The Initial Mass Function and internal dynamics of the starburst cluster Westerlund 1 from near-infrared adaptive optics observations.

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Introduction

Starburst cluster -
young and dense stellar system, which contains at least several 10,000 stars and houses several O-type stars with initial more than 50 Mo in its center

Westerlund 1

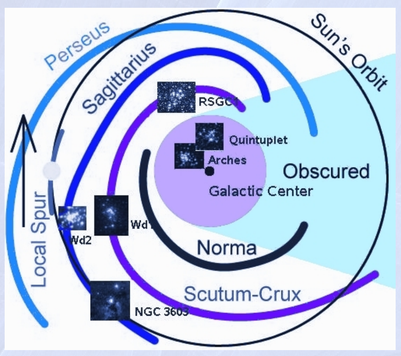
- 6 yellow hypergiants
- 4 red supergiants
- 24 Wolf-Rayet stars
- more than 100 OB supergiants

Around 10 starburst clusters are currently known in our galaxy and **Westerlund 1** (Wd1) with its rich population of high-mass stars **is the most massive one**. Strong winds and ultraviolet radiation from massive stars in the center of Wd1 have cleared away nearby interstellar material, revealing all clusters members with little differential extinction.

Why is it important to study starburst clusters?

- To derive the masses of the most massive stars in the single age, but at various stages of their evolution
- To get the spatially resolved Initial Mass Function (IMF) of the cluster
- To provide a resolved template for extragalactic star-forming regions
- Better to determine basic cluster properties, such as age, foreground extinction and distance
- Repeated collisions between such massive stars in the cluster might have led to formation of an intermediate-mass black hole in the core of Wd1

Why is it difficult to observe starburst cluster Wd1?



Location of Wd1:
Scutum-Crux spiral arm

- galactic longitude: l = 339.6°
- galactic latitude: b = - 0.35°

Very close location of Wd 1 to the galactic plane, yields a strong contamination by fore- and background nonmembers. For an unbiased determination of the cluster parameters and IMF, we have made a proper motion membership selection, based on 2 epochs VLT/ NACO observations with a 5 years time baseline.

At an age of 4 Myr, supernova explosions have already removed the ~65 most massive stars (Muno et al. 2006). Dynamical evolution of Wd1 has only just started, thus the present day mass function should still be represantative for the IMF. In this poster we discuss physical and dynamical properties of Wd 1 and present a new estimate of the intermediate to low-mass IMF of the cluster.

Methods

I. VLT/NACO adaptive optics observations of Wd1 with a 5 years time baseline

Westerlund 1 excerpt

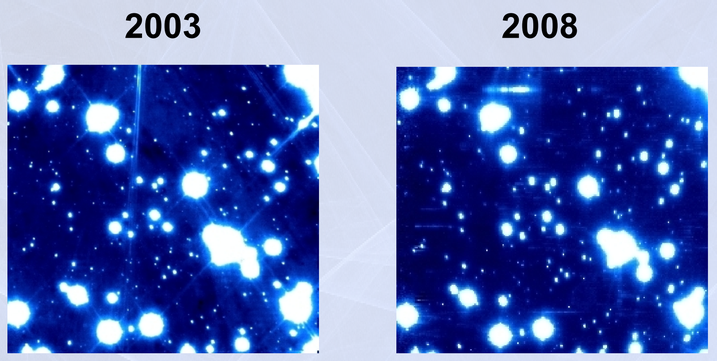
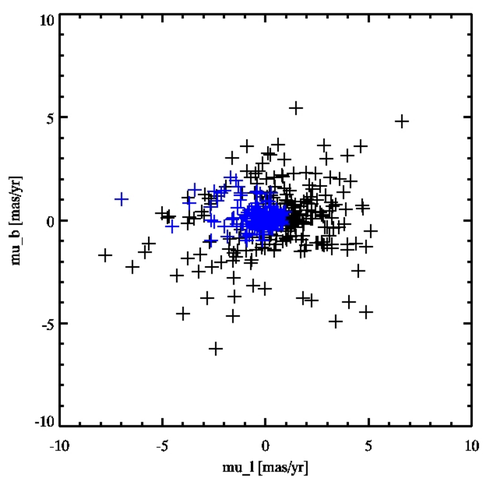


Image scale: 27 mas/pixel, Ks-band

II. Discrimination of cluster members from fore- and background stars

Proper motions of stars in galactic coordinates

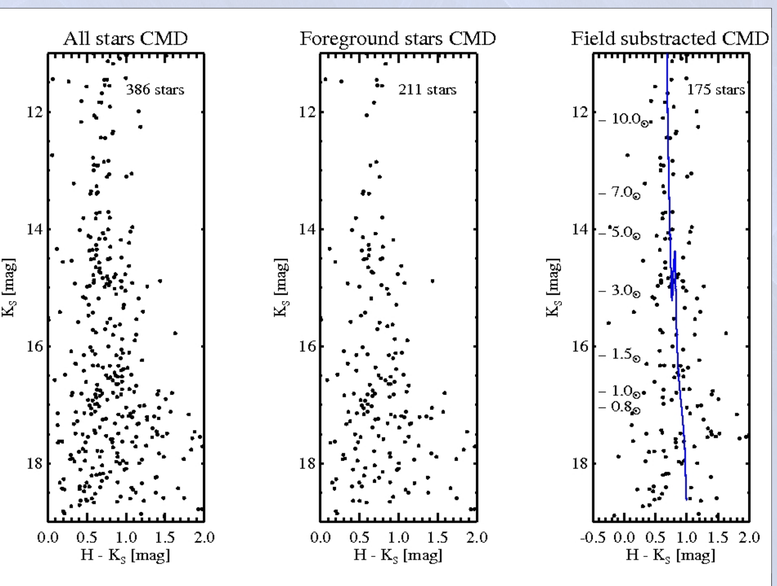


Cluster members- stars with membership probability ***P ≥ 90%*** (Jones&Walker,1988):

$$P(m,\mu_x,\mu_y,r) = \frac{\frac{\rho_0(m)}{f_0(m)} e^{-r/r_0(m)} \Phi_c(m,\mu_x,\mu_y)}{\Phi_f(m,\mu_x,\mu_y) + \frac{\rho_0(m)}{f_0(m)} e^{-r/r_0(m)} \Phi_c(m,\mu_x,\mu_y)}.$$

- membership probability of a star with proper motion μ_x, μ_y, magnitude m and distance from the cluster center r, where Φ_c, Φ_f are normalized distributions of cluster and foreground stars in the proper-motion diagram, and ρ_0, f_0 are central areal density of cluster stars and areal density distribution of foreground stars respectively

III. Cleaning of cluster Colour Magnitude Diagram (CMD)



Fitting of field subtracted CMD with main-sequence and pre-main sequence evolutionary tracks

For stars with **M > 4 Msun** : PADOVA isochrone (Marigo et al.)
For stars with **M < 4 Msun** : isochrone calculated using PISA-FRANEC evolutionary code (Tognelli et al.)

Results

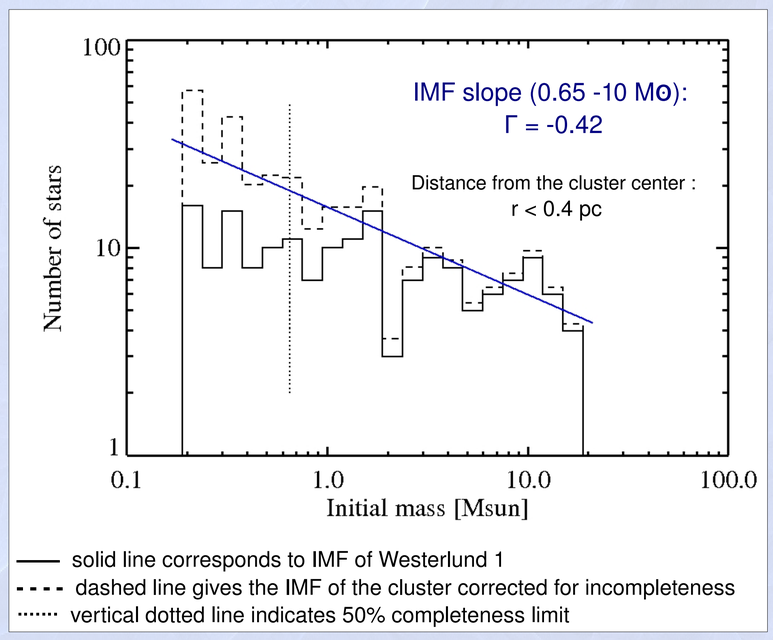
I. Estimation of extinction, distance and age from the fitted isochrone

Aks = 1.08 ± 0.01 mag

DM = 13.00 ± 0.25 mag or d = 3.98 ± 0.46 kpc

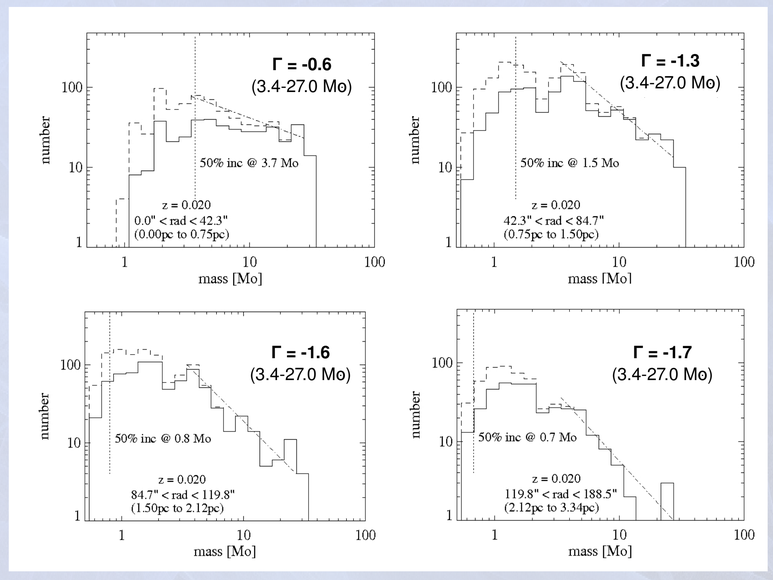
Age = 4.0 ± 0.5 Myr

II. The Initial Mass Function (IMF) of Wd1

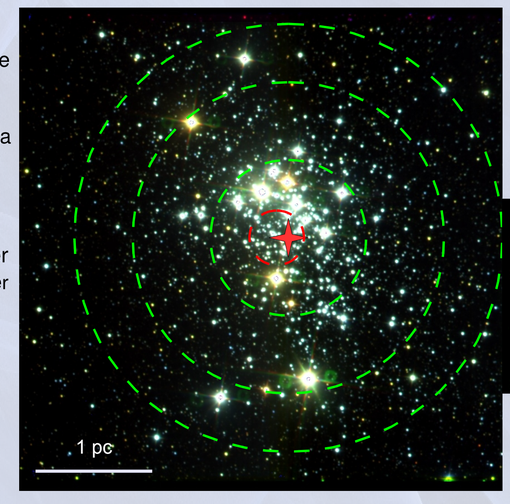


Discussion

The slopes of the stellar mass function of Wd1 for 4 annuli determined by Brandner et al. (2008) from NTT/SOFI observations:



JHK composite image of Wd1 based on the NTT/SOFI data



✦ - cluster center

VLT/NACO annulus

NTT/SOFI annuli

Our new value of IMF slope is in a good agreement with the change in mass function found for Wd1 by Brandner et al.(2008). With Γ= -0.42, the slope of the stellar mass function is quite shallow in the very cluster center, getting steeper with increasing distance center. This indicates that massive stars are highly segregated in the cluster core.

Thanks!
Any questions?
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