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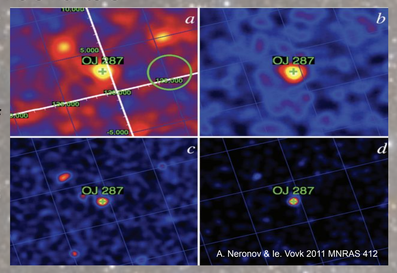
We are building BOBcat: a searchable binary supermassive black hole catalog for public use

Unlike LIGO, multi-messenger science with SMBHBs will be done over data spanning weeks, years, and decades. LISA and PTAs will thrive from access to historical observations (data archives) and a large set of inhomogenous archival observations.

BOBcat: A Catalog of Binary Black Hole Candidates

We are developing BOBcat: "Black holes Orbiting Black holes catalog" that will be a searchable, public-use database of SMBHB candidates. The catalog will include a fully-referenced, comprehensive database of candidate SMBHBs published in the literature, including relevant queryable information such as location, redshift, proposed binary signature, proposed binary models, and any limitations on the binary orbital parameters (chirp mass, mass ratio, frequency, orientation parameters). The database will also contain relevant targeted PTA limits. Similar catalogs currently available include PSRcat, FRBcat, Open Supernova Catalog, etc. BOBcat will thus serve as a centralizing reference point for pertinent information about SMBHB candidates in the literature. We intend that it may serve two communities: GW searchers/modellers (LISA and PTAs), and electromagnetic black-hole hunters.

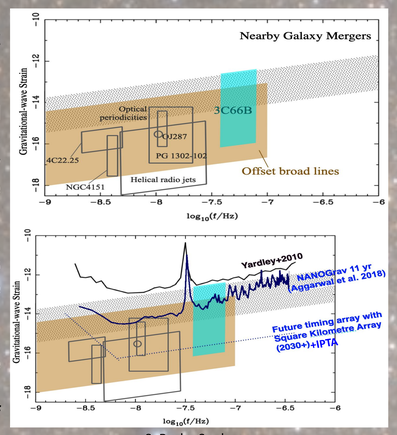
We have created a SQL-based database and continue to make adjustments within the structure as we obtain comments from the community. Additional python based coding will allow easy ingestion of candidates and manipulation of information. A Django framework is being created to develop a webpage and search process focused on easy user interface.



BOBcat: Current Status

As we build the framework and necessary structure we continue to collect candidates. BOBcat (offline) contains ~300 SMBHB candidates. PTAs are fast approaching upper error ranges of several candidates' predicted gravitational wave strain, while also probing the frequency space these candidates are expected to be seen in as shown in the plots to the right. In the future a full IPTA+SKA could probe many targets that are already known as indicated by the predicted sensitivity curve in the bottom plot at the right.

While we are aiming to organize BOBcat, we also aim for it to be a tool for the multi-messenger community. Thus, we welcome collaborators, or simply a list of requests for features you'd like to see included



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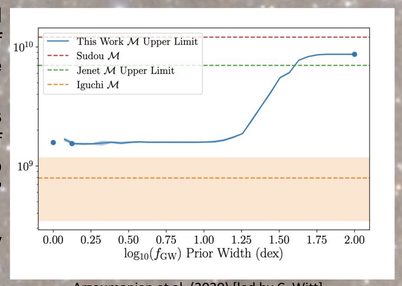
Example Use-Case: Targeted Search

Multi-messenger science aids targeted searches which can gain up to an order of magnitude in sensitivity for possible candidates[8]. Using electromagnetically derived priors for a targeted continuous gravitational wave search led to a factor of 4.3 improvement in the upper limit of chirp mass for 3C66B than that found in "blind" searches as seen in the plot to the right[8]. BOBcat allows easy access to binary parameters for such SMBHB candidates, therefore making targeted searches easy.



Arzoumanian et al. (2020) [led by C. Witt]

BOBcat is still in its infancy and we would like to hear from the researchers who would use it.

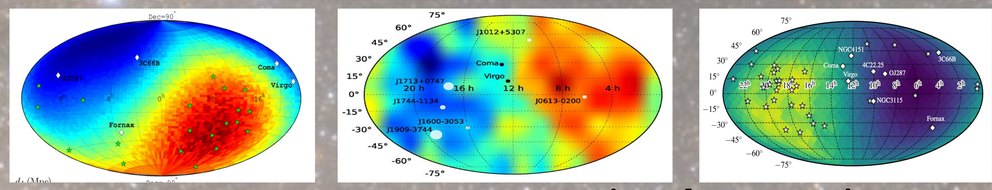
- ***What kinds of parameters or information would you like to see?***
- ***Would you use BOBcat, and how would you use it?***
- ***Do you have your own SMBHB candidate list you'd be willing to share with us?***

I'm happy to chat about any thoughts or questions you may have. I can be reached at my email: js0311@mix.wvu.edu

Exploration of space using gravitational waves is expanding rapidly:

• The PTA Horizon is Expanding

Supermassive black hole binaries (SMBHBs) separated by less than ~0.1 pc (periods of decades or less) can emit gravitational waves detectable by pulsar timing arrays (PTAs). PTAs' horizon to binaries of chirp mass ~10^9 M_{sun} has rapidly expanded over the past decade (from 50 to 120 Mpc[1,2]), and with upcoming IPTA sensitivity, is set to continue expanding in all sky directions. **<u>At least one to five blind SMBHB detections are expected in the coming decade</u>**.[3]



The most recent published sky sensitivity maps for the PPTA[6], EPTA[7], and NANOGrav[2]. Soon, continuous-wave searches of IPTA data will push the horizon of the constituent PTAs.

• LISA First Light in 2037

Gravitational waves with frequencies from 0.1 mHz to 0.1 Hz will be detectable with the Laser Interferometer Space Antenna (LISA)[4]. The last inspirals before coalesces of SMBHBs will therefore be detected by LISA within the next 15-20 years. In additional to SMBHB inspirals, gravitational waves from massive black hole binaries will also be seen by LISA[4]. **<u>This means a large influx of black hole binaries will be seen by the multi-messagener community at the latest in 20 years, most likely sooner.</u>**

References:

1. Yardley et al. 2020 MNRAS 407 669.
2. Aggarwal et al. 2019 ApJ 880 116.
3. Mingarelli et al. 2017 Nature Astronomy 1 886.
4. https://sci.esa.int/s/w5qyMBw
5. Tingting Liu & Sarah Vigeland 2021 arXiv:2105.08087.
6. Zhu et al. 2014 MNRAS 444.
7. Babak et al. 2016 MNRAS 455.
8. Arzoumanian et al. 2020 ApJ 900 102.

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