

On the effects of unresolved binaries on the deduced total mass and stellar mass function of stellar clusters

Henriette Wirth, František Dinnbier, Pavel Kroupa and
Ladislav Šubr

Warsaw, August 20th 2024

Introduction

visible mass



Figure: NGC 3201, obtained with the WFI instrument on the ESO/MPG 2.2-m telescope at La Silla, Credit:ESO

Introduction

visible mass

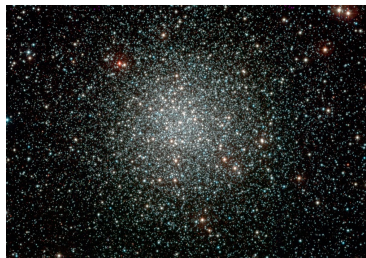


Figure: NGC 3201, obtained with the WFI instrument on the ESO/MPG 2.2-m telescope at La Silla, Credit:ESO

dynamical mass

Illingworth (1976):

$$M_{\text{dyn}} = 670 r_e \sigma_r^2$$

Introduction

visible mass



Figure: NGC 3201, obtained with the WFI instrument on the ESO/MPG 2.2-m telescope at La Silla, Credit:ESO

dynamical mass

Illingworth (1976):

$$M_{\text{dyn}} = 670 r_e \sigma_r^2$$

Introduction

visible mass

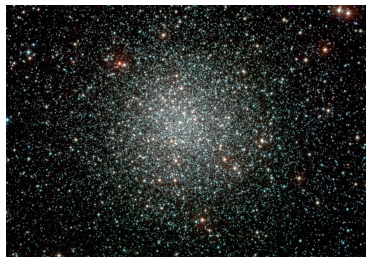


Figure: NGC 3201, obtained with the WFI instrument on the ESO/MPG 2.2-m telescope at La Silla, Credit:ESO

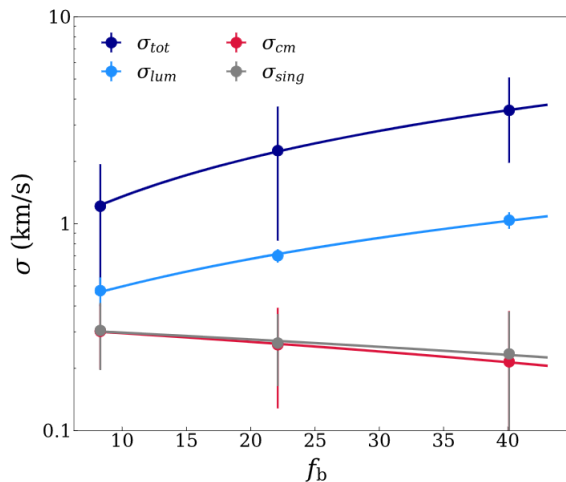
dynamical mass

Illingworth (1976):

$$M_{\text{dyn}} = 670 r_e \sigma_r^2$$

Overestimate of the dynamical mass

Rastello et al. (2020):



Illingworth
(1976):

$$M_{\text{dyn}} = 670 r_e \sigma_r^2$$

Underestimates of the Systemmass of Binaries

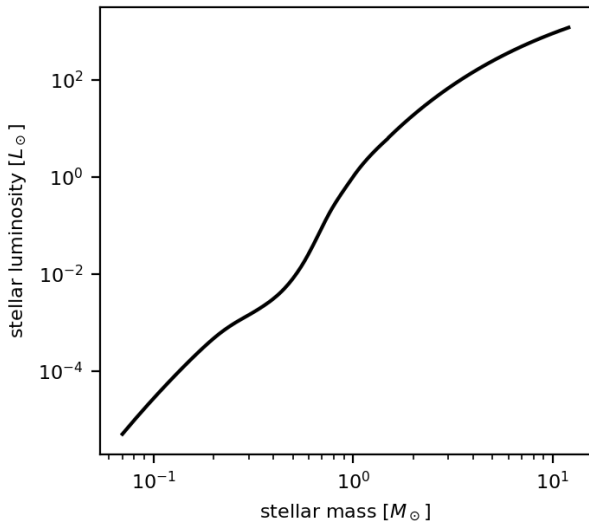
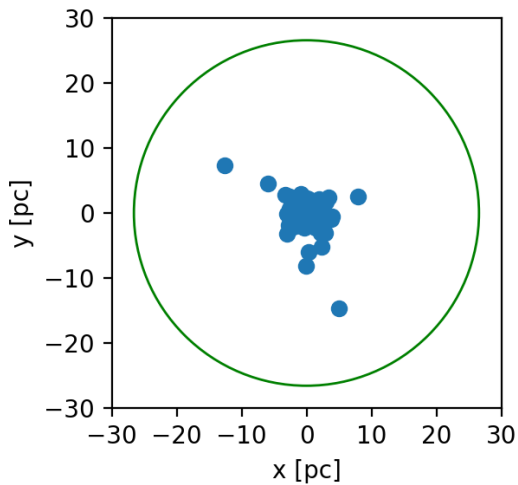


Figure: The mass-luminosity relation by Kroupa et al. (1993), plot from Wirth et al. (2024, in submission)

The model



$$M_{\text{ini}} = 6400 M_{\odot}$$

$$r_{\text{h}} = 0.31 \text{ pc}$$

The model

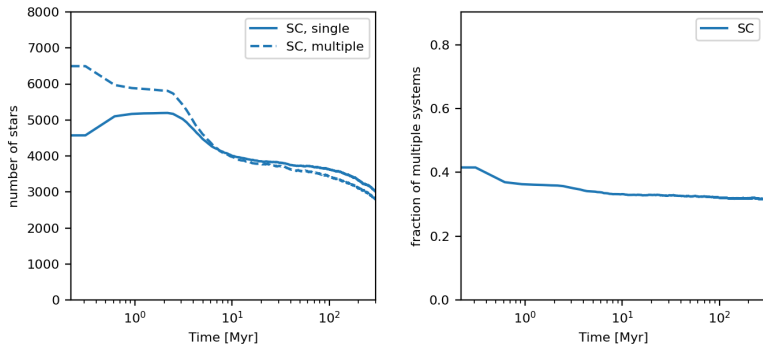


Figure: Wirth et al. (2024, in submission)

The model

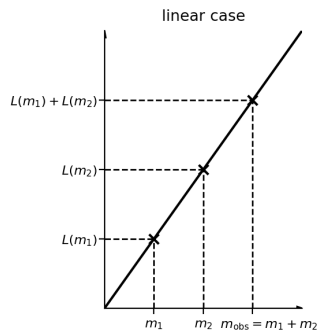


Figure: Wirth et al. (2024, in submission)

The model

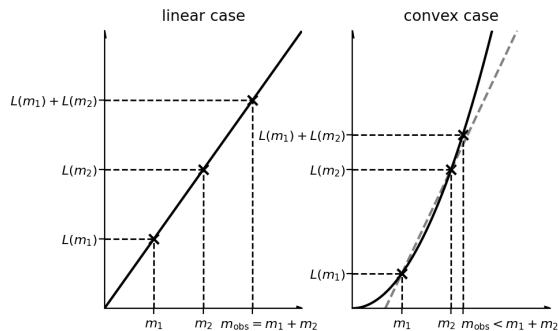


Figure: Wirth et al. (2024, in submission)

The model

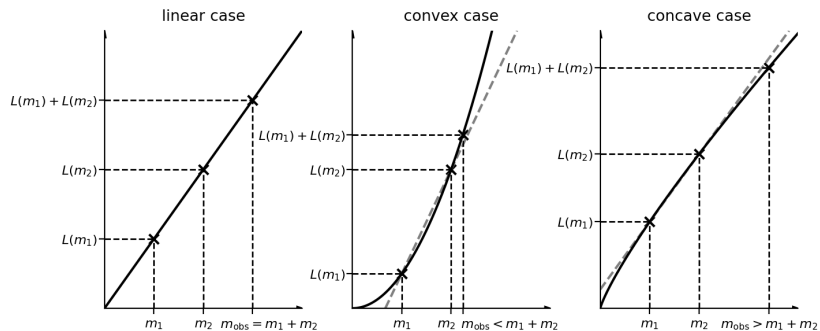


Figure: Wirth et al. (2024, in submission)

The model

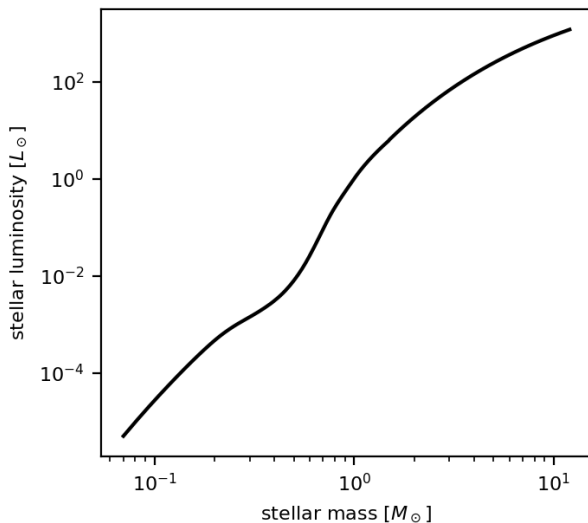


Figure: The mass-luminosity relation by Kroupa et al. (1993), plot from Wirth et al. (2024, in submission)

Underestimates of the Systemmass of Binaries

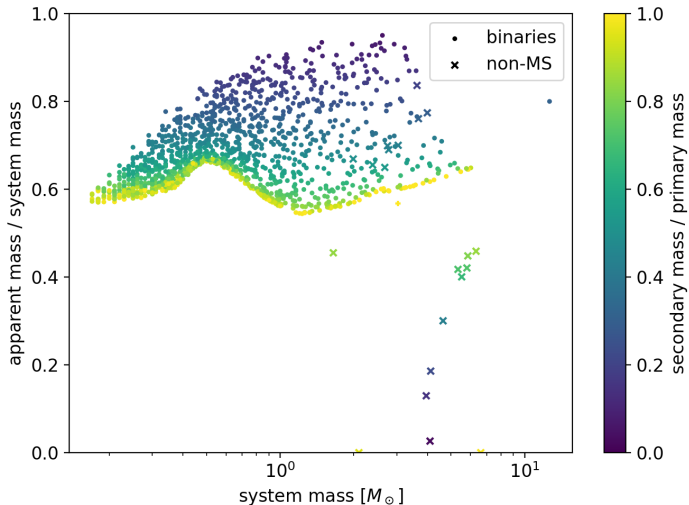


Figure: Wirth et al. (2024, in submission)

Underestimates of the total mass of the cluster

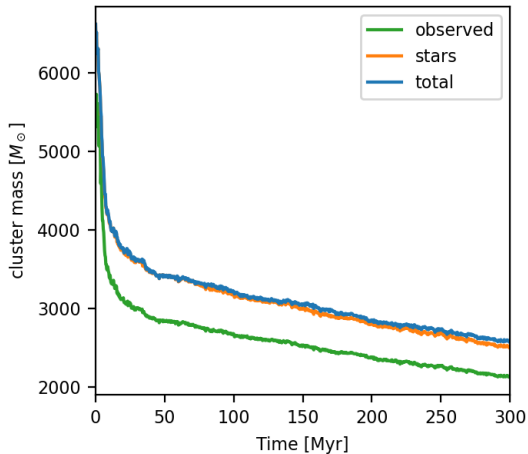


Figure: Wirth et al. (2024, in submission)

Underestimates of the total mass of the cluster

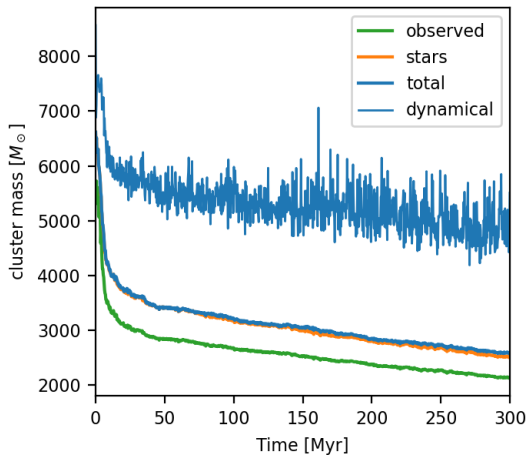


Figure: Wirth et al. (2024, in submission)

The apparent mass function

$$dN = \xi(m)dm$$
$$\xi(m) = k_i m^{-\alpha_i}$$

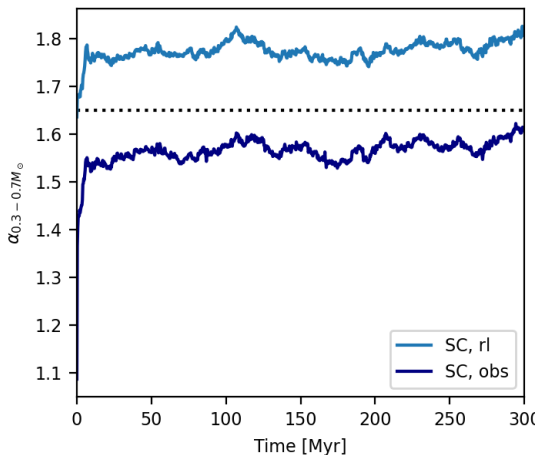


Figure: Wirth et al. (2024, in submission)

The apparent mass function

$$dN = \xi(m)dm$$
$$\xi(m) = k_i m^{-\alpha_i}$$

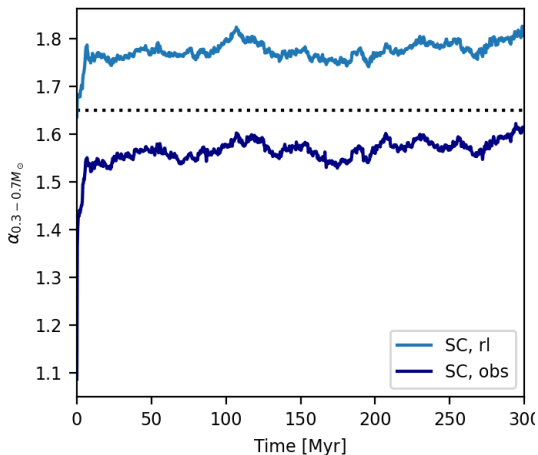


Figure: Wirth et al. (2024, in submission)

The apparent mass function

$$dN = \xi(m)dm$$
$$\xi(m) = k_j m^{-\alpha_j}$$

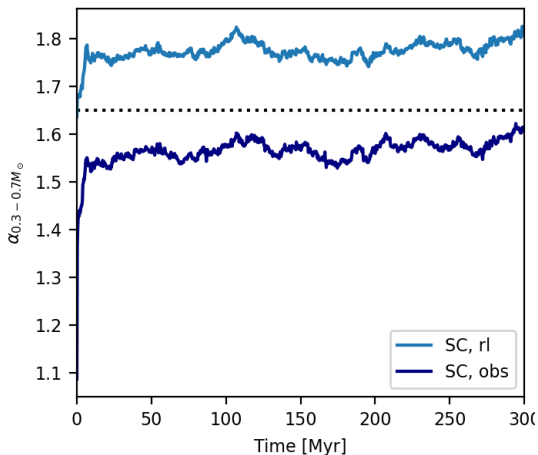
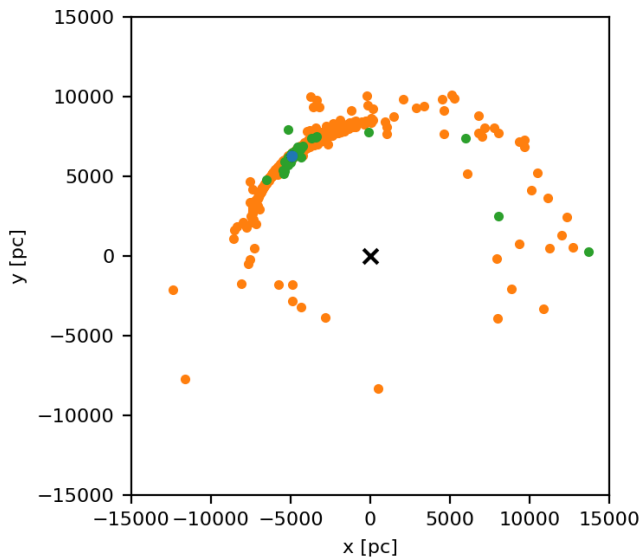


Figure: Wirth et al. (2024, in submission)

The tidal tails



Changes to the tidal tails

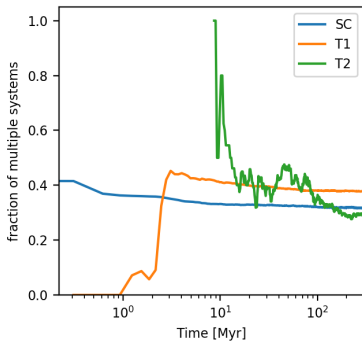
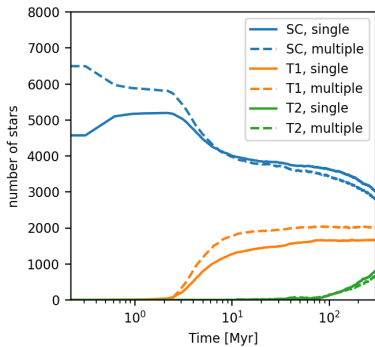


Figure: Wirth et al. (2024, in submission)

Changes to the tidal tails

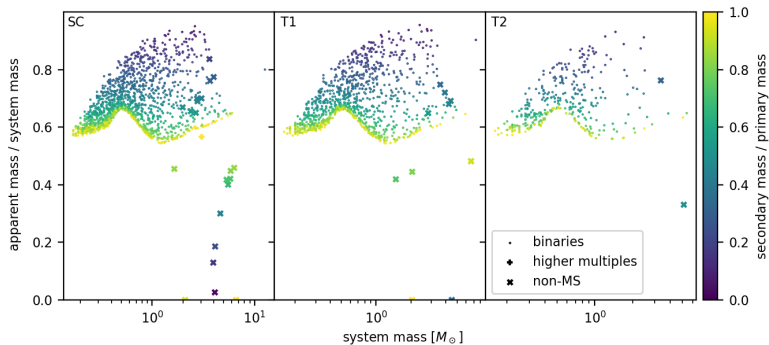


Figure: Wirth et al. (2024, in submission)

Changes to the tidal tails

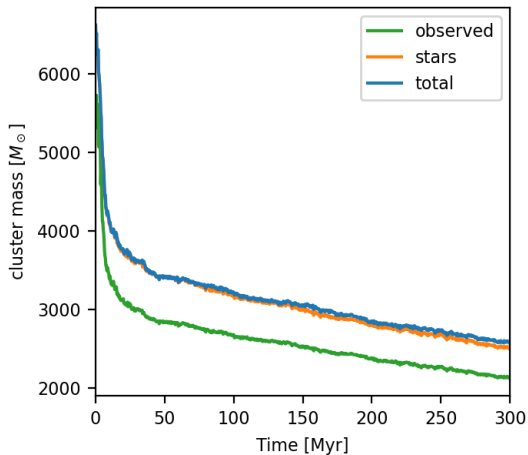


Figure: Wirth et al. (2024, in submission)

Changes to the tidal tails

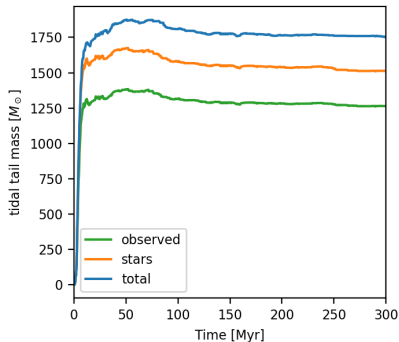


Figure: Wirth et al. (2024, in submission)

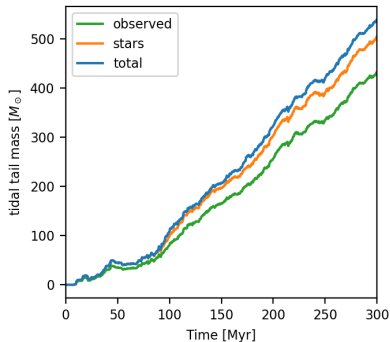


Figure: Wirth et al. (2024, in submission)

Changes to the tidal tails

$$dN = \xi(m)dm$$
$$\xi(m) = k_j m^{-\alpha_j}$$

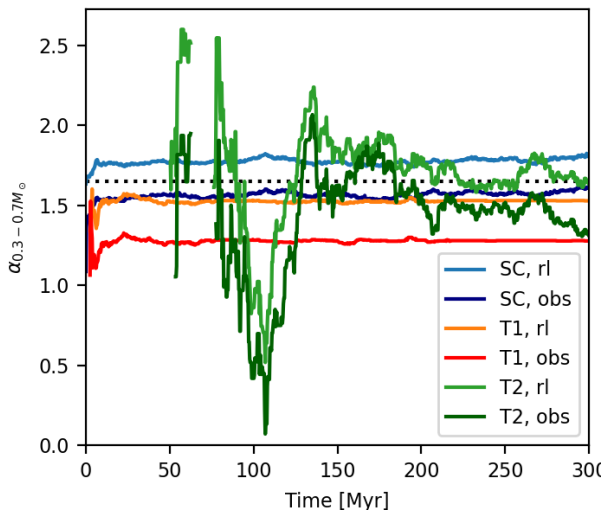


Figure: Wirth et al. (2024, in submission)

Summary

- Unresolved binaries lead to and underestimate of the total mass of the binary system.
- The total mass of the SC is underestimated by up to 20 % due to binaries and dark objects.
- The masses of the tidal tails are underestimated by a similar amount.

References

Illingworth G., 1976, *ApJ*, 204, 73

Kroupa P., Tout C. A., Gilmore G., 1993, *MNRAS*, 262, 545

Rastello S., Carraro G., Capuzzo-Dolcetta R., 2020, *ApJ*, 896, 152

Röser S., Schilbach E., Piskunov A. E., Kharchenko N. V., Scholz R. D., 2011, *A&A*, 531, A92

Additional material



Figure: Credit: NASA, ESA, and STScI.

Additional material



Röser et al.
(2011):

$$M_{\text{obs}} = 276M_{\odot}$$

Figure: Credit: NASA, ESA, and STScI.

Additional material



Figure: Credit: NASA, ESA, and STScI.

Röser et al.
(2011):

$$M_{\text{obs}} = 276M_{\odot}$$

- up to a factor 4 larger using the velocity dispersion