Science synergies between the DSA-2000 and ngVLA: pulsars

Thankful Cromartie

National Research Council Postdoctoral Associate | U.S. Naval Research Laboratory

Chair, NANOGrav Pulsar Timing Working Group

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DSA-2000 and the ngVLA have complementary capabilities that will not only drive next-gen **pulsar timing array science**, but also uncover thousands of new pulsars—helping constrain **NS interior physics**, **test general relativity**, and **explore the center of our Galaxy**.

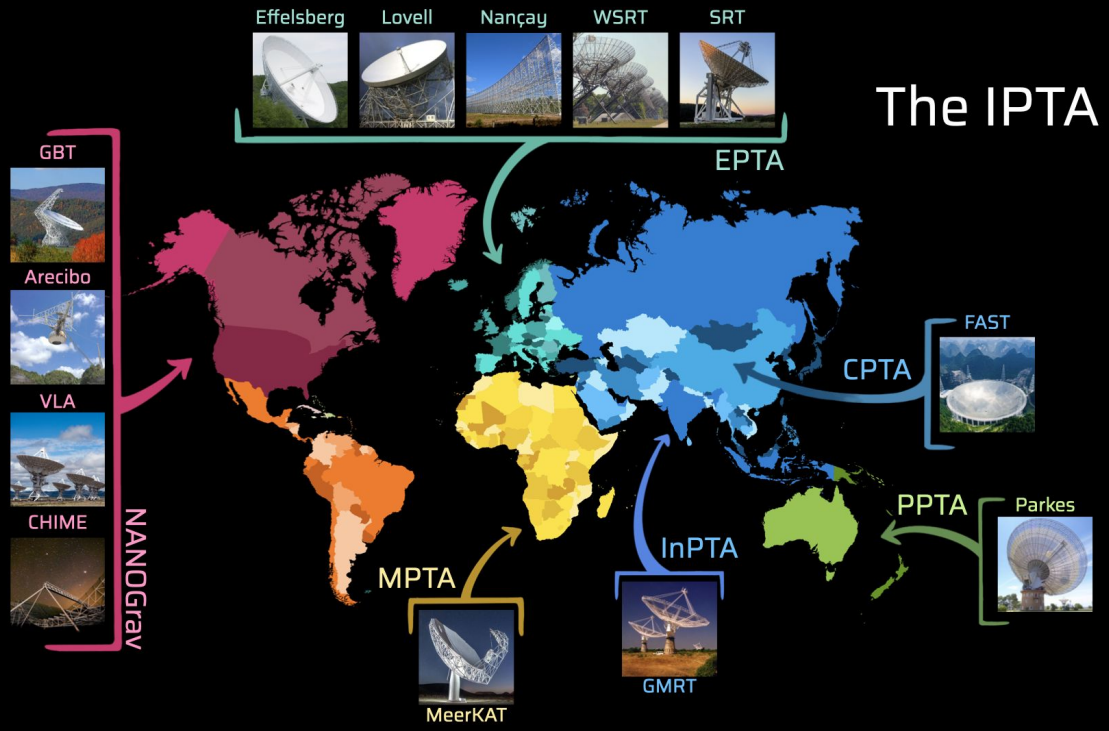
Their individual strengths and potential for synergistic science will shape the future of North American pulsar astrophysics for decades to come.

Pulsar Timing Arrays

Characterize the nHz gravitational wave universe through high-precision millisecond pulsar timing

- Most likely source = supermassive black hole binary mergers
- Last parsec problem, merger rates, SMBHB populations
- BSM physics, tests of GR

NANOGrav: ~monthly GBT/VLA, daily CHIME, formerly ~monthly Arecibo



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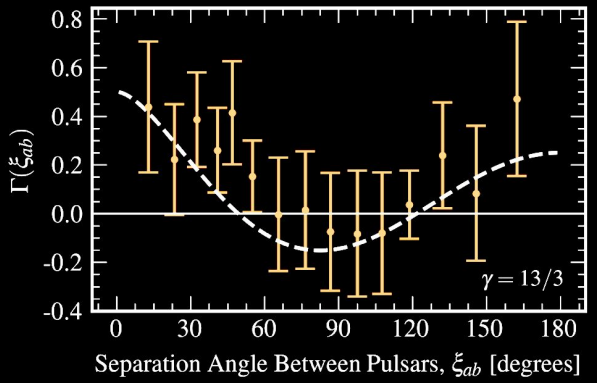
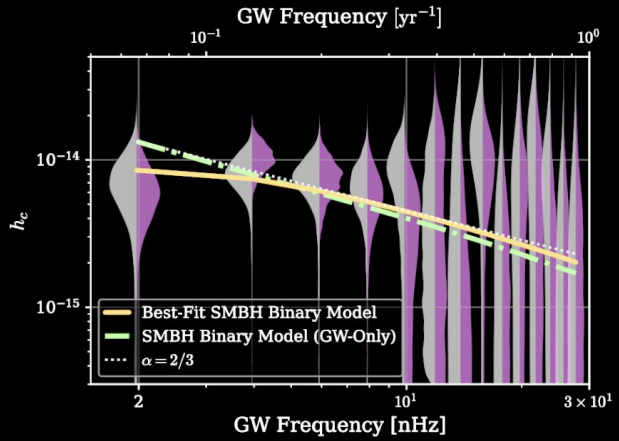
Pulsar Timing Arrays: Recent Results

Recent evidence for nHz GWB, likely from SMBHBs (Agazie+23a, EPTA+23b, Reardon+23, Xu+23, Miles+24)

- Common-spectrum stochastic signal more significant (BF~10^{12})
- **First compelling evidence of Hellings-Downs correlations**
  - A_{GWB} = 2.4 (+0.7, -0.6) x 10^{-15}
  - $p = 10^{-3}$ and $p = 5 \times 10^{-5}$ to 1.9×10^{-4} **(3-4σ)**



Low-freq spectral turnover: gas, star interactions necessary for merger evolution?



High GW amplitude — **more frequent or more massive mergers**

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DSA-2000 and ngVLA for PTAs

$$N_{\rm PSR} T^{1/2} \sigma^{-3/13}$$

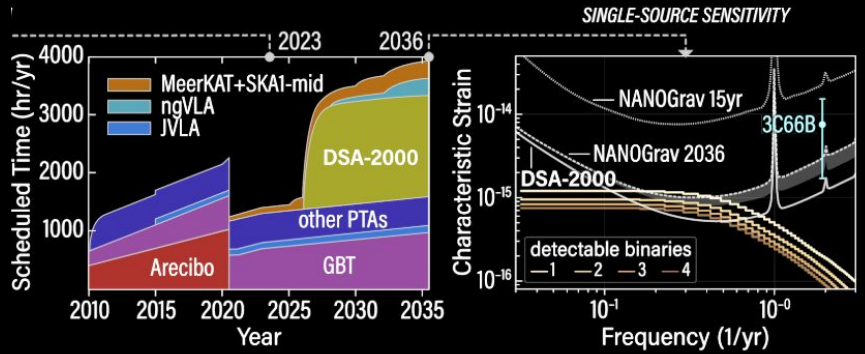
DSA-2000

25% of on-sky time for NANOGrav: 80 → **200 MSPs** over decades-long timescales to <1μs precision

2-4 week cadence, high-cadence campaigns, scheduling flexibility

~Arecibo sensitivity, ideal 0.7-2 GHz bandwidth

DSA-2000 will be the workhorse instrument for NANOGrav science, enabling GWB characterization *and continuous wave detection*



ngVLA

Sensitivity → great timing precision

High-frequency coverage (1.2-116 GHz): faint, highly scattered/dispersed PSRs

Follow up steep-spectrum sources from surveys

Less extensive but very unique PTA observations

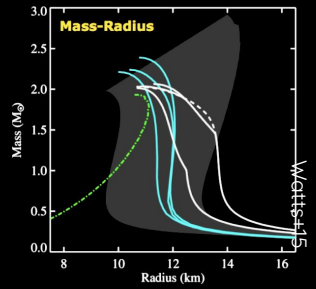
"Pulsar term" constraints with astrometry

ngVLA will uncover new PTA-ready MSPs and facilitate high-frequency + sensitivity timing to improve GWB and single-source sensitivity

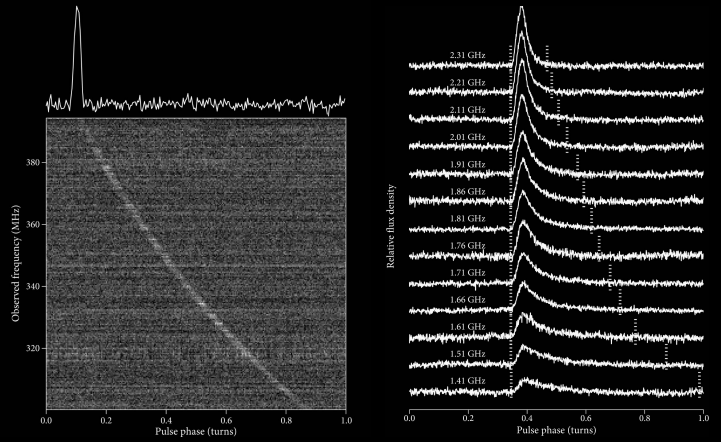
Exciting Pulsar Astrophysics

Discover many new **faint, dispersed,** and/or **accelerated** PSR binaries:

- **More high-precision NS masses** for dense matter equation of state constraints *(DSA-2000 community science book 5.6; ngVLA KSG4)*
- PSR-BH binaries: sample high spacetime curvature near BH for unique, **more extreme GR tests**
- Characterize GeV excess?



DSA-2000: Much of this comes "for free" with NANOGrav timing program; phase-targeted campaigns possible too



DSA-2000: searches → 1000s of new MSPs, deep globular cluster or galactic center searches for exotic accelerated binaries?

ngVLA: unprecedented high-frequency capabilities + sensitivity, PSRs near Sgr A* → ~1$M_\odot$ precision, GR tests

Both: DSA-2000 survey ability + ngVLA high-frequency follow-up

Splinter session today, 2pm ET: *Fundamental Physics and New Messengers* (ngVLA talks by Demorest, Cromartie)

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Summary

PTAs: DSA-2000 offers a tailor-made MSP timing machine with >25% of on-sky time and Arecibo-level sensitivity; ngVLA will contribute new MSPs to the array and improve single-source continuous wave sensitivity with astrometry

Pulsar astrophysics: DSA-2000 and ngVLA can eventually work together to carry out imaging and high-frequency pulsation searches. New exotic binaries will provide opportunities to test GR, probe the dense matter EoS, and uncover pulsars deep in the Galactic center

Thanks!

thankful.cromartie@nanograv.org