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Dynamical modeling of the Arches cluster using Fokker-Planck calculations

Joowon Lee[1] and Jihye Shin[2]

[1]School of Space Research, Kyung Hee University, Yongin, Gyeonggi 446-701, Korea
email: joowon.lee@khu.ac.kr

[2]Kavli Institute for Astronomy and Astrophysics, Peking University, 5 Yiheyuan Road, Haidian District, Beijing 100871, China

Abstract. The Arches cluster is a young, compact, and massive star cluster located in ∼30pc away from the Galactic Center in projection. The cluster is located in the extreme environment of the Galactic Center, making it an excellent target for understanding the effects of star-forming environment on the mass function of star clusters. In this study, we estimate the initial condition (mass, concentration parameter, and galactocentric radius) of the Arches cluster by comparing Fokker-Planck calculations with observed velocity dispersion, surface density and mass function data.

Keywords. Galaxy: globular clusters: individual(Arches), Galaxy: kinematics and dynamics

1. Introduction

Arches cluster, one of the starburst clusters near the Galactic Center (GC), is known to be young (2–2.5 Myr; Najarro *et al.* 2004, Martins *et al.* 2008), massive ($\sim 10^4$ M$_\odot$; Figer *et al.* 1999, 2002), and compact ($\sim 10^5$ M$_\odot$pc^{-3}; Espinoza *et al.* 2009). Arches cluster is located in ∼30 pc away from the GC in projection, thus it is expected to be formed under the extreme environments of high stellar and gas densities, turbulent motion, tidal forces, strong magnetic and radiation field (Stolte *et al.* 2002). Therefore, Arches cluster has been an excellent target for understanding massive star formation, stellar mass function, and dynamical evolution of the cluster near the GC.

2. Observation and models

Fokker-Planck (FP) results are compared with the observations of velocity dispersion (Clarkson *et al.* 2012), surface density (Espinoza *et al.* 2009), and mass function (Kim *et al.* 2006). We use the FP model that solves the two dimensional orbit-averaged FP equation and considers multi-mass clusters, three-body heating, tidal boundary condition, and stellar evolution (Takahashi 1997). For a mass spectrum, we use Kroupa initial mass function (Kroupa 2002) whose mass range is 0.1 - 150 M$_\odot$. King profile (King 1966) is adopted to assign the initial velocity and density distribution. We perform a parametric survey for concentration parameter W_0, galactocentric radius r_g, and initial mass of the cluster $M_{\rm init}$ and trace the best parameters for the current observations of the Arches cluster.

3. Results

The figure of merits for velocity dispersion, surface density, and mass function are calculated to quantify the similarity between the observations and FP results (Figure 1).

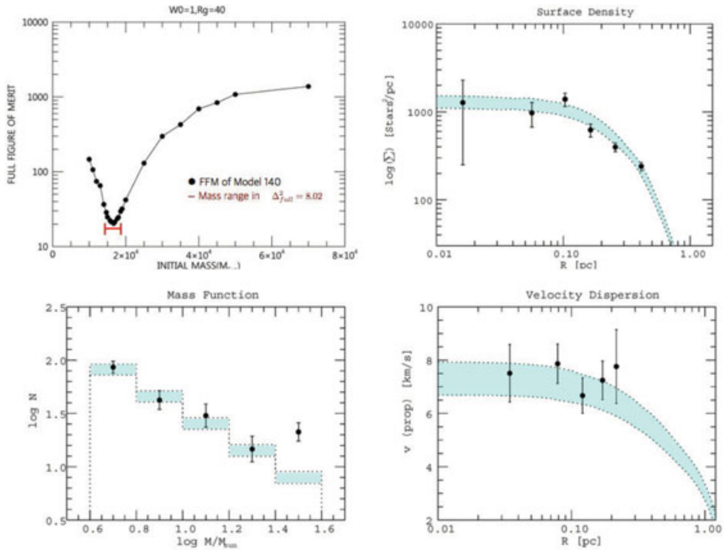

Figure 1. Left-top : Results of the full figure of merit of Model 140 (W_0=1 and r_g=40pc). **Right-top and bottom** : Comparisons of observations with FP results. Surface density (Espinoza *et al.* 2009), mass function (Kim *et al.* 2006), and velocity dispersion (Clarkson *et al.* 2012) data are used. Blue areas correspond to the results for 95.4% confidence level (2σ) of the best model.

Observed velocity dispersion, surface density and mass function are compared with the FP results in Figure 1 (right-top and two bottom panels). We calculate the *full figure of merit* (left-top panel of Figure 1) which is the total of three figure of merits, and find that the best model has $W_0 = 1$ and $r_g = 40$pc (Model 140). The initial mass range of the Arches cluster from our best model, which is $M_{\rm init} = (1.5{-}1.8) \times 10^4$ $M_\odot$ within the 95.4% confidence level.

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