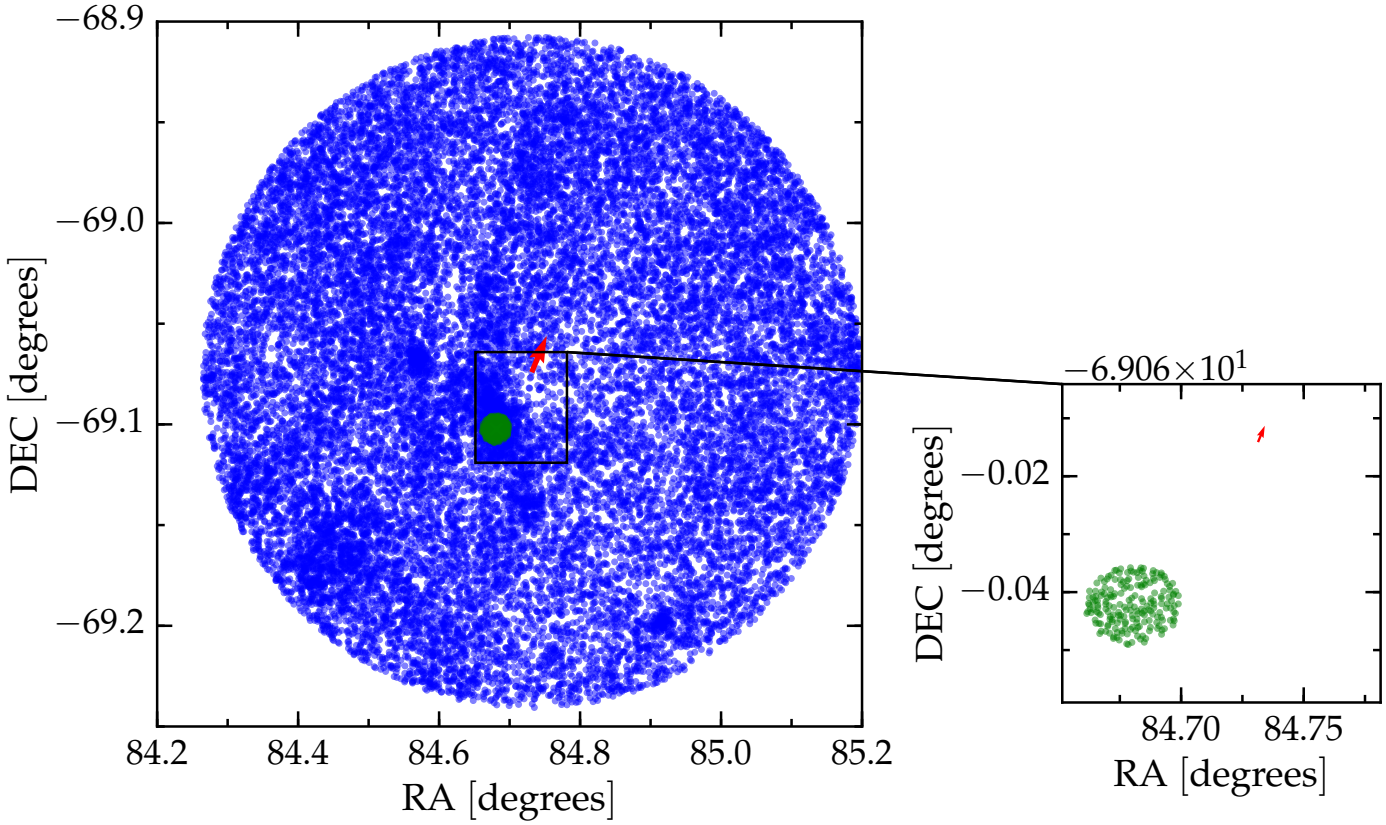

Fig. 1. position and projected relative velocity to R136