Probing mass segregation near the Galactic black hole with Red Clump giants

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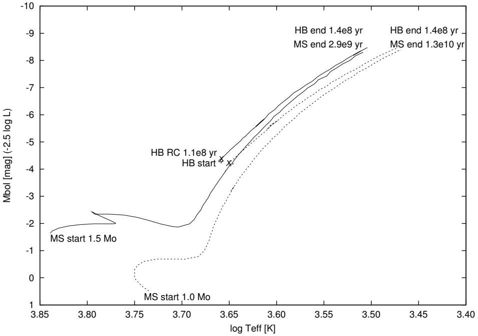
Strategies for probing mass segregation

- Find the massive objects that sank in
  - Stellar black holes:
    X-rays (Muno et al. 2004)
    IR Lensing (Chanamé, Gould & Miralda-Escudé 2001)
- Detect effects of massive objects
  - Collisions? Exotic object formation? (Morris 1993)
- Find the light objects that floated out
  - Neutron stars:
    Radio pulsars (Chanamé & Gould 2002; Pfahl & Loeb 2004)
  - White dwarfs:
    Cataclysmic variables (Muno et al. 2004)

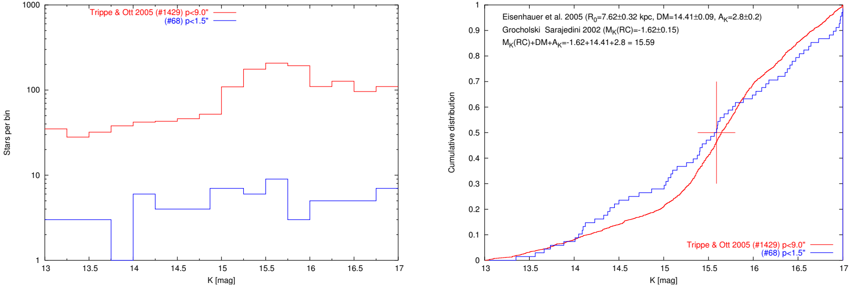
Red Clump giants



Girardi et al. 1999

- Progenitor masses
  $\sim 0.5\,M_\odot$–$2\,M_\odot$
- Main-sequence lifespan
  $t_{MS} > 10^9$ yr
- He-burning giant phase
  $t_{RC} \sim 10^8$ yr
  $R_\star \sim 10\,R_\odot$
  $T_\star \lesssim 5000^\circ\,K$
  $K \sim 15.5^m$–16^m

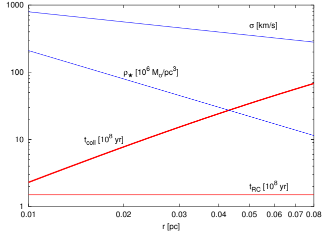
Red Clump giants in the GC



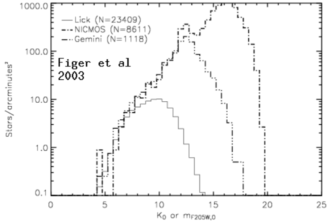
Trippe & Ott 2005

Other explanations?

- Tidal disruption? ▷ $r_t(\mathrm{RC}) \sim \mathcal{O}(10^{-5}\,\mathrm{pc}) \ll 0.04\,\mathrm{pc}$
- Collisional destruction? ▷



- Not Red Clump giants? ▷



Theoretical predictions of mass segregation

- The only robust prediction: The most massive stars ($m_1 \leq m \leq m_2$) come to dominate the mass density in the center and settle into the single-mass solution there,

$$n_{m_2}(r) \propto r^{-7/4}$$

- Bahcall & Wolf 1977 (analytic):

$$n_m(r) = A_m r^{-\alpha(M)}, \qquad \alpha(m) \sim 3/2 + (1/4)(m/m_2)$$

- Baumgardt, Makino, Ebisuzaki 2004 (n-body):

$$n_m(r) = A_m r^{-\alpha(m)}, \qquad \alpha(m) \sim 0.75 + (m/m_2)$$

- What about wide mass range? Continuous star formation?

A family of simple toy models

- Constant SFR with Miller-Scalo IMF at $t = 10$ Gyr
- Prompt mass segregation in a closed box ($r_1 \leq r \leq r_2$)
- Single power-law density distributions

$$n_m(r) = A_m r^{-\alpha(m)}$$

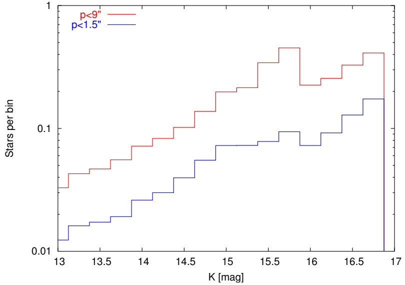
$$4\pi \int_{r_1}^{r_2} \mathrm{d}r\, r^2 n_m(r) = \left.\frac{\mathrm{d}N}{\mathrm{d}m}\right|_t$$

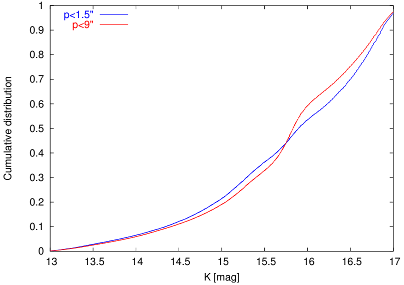
$$\int_{M_1}^{M_2} \mathrm{d}m \int_{r_1}^{r_2} \mathrm{d}r\, m n_m(r) = M$$

- Segregation mass scale: $m_2 \to m_s$ such that

$$t_\star(m_s) = t_{seg} = \frac{\langle m \rangle}{m_s} t_{rel}$$

Toy results





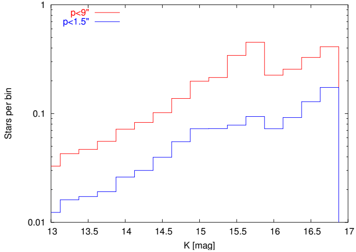
$$0.15 < m/M_\odot < 125$$

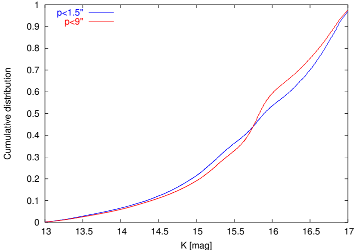
$$r_t < r < 5\,\mathrm{pc}$$

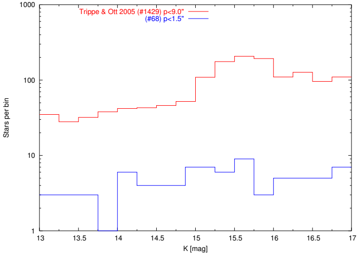
$$\alpha(m) = \begin{cases} 0.75 & m < m_s \\ 1.75 & m \geq m_s \end{cases}$$

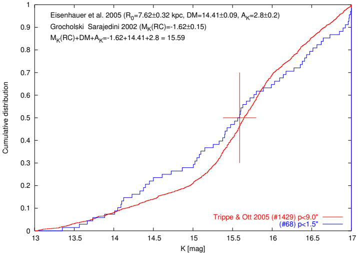
$$m_s = 2.5\,M_\odot$$

First comparison with observations









Trippe & Ott 2005

Summary

- Red Clump giants can probe mass segregation on <0.1 pc scales.
- The required stellar IR data is within reach.
- Predicted KLF sensitive to mass segregation model (but also to stellar pop. properties).
- Theoretical segregation predictions needed!