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MASS DISTRIBUTION IN THE CENTRAL FEW PARSECS OF THE MILKY WAY

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ABSTRACT

Near-IR observations of the central few parsecs of our Galaxy from the HST/NICMOS have been analyzed to produce H, K photometry. We have cross-identified our photometry with the Keck high-resolution spectrometry of the central 0.5 pc of our galaxy to distinguish evolved late-type stars from early-type stars, and use late-type stars as tracer population. We perform several statistical tests to find the best fitting parameters of stellar density distribution and velocity dispersion models, then derive volume number densities and velocity dispersions. The volume number density distribution has power law index $1.55 \sim 1.7$. We then derive the mass distribution in the Central region of our Galaxy using the Jeans equation.

Keywords: Galactic center, SMBH, Jeans equation, infrared observation

1. INTRODUCTION

The mass distribution at the Galactic center is critical to understanding the processes occurring there. Because of extinction of the Galactic center and the limiting of near-infrared instrument, the determination of the mass distribution at Galactic center have been difficult. By several recent developments, however, progress in extending infrared observations of the Galactic center to fainter magnitudes and higher angular resolutions yield a wealth of information on the distribution of stars in the Galactic center and more accurate determination of mass distribution at the Galactic center has become possible.

In this study we analyze the near-IR images taken with HST/NICMOS, model the number density and velocity dispersion, and derive the mass distribution in the central 4 pc of the Milky way using the Jeans equation.

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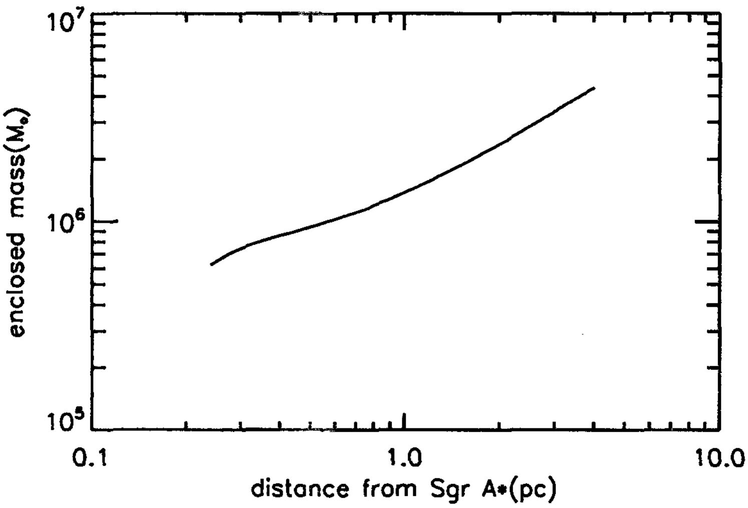

Figure 1. Plot of the mass distribution in the central 4 pc of the Milky way. The number density model (Genzel et al. 1996) is performed the K-S test to find best-fitting parameter. The enclosed mass in the central 4 pc is about 5×10^6 solar mass.

2. OBSERVATION AND DATA REDUCTION

The Galactic center phtometric images were obtained from HST/NICMOSat various epoch. All fields were imaged in F160W ($\lambda_{center} = 1.60\mu m$) and F222M ($\lambda_{center} = 2.22\mu m$) of the NIC2 aperture. We performed PSF photometry using the DAOPHOT package (Stetson 1987) within the Image Reduction and Analysis Facility (IRAF). Then instrumental magnitudes were calibrated and converted into the VEGAMAG phtometric system of HST, defined such that the absolute magnitude of Vega would be 0.02 in all bandpasses. By adding the artificial stars on the observed images, we calculated recovery fractions of stars as a function of magnitudes. Then we determine the limiting magnitude, at which the recovery fraction is 85% from the most crowded field. We assumed that the $(F160W\text{-}F222M)_0$ color is 0.3 mag for both early- and late-type stars and calculated the interstellar extinction toward the stars in our fields (Rieke & Lebofsky 1985, Rieke, Rieke & Paul 1989). Evolved late-type stars have a CO absorption band longward of $2.29\mu m$. Thus the narrow band color $K_{cont}(2.26\mu m) - CO(2.29\mu m)$ can photometrically distinguish evolved late-type stars from early-type stars. We identify late-type stars among our NICMOS data by the Gemini K_{cont} and CO band observations.

We obtain the velocity data of stars in the Galactic center in several published radial velocity and proper motion data sets: Genzel et al. (1996, 2000) and Figer et al. (2003). Genzel et al. (1996) observed line of sight velocities of 223 stars with 3D+SHARP, Figer et al. (2003) obtained radial velocities for 85 stars using NIRSPEC on Keck II, and Genzel et al. (2000) published the proper motion data taken MPE-SHARP camera on the 3.5-m New Technology Telescope (NTT) of the European Southern Observatory (ESO) in the central parsec of the Galaxy.

3. ANALYSIS OF THE MASS DISTRIBUTION

The mass distribution in the central region of our galaxy can be derived using Jeans equation.

The spherically symmetric Jeans equation becomes (Binney & Tremaine 1987, Genzel et al. 1996)

$$\frac{1}{n}\frac{d}{dr}[n\sigma_{\gamma}^{2}] + 2\frac{\beta\sigma_{\gamma}^{2}}{\gamma} - \frac{v_{rot}^{2}}{\gamma} = -\frac{GM(\gamma)}{\gamma^{2}} \quad (1)$$

Here M(r), $\beta = 1 - \sigma_{\theta}^{2}/\sigma_{\gamma}^{2}, n, \sigma_{\gamma}$, and v_{rot} are the total mass enclosed within radius r, the anisotropy parameter (we assume $\sigma_{\theta}^{2} = \sigma_{\phi}^{2}$), the volume number density, radial velocity dispersion, and rotational velocity function as a function of radius r.

Assuming three different number density models (Saha, Bicknell, & McGregor 1996, Genzel et al. 1996, Alexander 1999), we perform the chi-square test, the Kolomogorov-Smirnov (K-S) test, and the maximum likelihood (ML) test to find best-fitting parameters of each number density models. The chi-square test has the arbitrariness of binning, the K-S test is sensitive to the mid-range of the projected distance, and the ML test is sensitive to the inner, high-probability region.

For the anisotropy velocity dispersion, we perform the K-S test to the velocity dispersion models (Genzel et al. 1996, 2000), proper motion and line-of-sight velocity data.

4. CONCLUSIONS

All number density models are assumed power law distribution n $\propto \gamma^{-\alpha}$. By performing χ^2 test, K-S test, and ML analysis, we obtain power law index $\alpha = 1.55 \sim 1.7$ in the central 4 pc. These values are less than the previously known value, $\alpha = 1.8$.

We derive the mass distribution in the central 4 pc using the Jeans equation. We plot the mass distribution in the central 4 pc of our Galaxy. Figure 1 shows that enclosed mass within 4 pc from the Galactic center is about $5 \times 10^{6}_{\odot}$.

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