Optical Identification of the Black-Widow M71A and the Dynamical Status of its Host GC

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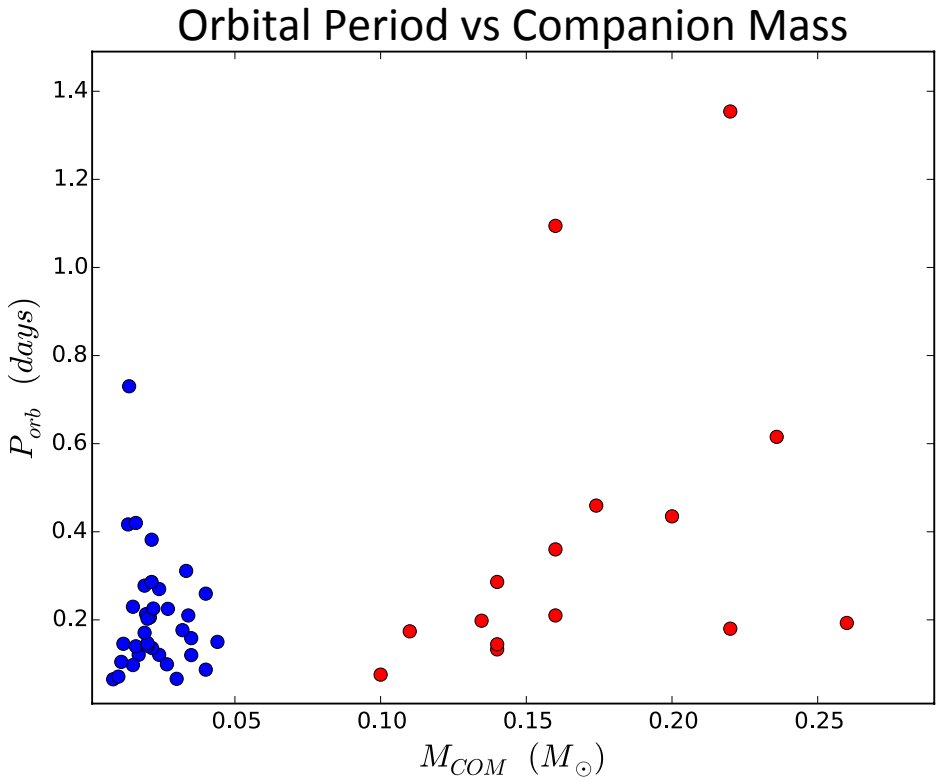
Eclipsing Millisecond Pulsars

- Periodical Eclipses of the Radio Signal
- Orbital Periods Usually Shorter Than 1 Day
- No Orbital Eccentricity → Tidal Circularization
- X-ray and γ-ray Counterparts



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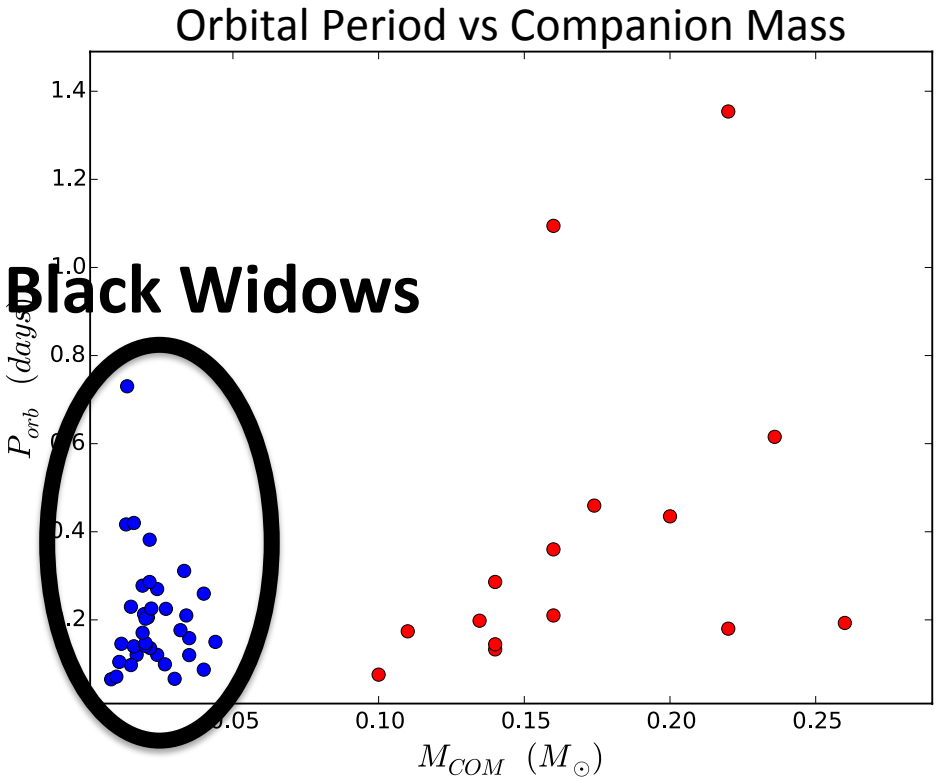
Black Widows

$M_{COM} < 0.1\ M_{SUN}$



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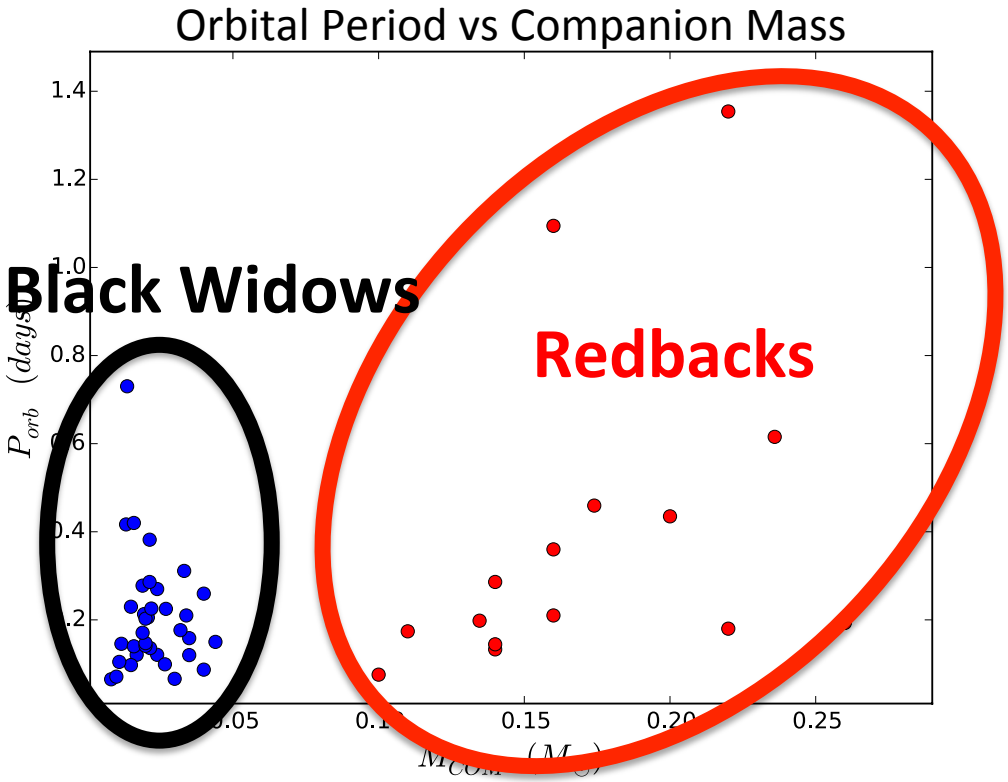
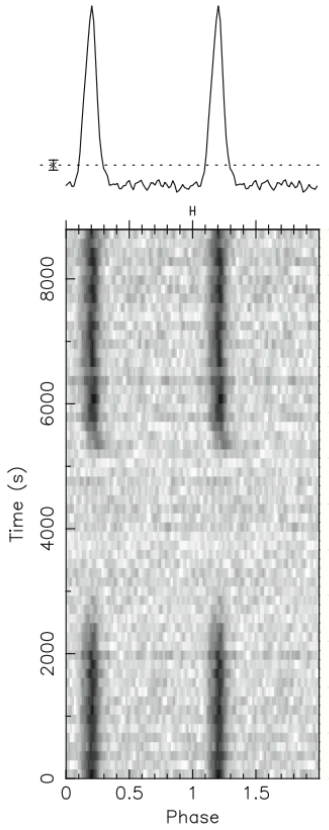
Redbacks

$0.1\ M_{SUN} < M_{COM} < 0.5\ M_{SUN}$



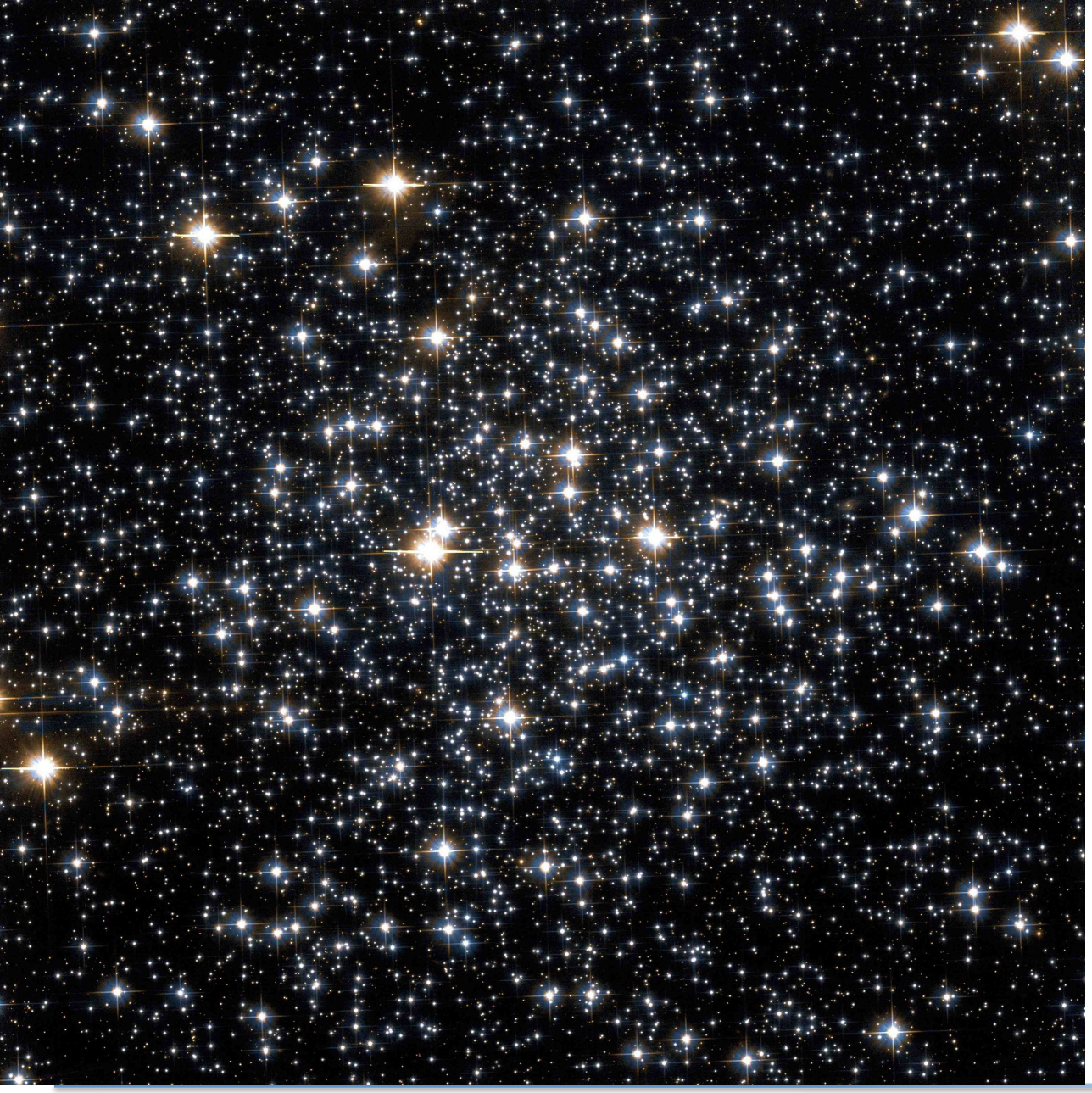
PSR J1953+1846A (M71A)

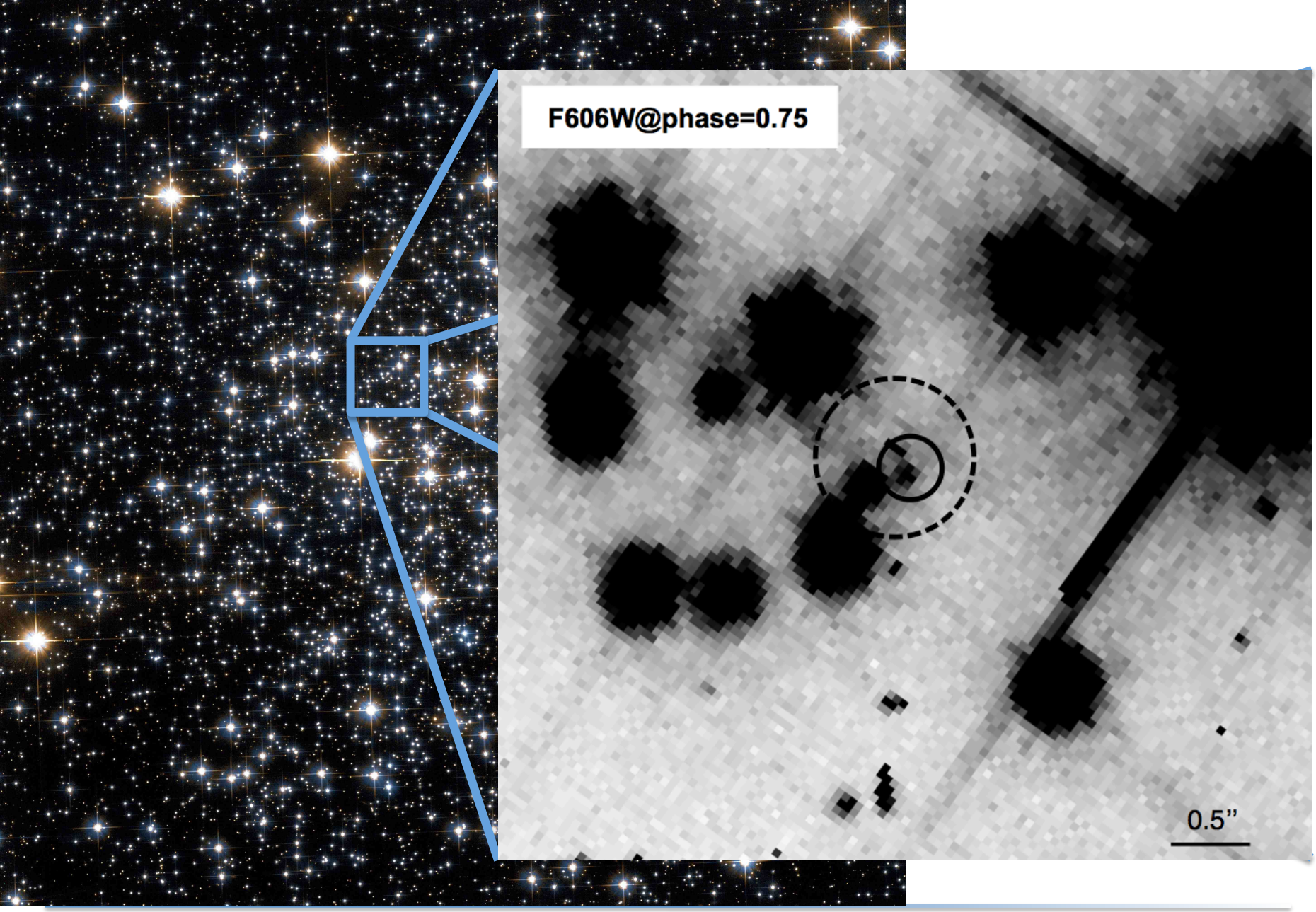
- Short Orbital Period of ~4 hours. No orbital eccentricity.
- Eclipses for about 20% of the orbital period during the PSR superior conjunction.
- Companion mass of ~0.03 Msun.
- X-ray counterpart. Non thermal emission likely due to an intrabinary shock.

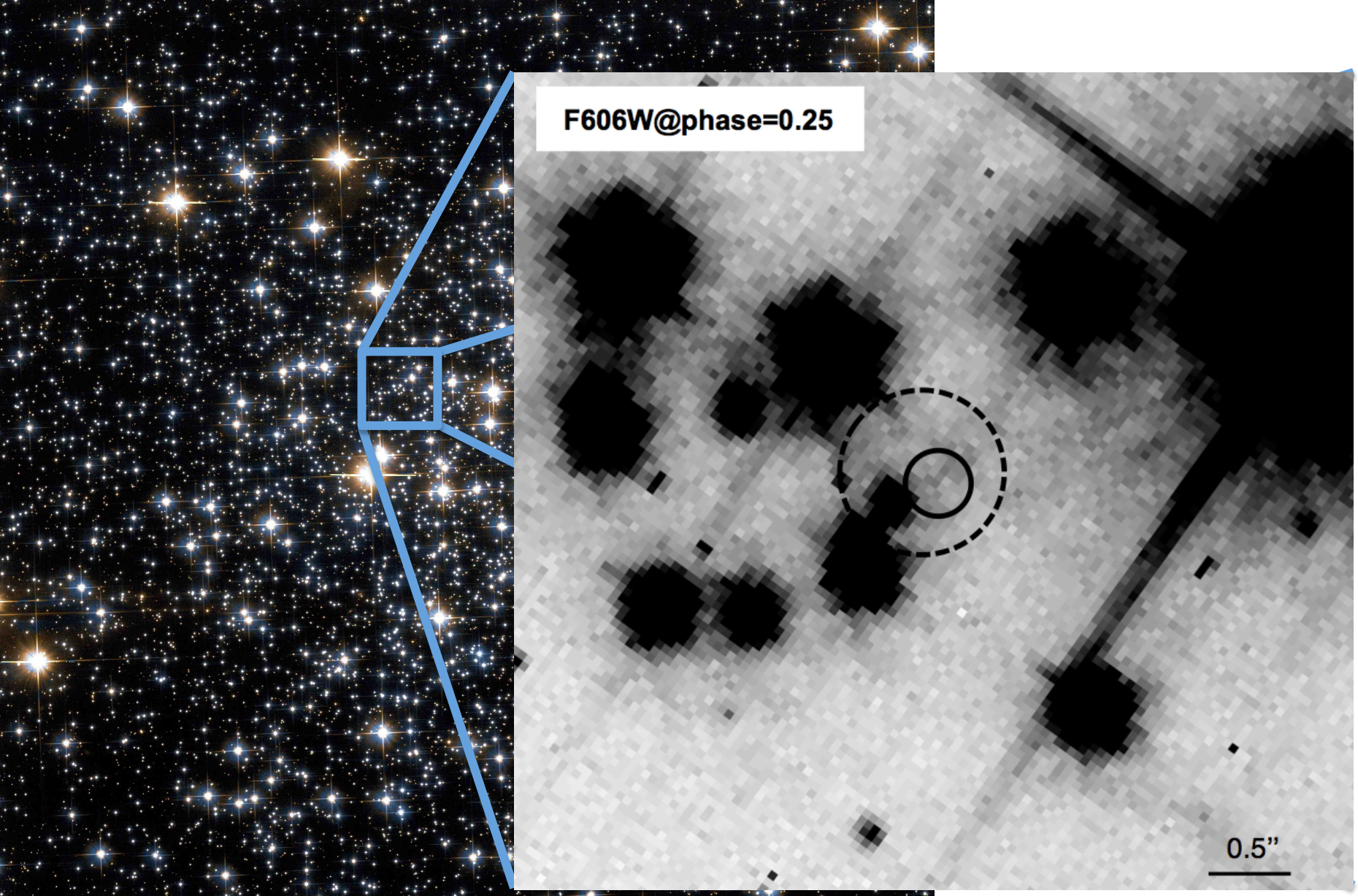


Hessels et al., 07
Elsner et al., 08
Cadelano et al., 15a

We identified the optical counterpart by using deep observation obtained with the ACS@HST




F606W@phase=0.75
0.5”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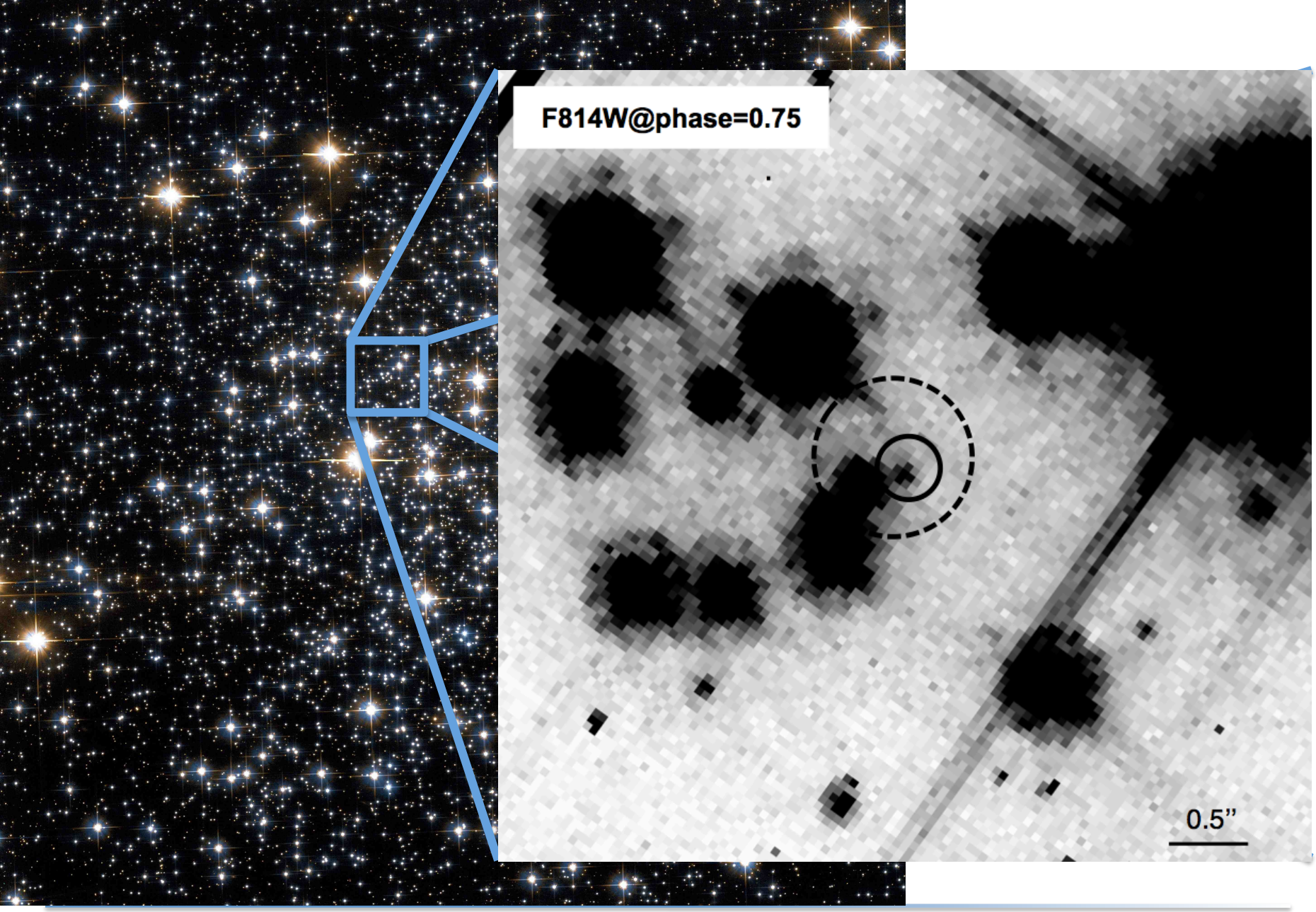
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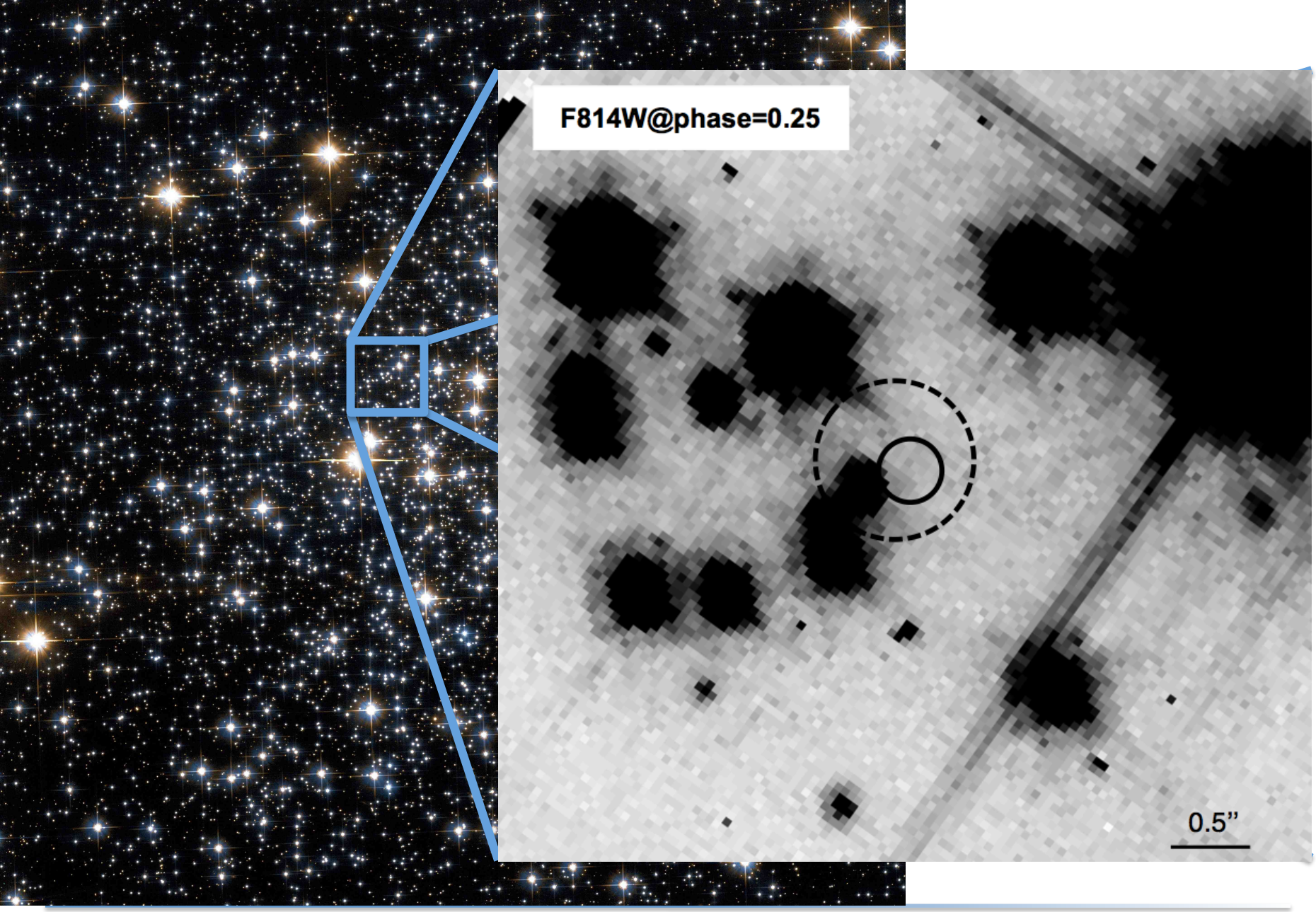
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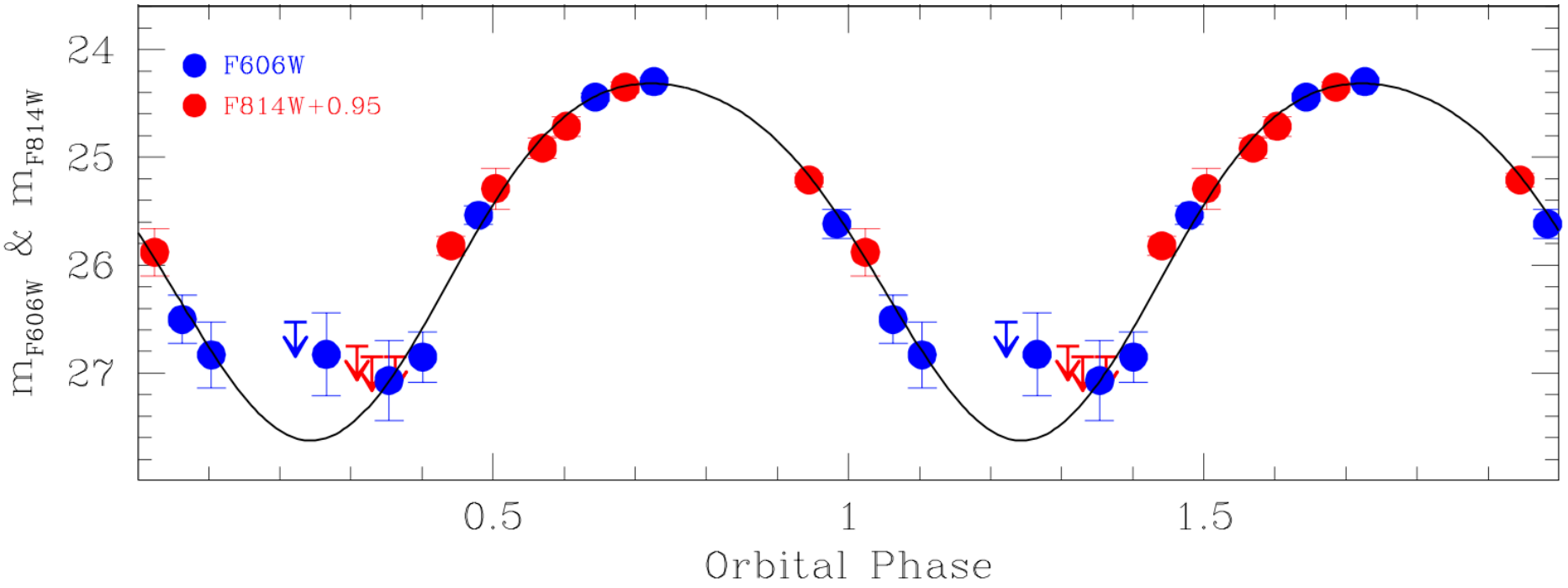
COM-M71A light curve



Cadelano et al., 2015a

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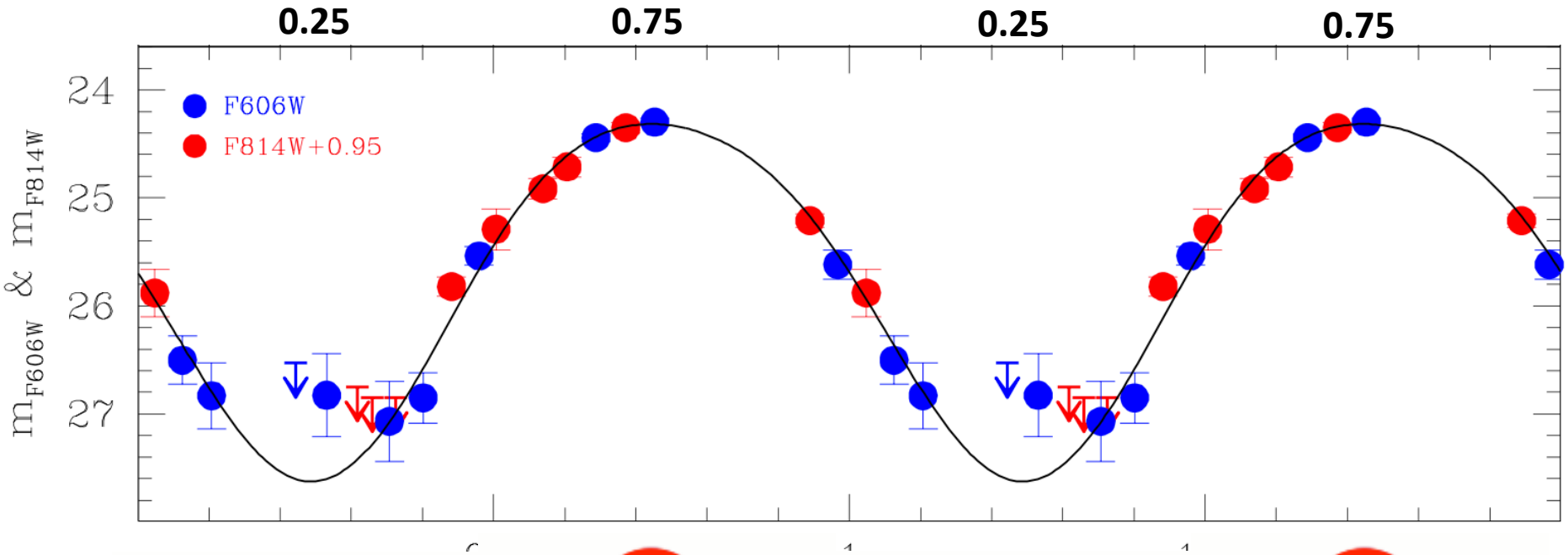
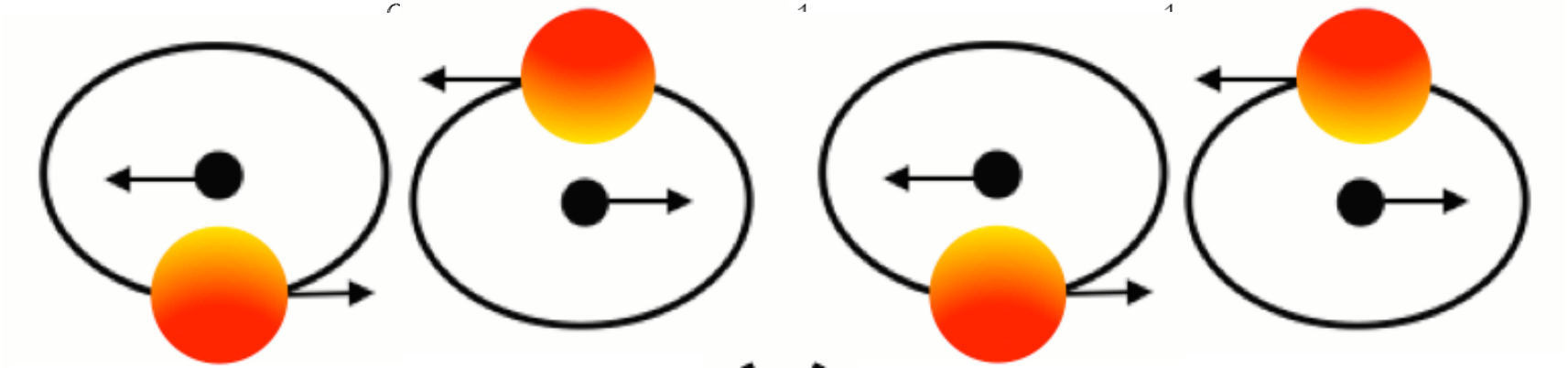
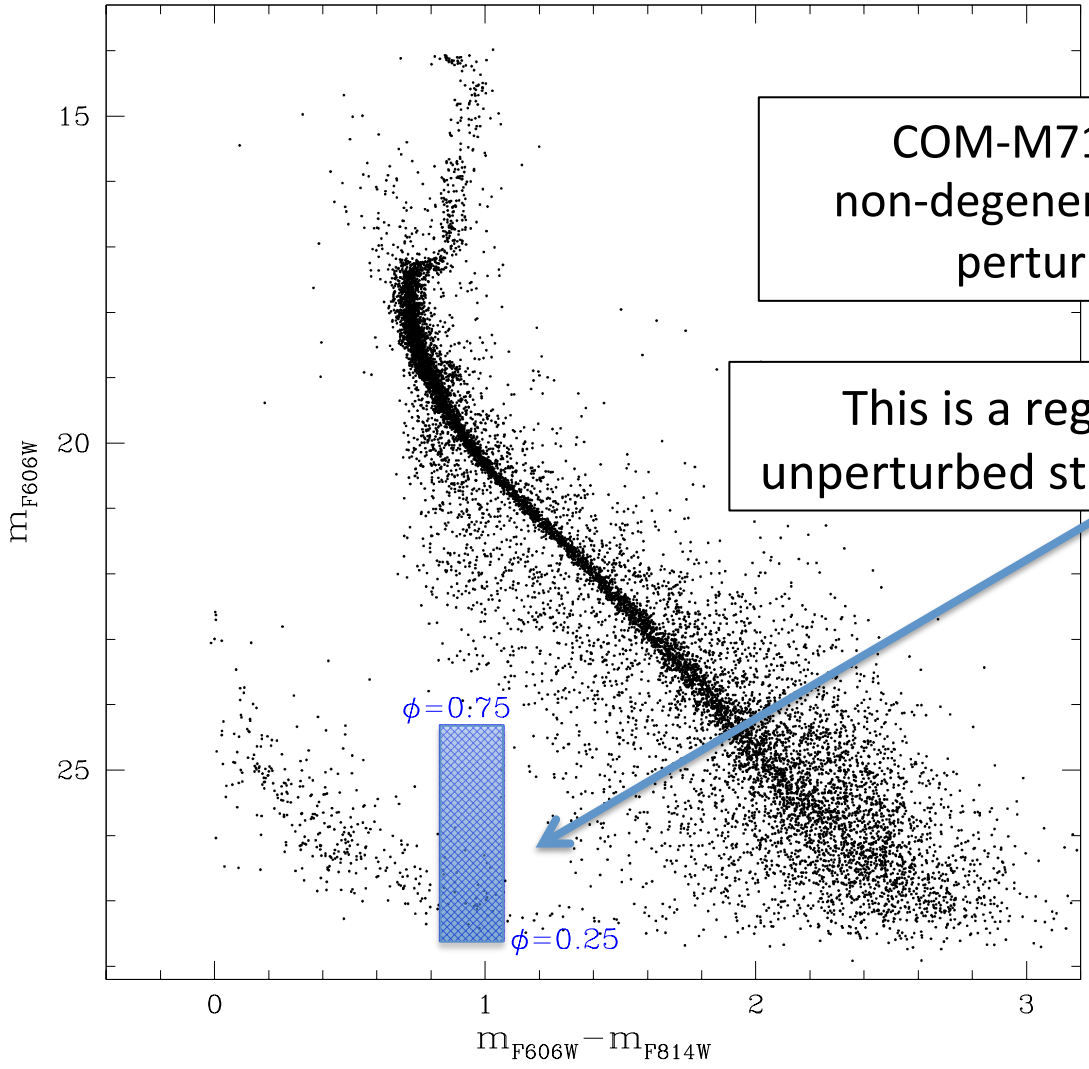




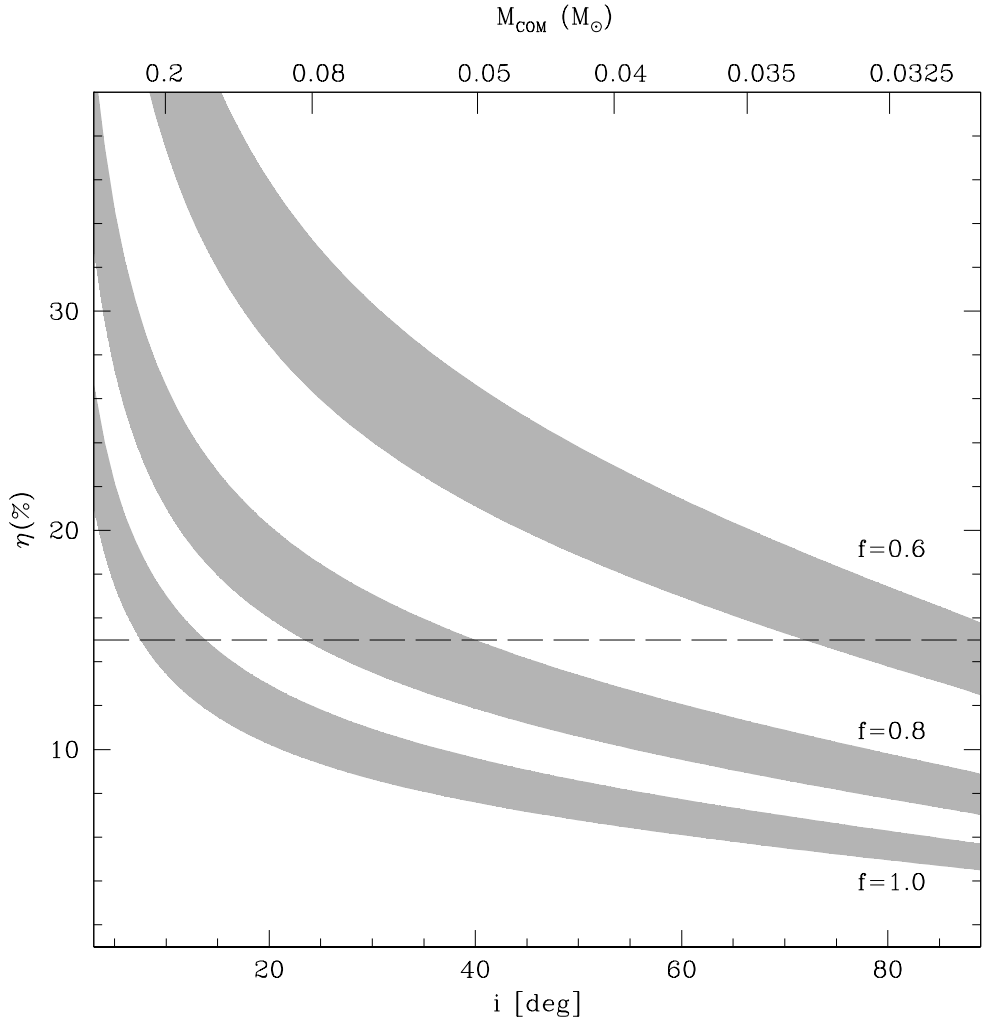
CMD Position



COM-M71A is likely a non-degenerate and highly perturbed star.

This is a region where no unperturbed stars are expected!

Reprocessing efficiency and RL filling factor



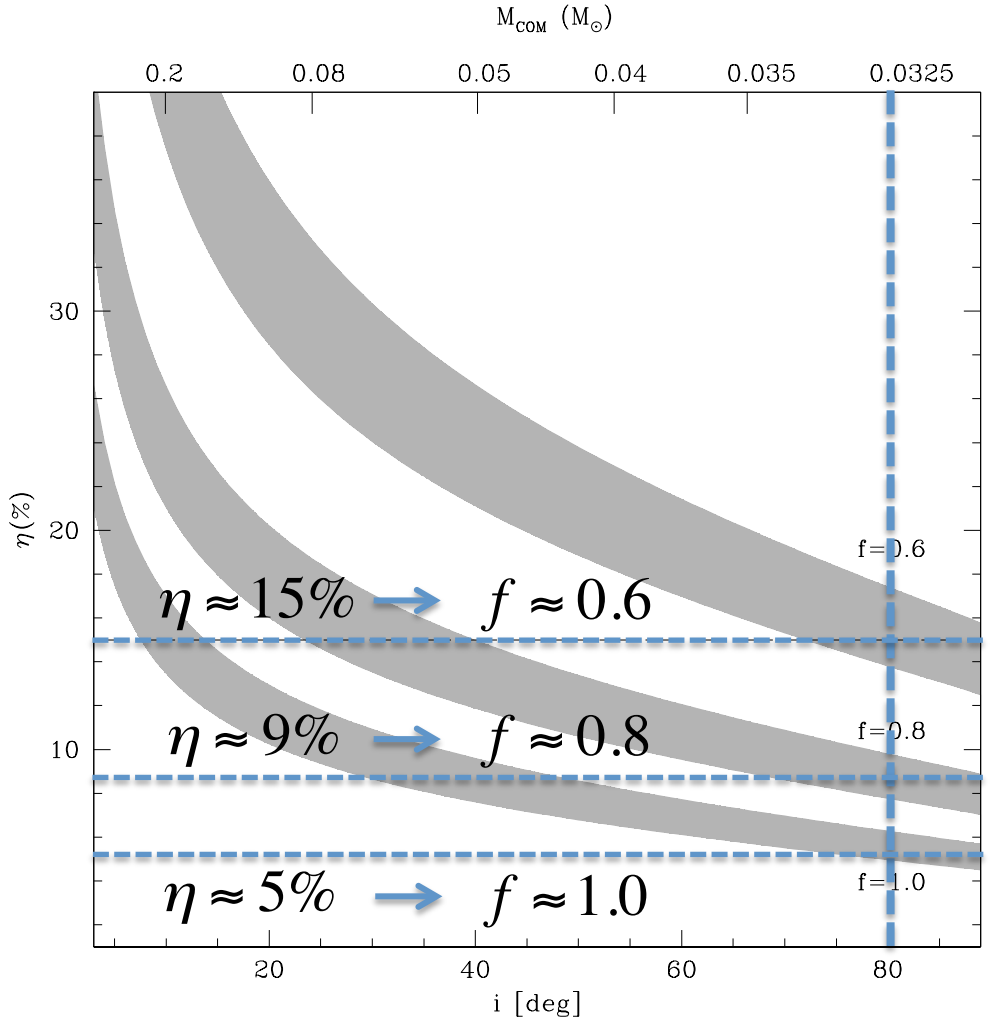
Magnitude modulation due to the **reprocessing of the PSR injected flux**

$$\dot{E}_{rot} \cong 4.6 - 5.8 \times 10^{33} ergs/s$$

$$\Delta F_{\exp}(i) = \eta \frac{\dot{E}_{rot}}{a^2} (fR_{RL})^2 \frac{\varepsilon(i)}{4\pi d_{PSR}^2}$$

Flux difference between the minimum and the maximum.

Reprocessing efficiency and RL filling factor



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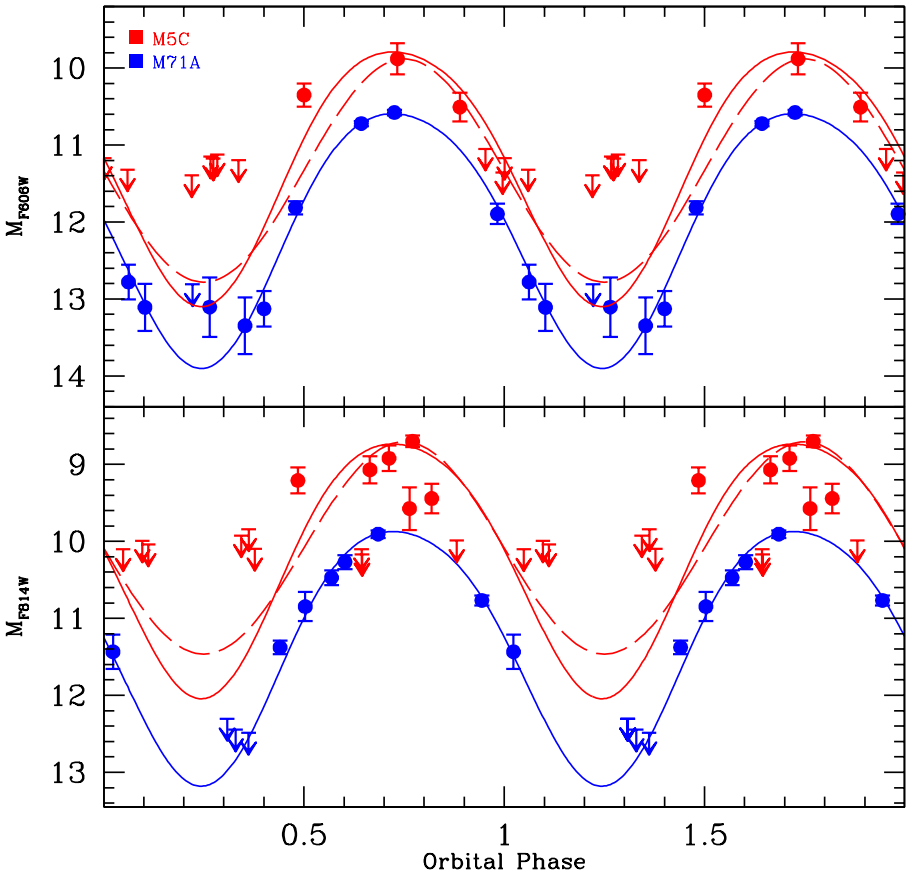
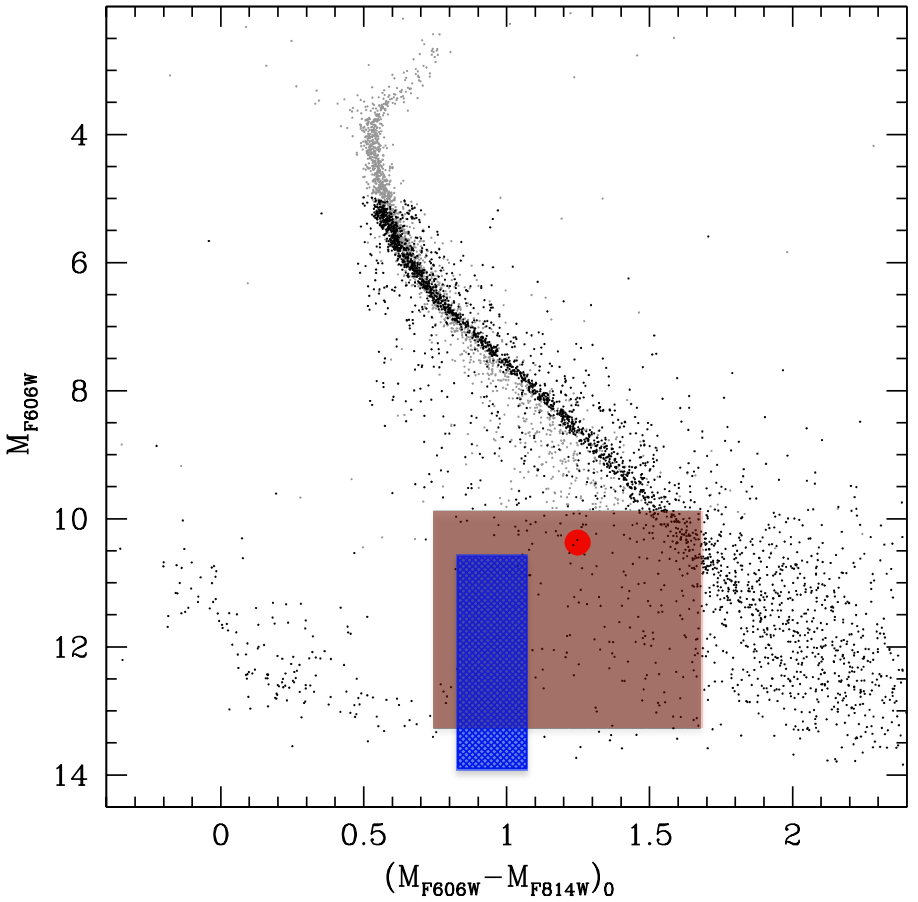
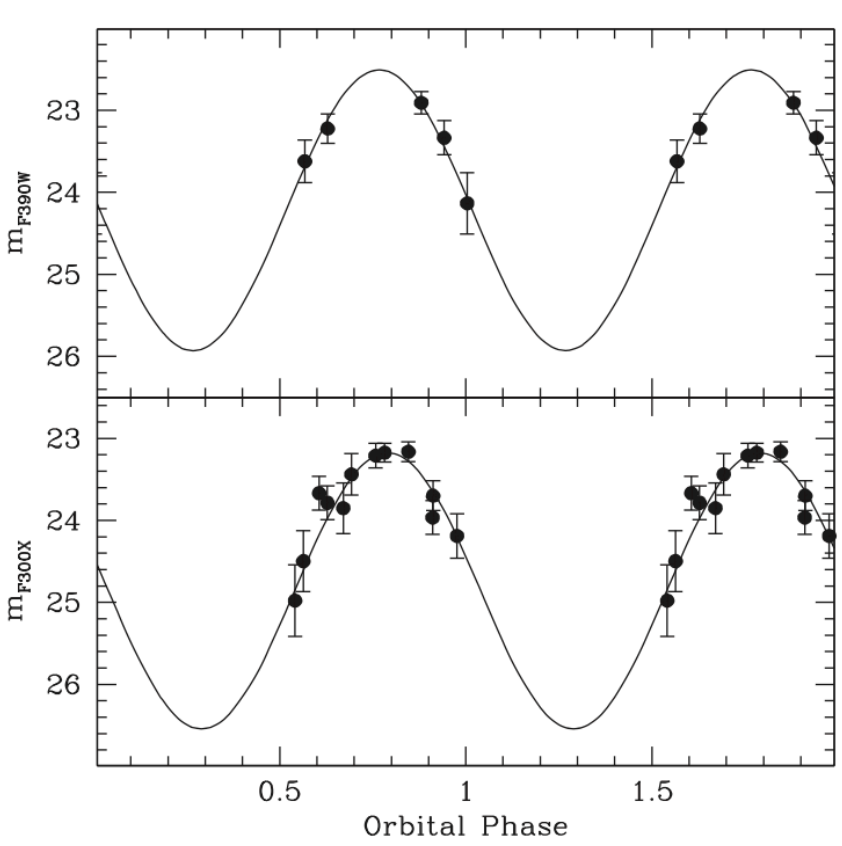
M71A vs M5C

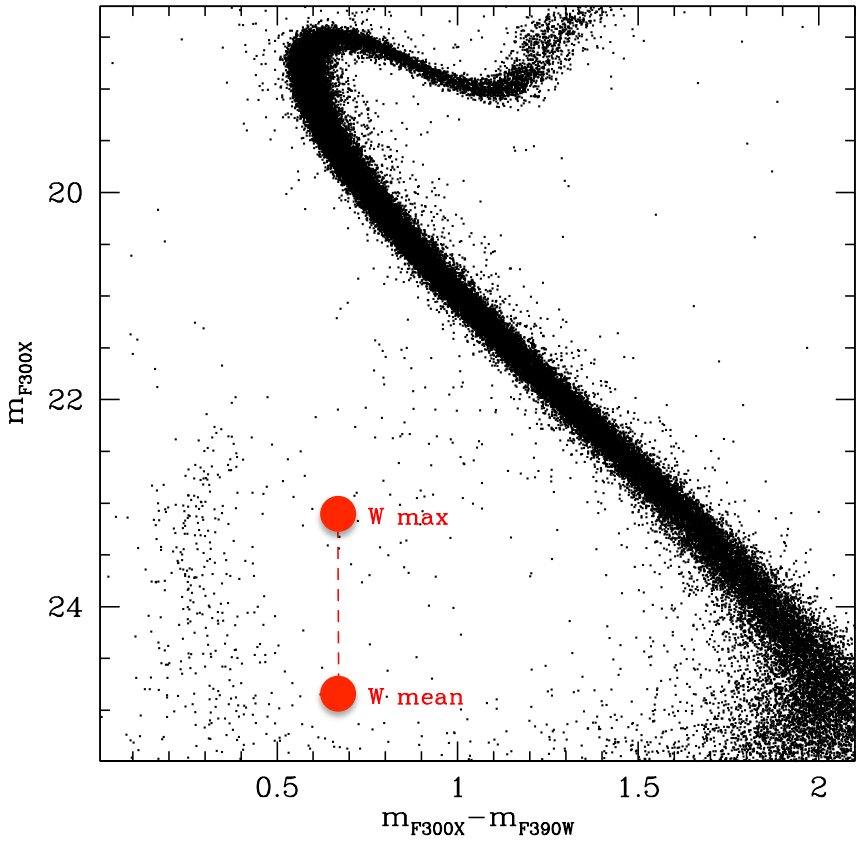




Pallanca et al., 14 ; Cadelano et al. 15a

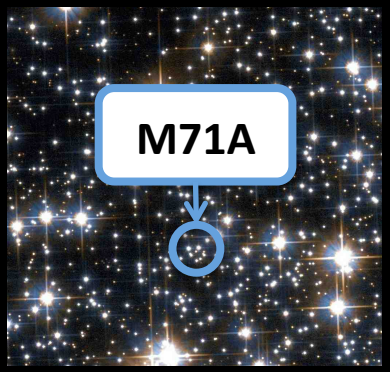
M71A vs 47TucW

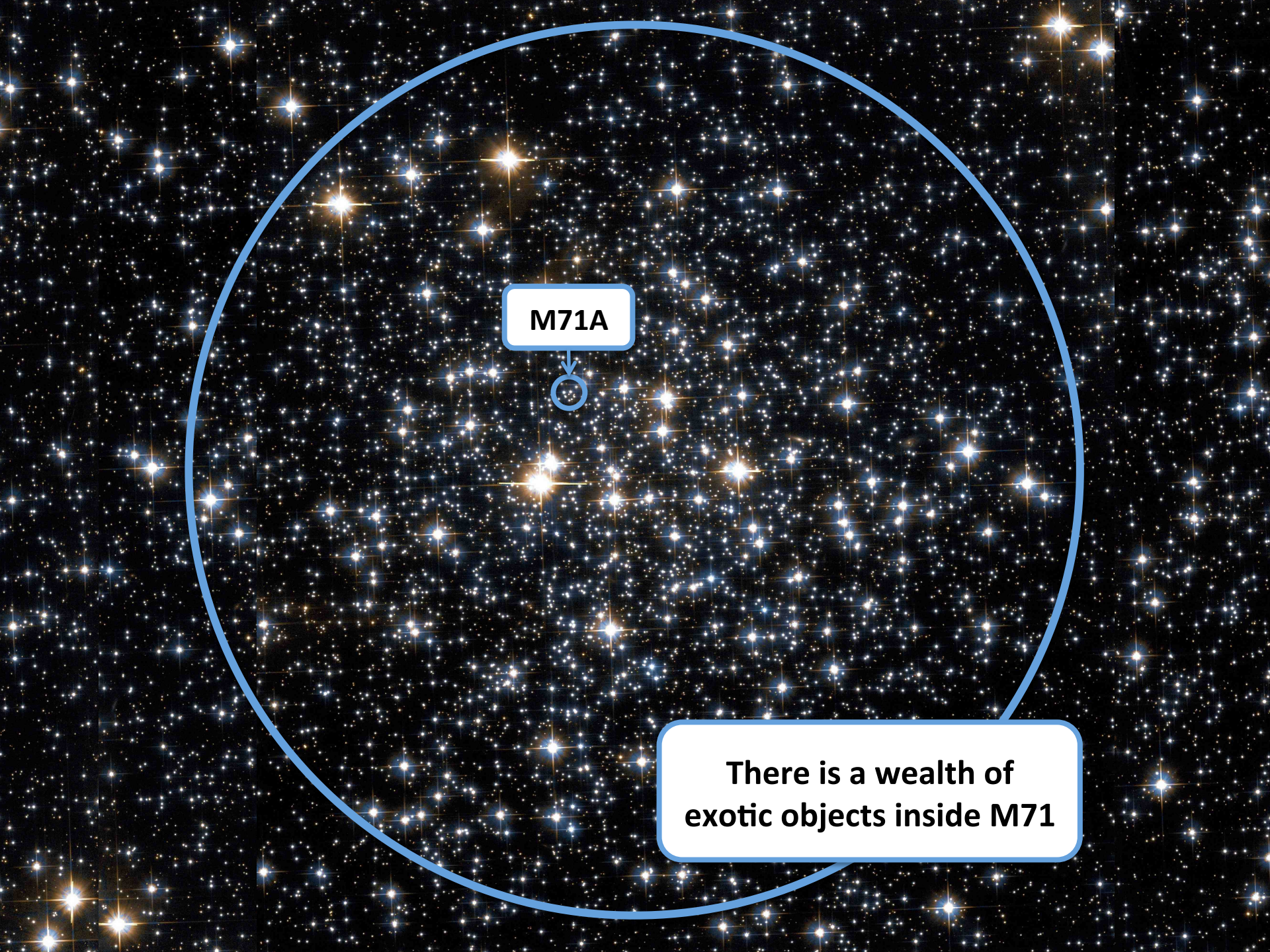




Irradiation not only on Black Widow companions but also in some Redbacks!

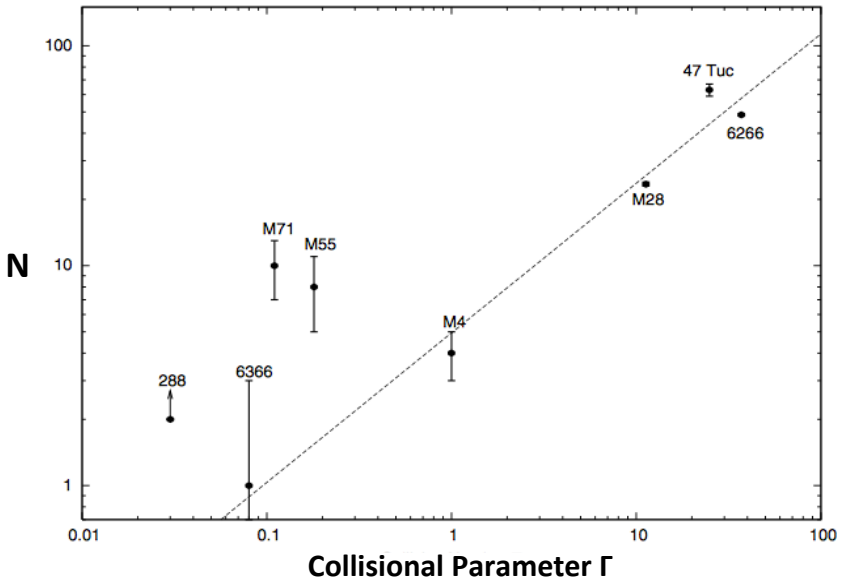
Cadelano et al. 15b, see also Edmonds et al. 02

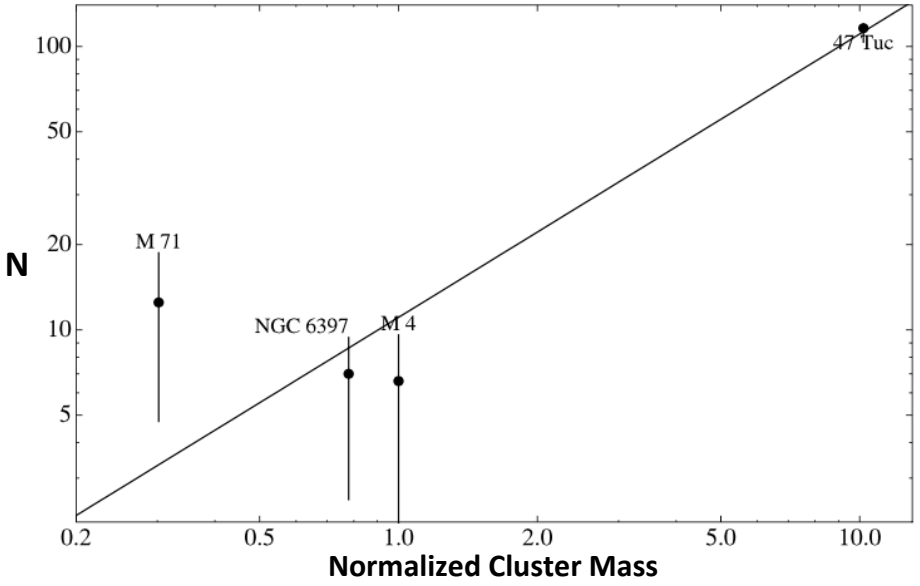

M71A


M71A
There is a wealth of exotic objects inside M71

The X-ray source population in M71

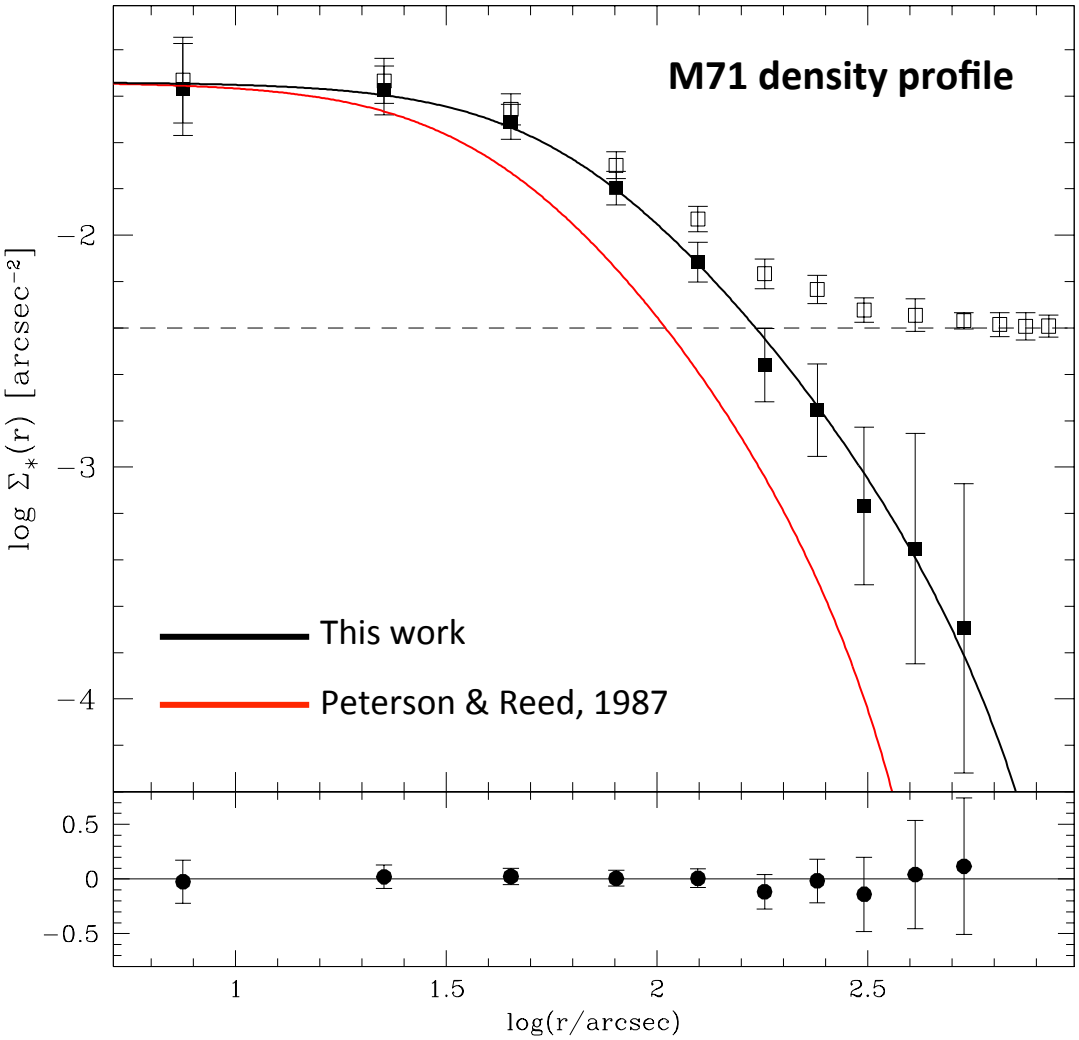
M71 is a low-mass (2×10^4 Msun) and low-density GC.
However, it harbors a very rich population of X-ray sources, larger than predicted by its **COLLISIONAL PARAMETER** and by its **CURRENT TOTAL MASS**.





Elsner et al., 08 ; Huang et al., 10

The collisional parameter $\Gamma \propto \rho_0^{1.5} r_c^2$



M71 structural parameters

Param.	OLD	NEW
W_0	5.5	6.2
R_c	38''	59''
R_h	100''	174''
R_t	534''	1280''
c	1.15	1.3

$$\Gamma_{NEW} \approx 2\Gamma_{OLD}$$

Cadelano et al., to be submitted

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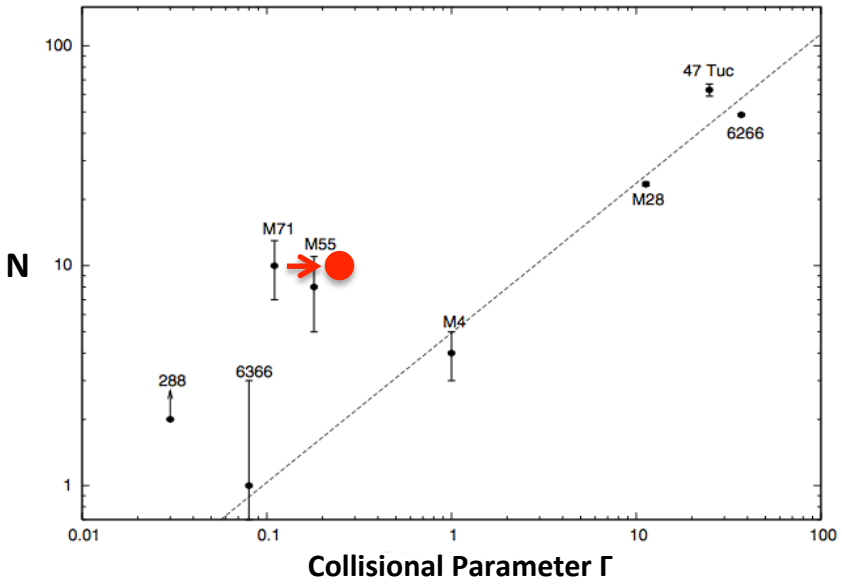
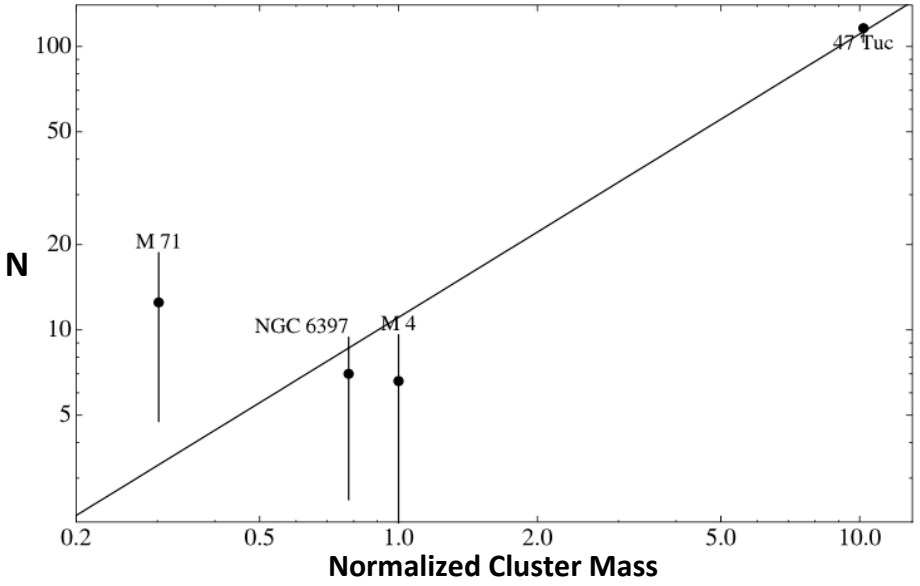
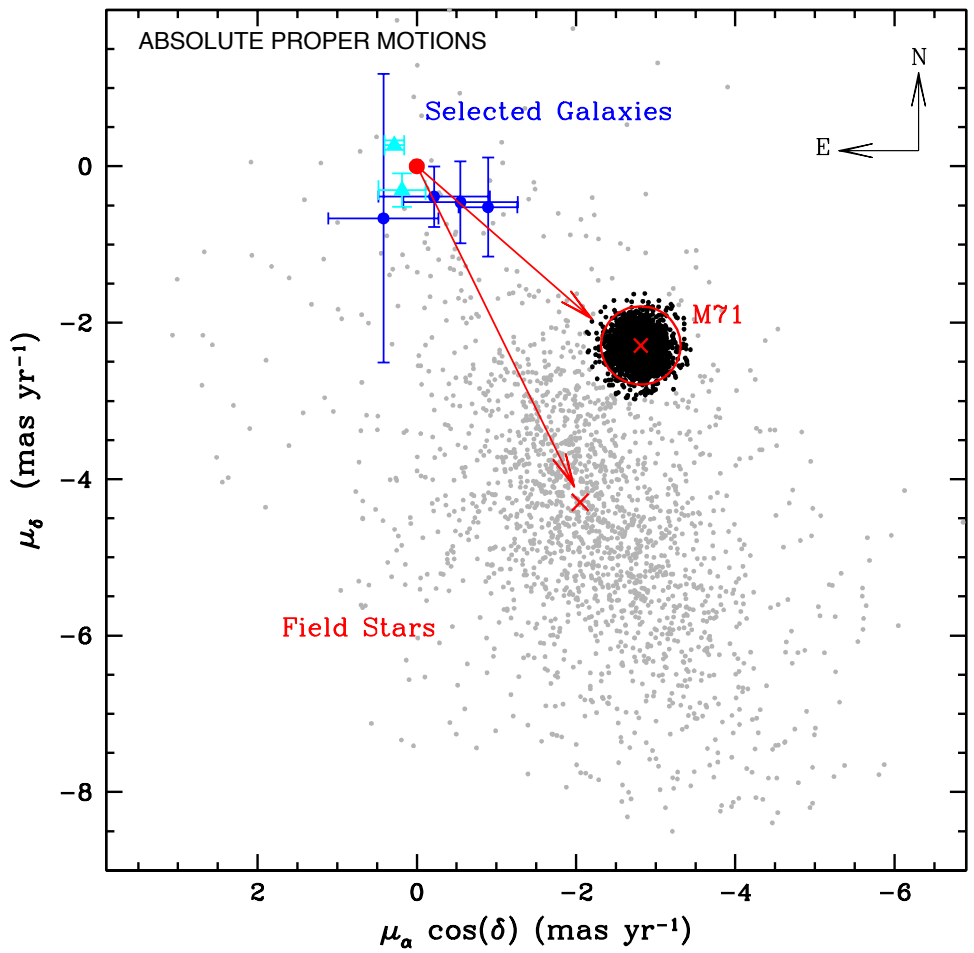




Not enough to explain the
X-ray source overabundance!

Elsner et al., 08 ; Huang et al., 10

The Cluster Absolute Proper Motion



We used two ACS datasets, separated by a temporal baseline of 7 years to derive the stellar proper motions.

Then we used background galaxies to determine the cluster absolute proper motion:

$$(\mu_\alpha \cos\delta, \mu_\delta) = (-2.8 \pm 0.5, -2.3 \pm 0.4) \text{ mas yr}^{-1}$$

In a Cartesian Galactocentric frame rest, this corresponds to:

$$(V_X, V_Y, V_Z) = (54 \pm 10, 203 \pm 6, 32 \pm 12) \text{ km s}^{-1}$$

Cadelano et al., to be submitted

The Cluster Orbit

Starting from the current M71 position and 3D, we used a three-component Galactic potential to reconstruct the cluster orbit within the Galaxy.

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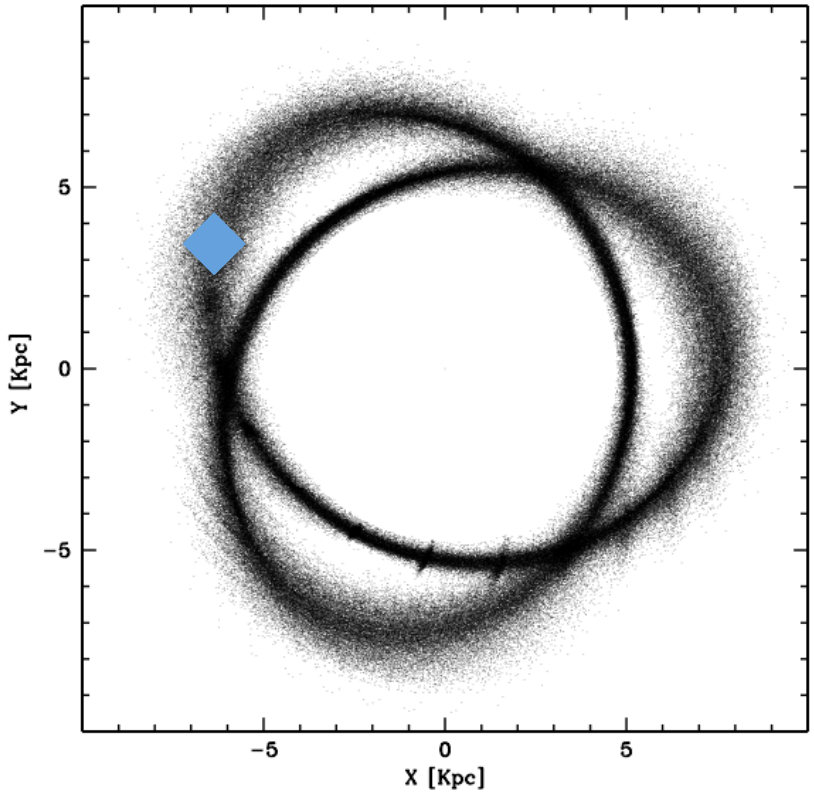

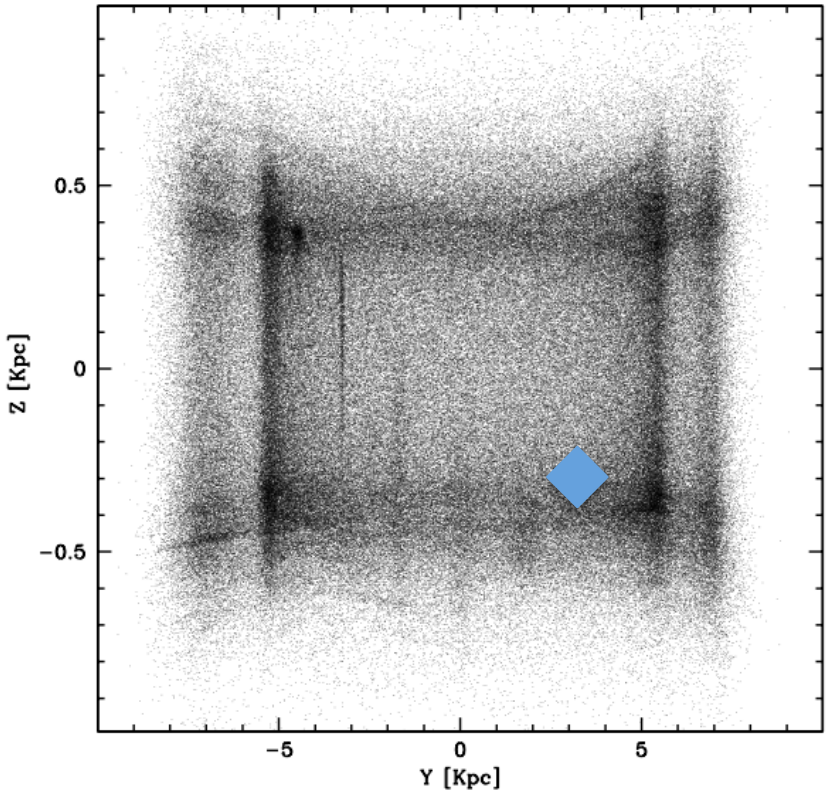

Current Position

Cadelano et al., to be submitted

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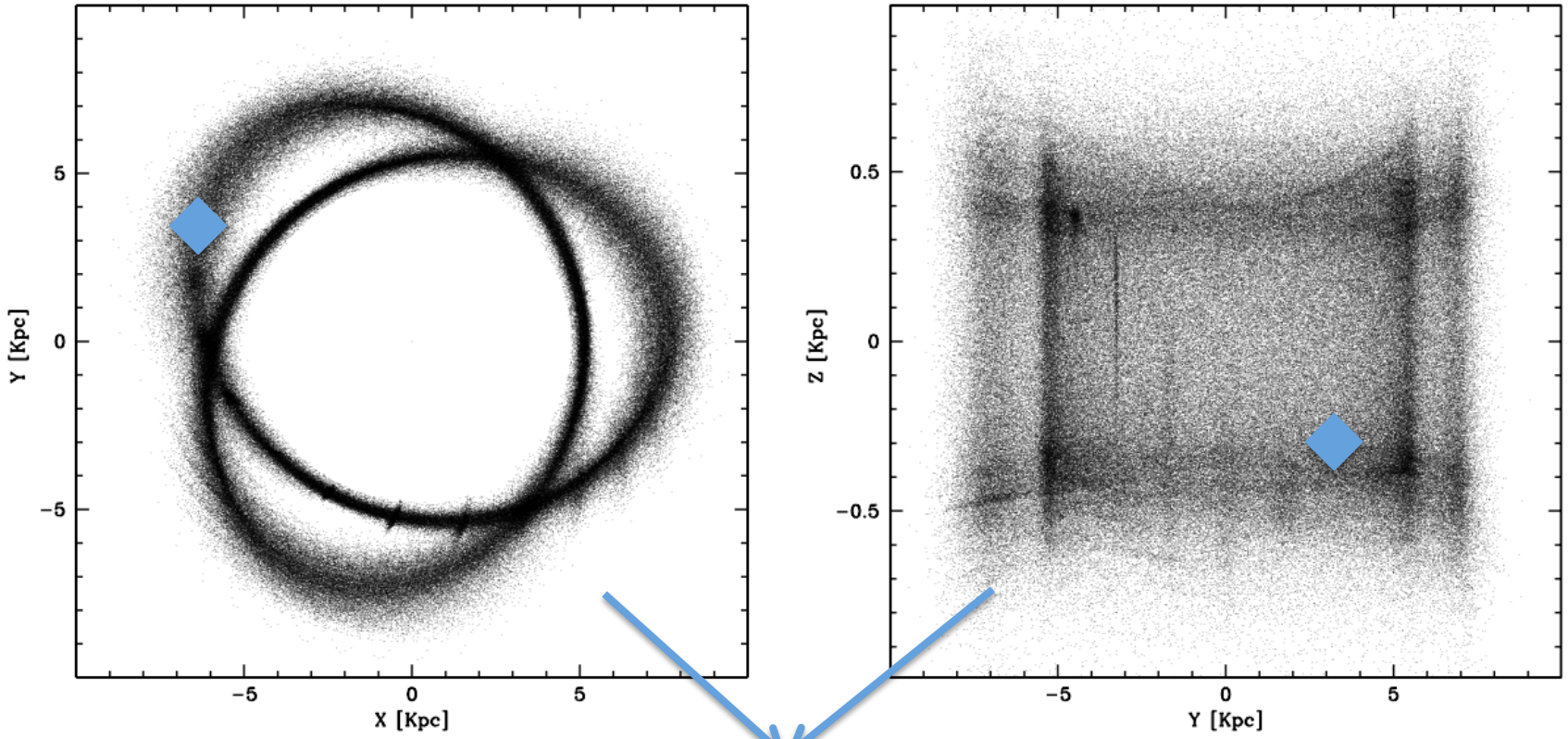
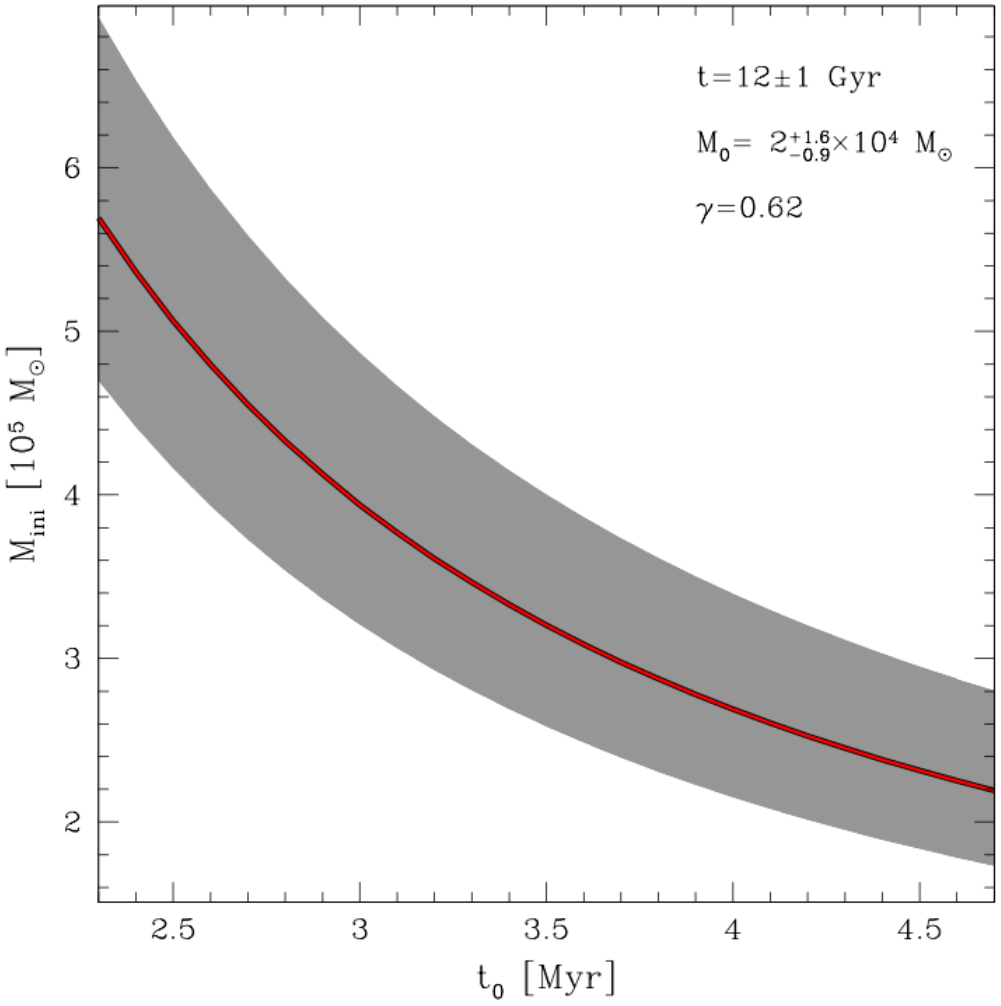


Current Position

Disk-Like Orbit Inside the Galactic Disk!

Cadelano et al., to be submitted

The Cluster Initial Mass



Following Lamers et al., 15, we estimated the cluster initial mass.

For every reasonable value of t0, the cluster initial mass is at least:

$$M_{ini} \sim 10^5 M_{SUN}$$

which is the typical mass value measured for halo GCs.

Cadelano et al., to be submitted

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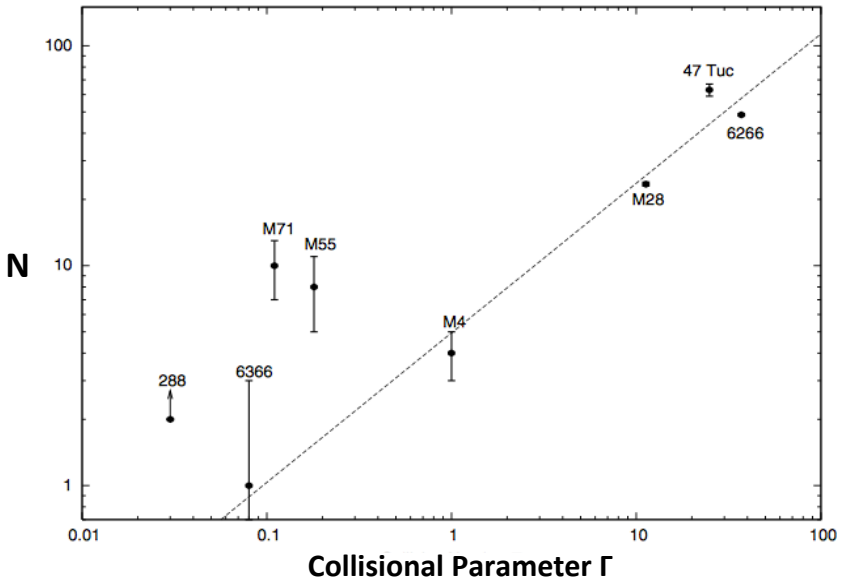

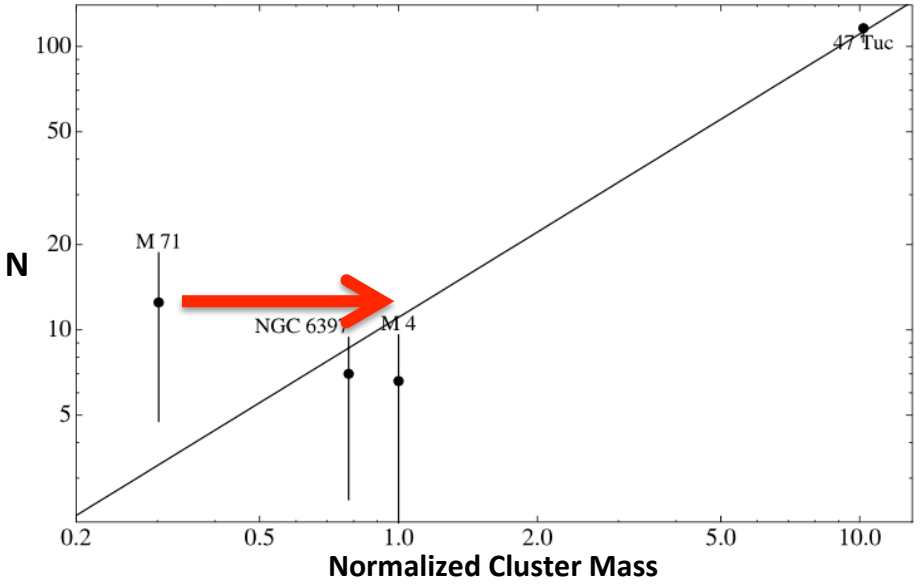

The X-ray source overabundance can be explained accounting for the cluster **INITIAL MASS**!

Elsner et al., 08 ; Huang et al., 10

Thanks for your kind attention!