Galactic runaway O and Be stars found using *Gaia* DR3

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ABSTRACT

- A relevant fraction of **massive stars** are **runaway** stars. They can be produced either by the Dynamical Ejection Scenario (DES) in clusters or by the Binary Supernova Scenario (BSS) in close binary systems.
- We **discover and characterize** the population of **massive and early-type runaway stars** among the **GOSC and BeSS catalogs** using **Gaia DR3** astrometric data.
- We present a **2-dimensional method** in the velocity space **to discover runaway stars** as those that deviate significantly from the velocity distribution of field stars, which are considered to follow the Galactic rotation curve.
- Several **high-energy systems** are related to **massive runaway stars**.

METHODOLOGY

1. CROSS-MATCH

GOSC Catalog

- 643 Galactic O-type stars

BeSS Catalog

- 2330 Be, Herbig Ae/Be stars

Cross-match with **Gaia DR3** + quality cuts

Output catalogs

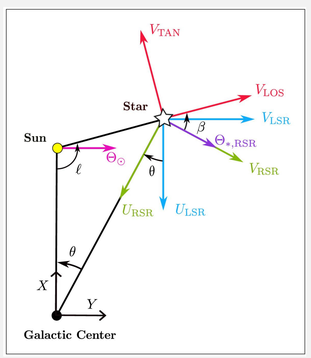
GOSC-*Gaia* DR3 Catalog

- **417 stars**

BeSS-*Gaia* DR3 Catalog

- **1335 stars**

2. COMPUTE VELOCITIES



3. RUNAWAY CRITERION

$$E = \sqrt{\left(\frac{V_{TAN} - \mu^{GF}_{V_{TAN}}}{3\bar{\sigma}_{V_{TAN}}}\right)^2 + \left(\frac{W_{RSR} - \mu^{GF}_{W_{RSR}}}{3\bar{\sigma}_{W_{RSR}}}\right)^2}$$

- Runaway star: that with a high peculiar 2D velocity (V_{TAN};W_{RSR}) with respect to the mean Galactic rotation at a 3-sigma confidence level

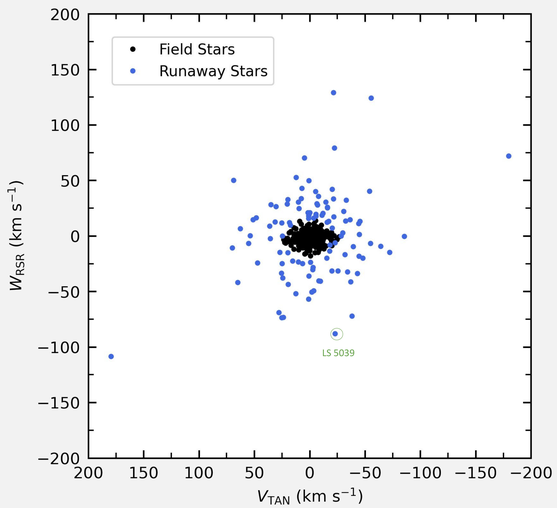
$$E > 1$$

RUNAWAY STAR

RESULTS

Runaways in GOSC-*Gaia* DR3 Catalog

- **106 runaway stars**, 42 of them with no previous identification as runaways.
- Peculiar velocities: 16-210 km s^{-1} , with a median (mean) of 40 (46) km s^{-1}.



Runaways in BeSS-*Gaia* DR3 Catalog

- **69 runaway stars**, 47 of them with no previous identification as runaways.
- Peculiar velocities: 16-131 km s^{-1}, with a median (mean) of 30 (37) km s^{-1}.

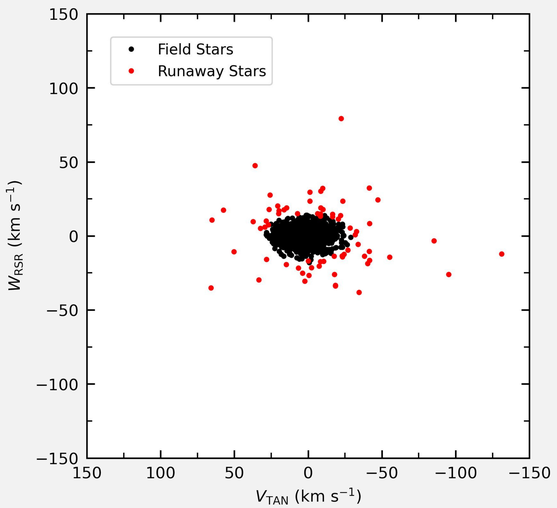


Table 1. Means and standard deviations of different distributions for the field stars after clipping.

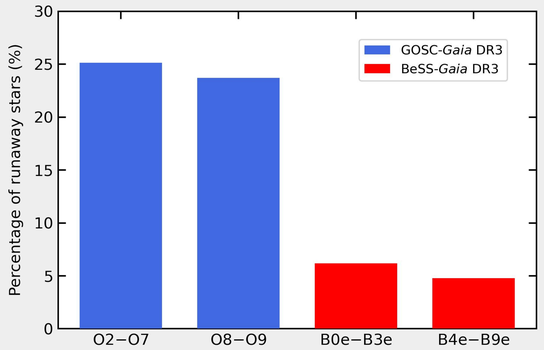
Catalog	Stars #	Field Stars #	$\mu^{GF}_{V_{TAN}} \pm \sigma^{GF}_{V_{TAN}}$ (km s^{-1})	$\mu^{GF}_{W_{RSR}} \pm \sigma^{GF}_{W_{RSR}}$ (km s^{-1})	$\mu_Z \pm \sigma_Z$ (kpc)	$\mu_b \pm \sigma_b$ (°)
GOSC-*Gaia* DR3	417	311	1.0 ± 6.6	−1.0 ± 5.3	−0.01 ± 0.07	−0.1 ± 2.0
BeSS-*Gaia* DR3	1335	1266	1.6 ± 9.3	−0.5 ± 4.9	−0.01 ± 0.11	−1.0 ± 6.5

Table 2. Means and standard deviations of different distributions for the runaway stars after clipping.

Catalog	Stars #	Runaway Stars #	$\mu_{V_{TAN}} \pm \sigma_{V_{TAN}}$ (km s^{-1})	$\mu_{W_{RSR}} \pm \sigma_{W_{RSR}}$ (km s^{-1})	$\mu_Z \pm \sigma_Z$ (kpc)	$\mu_b \pm \sigma_b$ (°)
GOSC-*Gaia* DR3	417	106	−3.1 ± 39.7	1.1 ± 38.7	0.01 ± 0.19	0.2 ± 4.3
BeSS-*Gaia* DR3	1335	69	−7.7 ± 34.6	1.0 ± 22.3	−0.09 ± 0.66	−3.4 ± 21.2

RUNAWAY PERCENTAGE

- There is a factor of 5 between the percentage of runaway stars among O versus Be stars in the Galaxy, which reinforces the dominance of the DES versus the BSS.



CONCLUSIONS AND FUTURE WORK

- The unprecedented accuracy of the Gaia DR3 data has allowed us to find 175 (89 new) massive runaway stars.
- We find larger velocities for O-type runaways than for Be type ones, and a factor of 5 between the percentage of runaway stars among O-type stars versus Be-type stars. Both facts reinforce the dominance of the DES scenario versus the BSS one.
- This work opens the door to identify new high-energy systems among our runaways.

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