Intermediate-Mass Black Holes in Globular Cluster Systems

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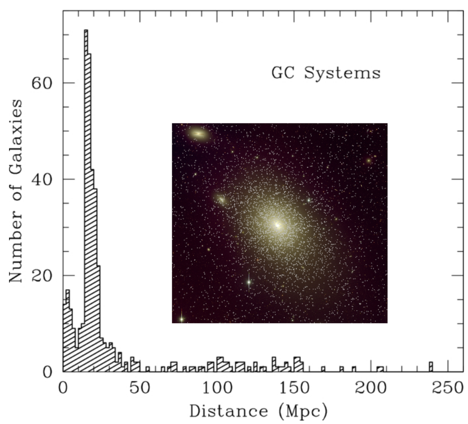
Globular Cluster Systems

The figure shows that tens of GC systems have distances out to 10 Mpc. Hundreds of GC systems have distances between 10 and 25 Mpc, and hold tens of thousands of GCs in total [6].



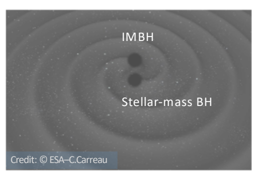
The inset shows the GC system of the early-type galaxy NGC4365 at 23 Mpc [3]. The small circles mark GC candidates in the inner 18 arcmin (120 kpc) of a *gri* Suprime-Cam image.

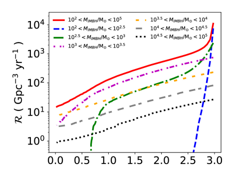
Abstract

Using the Next-Generation Very Large Array (ngVLA), we will make a comprehensive inventory of intermediate-mass black holes (IMBHs) in hundreds of globular cluster (GC) systems out to a distance of 25 Mpc [14]. These systems hold tens of thousands of GCs in total. We describe how to convert an ngVLA signal to an IMBH mass according to a semi-empirical accretion model. Simulations of gas flows in GCs would help to improve the robustness of the conversion. Our IMBH inventory is well suited for ngVLA Early Science. IMBHs have masses M_{IMBH} ~ 100 - 100,000 $M_\odot$. Finding them in GCs would validate a formation channel for seed black holes in the early universe and inform event predictions for gravitational wave (GW) facilities. Reaching a large number of GCs is key, as [5] predicts that only a few percent will have retained their GW fostering IMBHs.

Gravitational Waves Fostered by IMBHs

[5] explored the fate of primordial GCs, each born with a central IMBH. They modelled the evolution of the GCs in their host galaxy, and of the IMBHs undergoing successive, GW-producing mergers with stellar-mass BHs in the GCs. For primordial GCs that survived to the present day, they found that a few percent retained their IMBHs and the balance lost their IMBH when a GW recoil ejected it from the GC host.

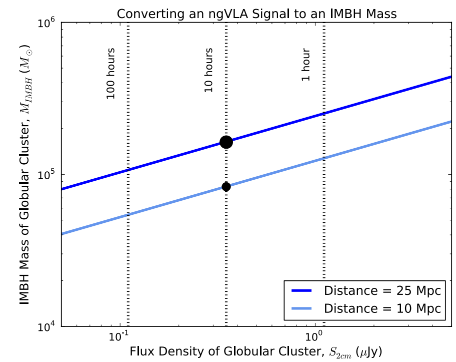




For IMBHs with masses $M_{IMBH} \gtrsim$ 10,000 $M_\odot$ they predicted mergers at rates detectable with the *Laser Interferometer Space Antenna (LISA)* [2]. If the ngVLA searches do not find the expected mix of IMBHs in GC systems, it could challenge the framework underlying the GW predictions.

Converting ngVLA Signals to IMBH Masses

The figure shows ngVLA signals at 2cm from IMBH masses in GCs at 10 and 25 Mpc [14]. The small and big black dots highlight 3σ mass sensitivities at 10 and 25 Mpc after 10 hours on target [12].



GC systems at 10 to 25 Mpc hold tens of thousands of GCs in total [6]. Model details appear below.

Synchrotron Radio Model

We invoke a semi-empirical model to predict the mass of an IMBH that, if accreting slowly from the tenuous gas supplied by evolving stars, is consistent with the synchrotron radio luminosity of a GC [13]. We assume gas capture at 3% of the Bondi rate [8,9] for gas at a constant density of 0.2 cm^{-3} as measured by [1], and at a constant temperature of 10^4 K as justified by [11]. We also assume that accretion by the IMBH proceeds at less than 2% of the Eddington rate, thus involving an advection-dominated flow with a predictable, persistent X-ray luminosity. We then use the empirical fundamental plane of BH activity [4,7,10] to predict the synchrotron radio luminosity. The radio emission is expected to be persistent, flat-spectrum, jet-like but spatially unresolved, and located near the dynamical center of the GC.

References

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Notional Timeline

2028 Start ngVLA Early Science
2034 Launch *LISA*
2034 Start ngVLA Full Science
2036 Start *LISA* science

10/29/2018

ngvla

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