Data Management and Visualization Concept

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Cygnus X-1 and High Mass X-Ray Binaries

Target Audience: General Public and Science Communicators
Publication:

This data concept is part of my Masters' Thesis on High-Mass X-Ray Binaries (HMXBs) in the Galaxy. These are stars made of a massive star and a black hole (or neutron star) that orbit around each other. My thesis also involves using archive data from the GAIA space telescope. I searched through the literature to find these stars specifically with GAIA. There are many catalogues, me and my thesis supervisor selected [Neumann et al.(2023)Neumann, Avakyan, Doroshenko, and Santangelo] and crossed references with [**?**] which has the most up-to-date information about HMXBs, each star as a unique GAIA identifier which I can use to query the position of stars from the GAIA database, which is free to use for anyone. The catalogue is free to use and I have provided the link to the dataset. link to the catalgoue The .csv file I share has all the information about the stars including spectral type which I color coded by hand. There are also additional columns in the file about velocities, mass and proper motion but these aren't required to recreate the data. To replicate the data you need these columns

1. ra :right ascension
2. dec: declination
3. l : galactic longitude
4. b : galactic latitude
5. d : distance to object
6. SpColor: Spectral Type Color

The first part of my thesis was to visualize where these stars are in the galaxy, the catalogue and GAIA let you plot the 2D position of each star in galactic

coordinates.
My data story was to show the public where exactly these stars are in the galaxy. I want to show simple maps of the stars in the galaxy using coordinate systems that other astronomers use; figure 1 in the poster is a galactic map in unit degrees to represent the 2D position of each star in the catalogue, the map is an edge on view of the galaxy. Stars also have Z-component which represents the height above or below the midplane of the galaxy, which is represented in figure 2 in the poster. Unlike figure 1, the height also depends on the distance to the star from us, stars closer to us will have a smaller projected height for the same galactic latitude (I show this in the code). So I chose to show the height over galactic longitude so the reader has a constant axis to refer to.
Cygnus X-1: This is one of the most famous and well studied HMXBs ever since its discovery in 1964. I wanted to show what a typical HMXB could look like with a simple drawing. I scaled the image with respect to earth's distance to the sun And I tried to give everything in scales the general public could understand such as 1AU 150 million Km or mass and radii in solar values. I also emphasized the location of Cygnus X-1 so the reader was always engaged with the system while viewing the poster. The facts about the system come from [**?**]

CYGNUS X-1
AND HIGH MASS-X-RAY BINARIES

The Black Hole

- Mass - 21 solar mass
- Diameter - 126 km
- Distance - 7600 light years
- First observed in 1964

The Blue SuperGiant

- Mass - 40 solar mass
- Radius- 20 solar radii
- Temperature-30,000 K

WHERE ARE THEY?

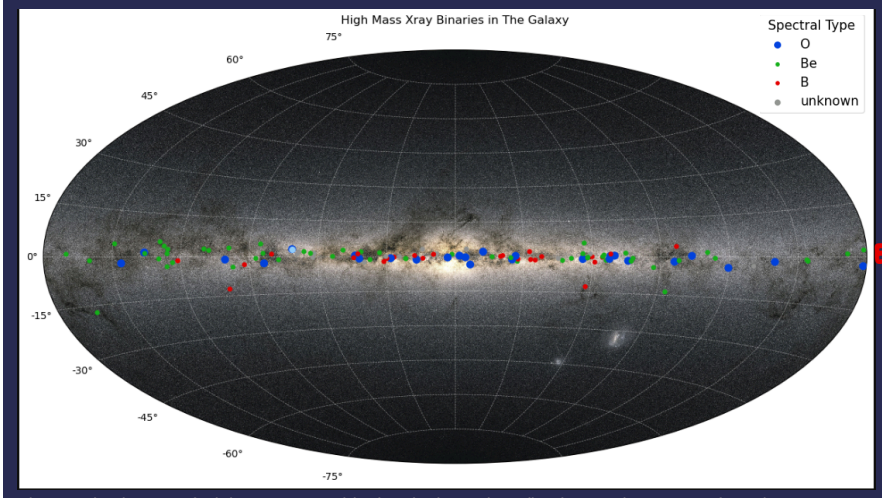
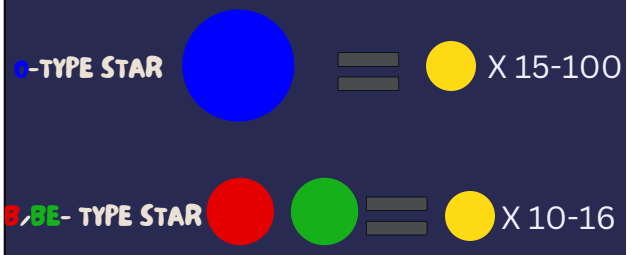


Fig 1. Galactic map of High mass X-ray binaires in the Galaxy (background courtesy of ESA)

STELLAR MASS

COMPARED TO SUN



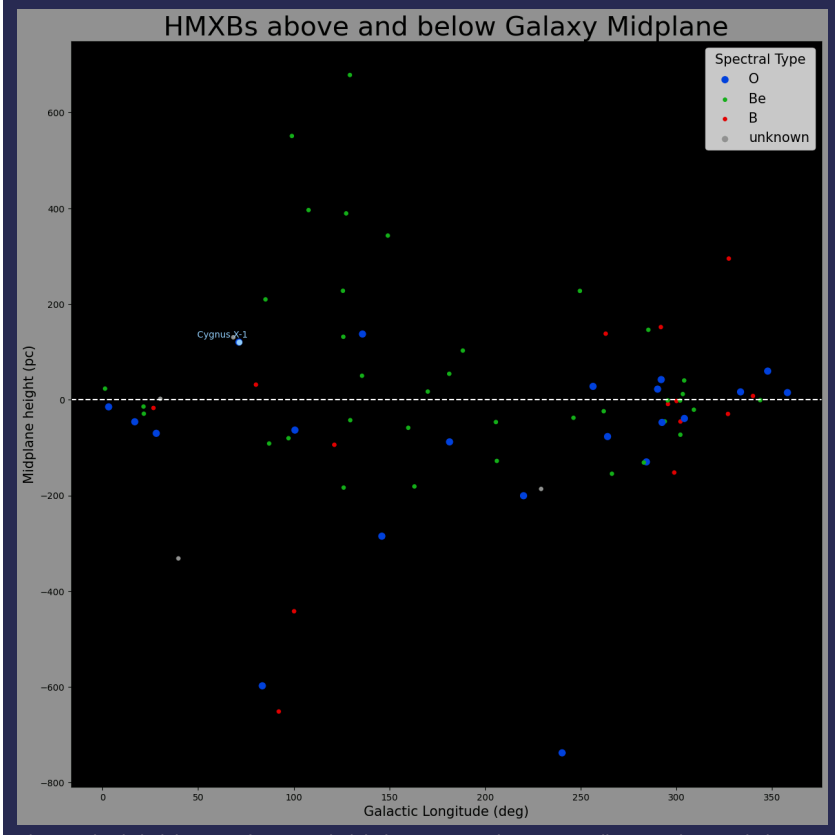


Fig 2. Galactic height map of HMXBs, height is represented as a star's distance above or below the galactic midplane in unit parsec.

WHAT ARE THEY?

- High Mass X-Ray Binaries (HMXBs) consist of a massive OB star (≥ 8 solar mass) orbiting around a black hole or neutron star. HMXBs have bright OB-type stars that are detectable with telescope such as GAIA.
- Cygnus X-1 is the most well studied HMXB source.Matter from the super-giant collects as the black hole's disk. The disk emits X-rays **1000** times more powerful than our sun.
- The massive OB-type stars in HMXBs live for 10 millions years and are excellent tracers for star formation.
- By observing their position and velocity in the galaxy, HMXBs are found in spiral arms of the galaxy Many young star clusters have the most massive stars in the galaxy.

REFERENCES

[1] Jiang, J., "Fifty Years After the Discovery of the First Stellar-Mass Black Hole: A Review of Cyg X-1", arXiv e-prints, Art. no. arXiv:2411.12507, 2024. doi:10.48550/arXiv.2411.12507.

[2]Neumann, M., Avakyan, A., Doroshenko, V., and Santangelo, A., "XRBcats: Galactic High Mass X-ray Binary Catalogue ★ ", Astronomy and Astrophysics, vol. 677, Art. no. A134, 2023. doi:10.1051/0004-6361/202245728.

[3]Carretero-Castrillo, M., Ribó, M., and Paredes, J. M., "Galactic runaway O and Be stars found using Gaia DR3", Astronomy and Astrophysics, vol. 679, Art. no. A109, 2023. doi:10.1051/0004-6361/202346613.

References

[Neumann et al.(2023)Neumann, Avakyan, Doroshenko, and Santangelo] M. Neumann, A. Avakyan, V. Doroshenko, and A. Santangelo. XRBcats: Galactic High Mass X-ray Binary Catalogue. , 677:A134, Sept. 2023. doi: 10.1051/0004-6361/202245728.