Scientific Justification *Be sure to include overall significance to astronomy. For standard proposals limit text to one page with figures, captions and references on no more than two additional pages.*

As galaxies merge, the supermassive black holes (SMBH) ($M_{BH} > 1 \times 10^5 M_\odot$) at their cores are destined to similar fates [Burke-Spolaor et al., 2019]. Once the SMBHs reach an orbital separation of milliparsecs, their binary evolution is governed by nanohertz gravitational wave (GW) emission [Kelley et al., 2019]. Recently evidence for a stochastic background made up of these nHz gravitational waves was reported by several PTA experiments around the world, hinting at a population we have yet to directly confirm [Agazie et al., 2023]. While these SMBHs emit GWs through their inspiral, they are expected to emit electromagnetic (EM) radiation through interactions with their circumbinary disk [Kelley et al., 2019]. One such EM tracer of a binary is through relativistic doppler boost. This effect would introduce a periodic variability in the brightness of the system, related to the kinematics of the binary [Charisi et al., 2018]. D'Orazio et al. [2015] determined a model of a SMBHB candidate based on this doppler boost hypothesis, but further observations are required to follow up and confirm the model's predictions. We will observe PG 1302-10 to see if the predictions are accurate, revealing the validity of the doppler boost model for this system. If the observations are consistent with the model, multimessenger followup through targeted GW searches is possible.

Experimental Design *Describe your overall observational program. How will these observations contribute toward the accomplishment of the goals outlined in the science justification?*

NOIRLab's COSMOS Imager on the Blanco 4-meter telescope is perfectly suited for observing this target. PG1302-102 will be visible throughout the summer months of 2024 from CTIO.

OUTLINE scientific justification

- explain doppler boosting a bit (I only kinda understand it at this point)
- why is long term status needed - what happens if I only get 6 months of a light curve? How does this negatively affect my science?
- include picture of time series data from ZTF - showing light curve over last year ish – include date of last observation in the proposal — proof of variability ongoing? include date of last observation in the proposal
- if light curve exists why should they give me time? What does COSMOS bring?
- add to science justification about importance of confirming a SMBHB. Connect to orbital separation of the SMBHBs – see if there is an estimated separation in original D'Orazio
- what else from original paper + other doppler boost papers can i expand upon using these observation - any secondary science?
- explain how further light curve data will further constrain model of doppler boosting and increase its significance

experimental design

- 3 observations spaced out over summer months of 2024 and 3 more next summer (2 semesters from now)
- figure out exposure time from other COSMOS papers - use ones that maybe observe TDEs as well as quasars?
- related to exposure time - what S/N is needed throughout observation to confidently construct a light curve that I could later fit to?
- more general item – need to find references for the measurement etc like the outline notebook says

technical justification

- number I would love to know: estimate the minimum magnitude of the quasar to know the range of exposure time between brightest and dimmest quasar
- explain how further light curve data will further constrain model of doppler boosting and increase its signifigance
- nyquist sampling with pixel scale?
- not sure what other pieces go into tech just/exp design

References

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G Agazie, J Antoniadis, A Anumarlapudi, AM Archibald, P Arumugam, S Arumugam, Z Arzoumanian, J Askew, S Babak, M Bagchi, et al. Comparing recent pta results on the nanohertz stochastic gravitational wave background. *arXiv preprint arXiv:2309.00693*, 2023.

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