An Extreme Population of Heavily Buried AGN

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Objective
Obscured quasars represent a large fraction of the total number of powerful active galactic nuclei (AGN). Understanding the complete quasar population requires a full accounting of these sources, which is difficult in the presence of complex selection effects. Additionally, dust extinction in obscured quasars allow us to observe their host galaxies and make connections between AGN emission and physical properties of their hosts. Using optical to mid-IR broadband photometry we model the spectral energy distributions (SEDs) for these systems with no prerequisite AGN selection and uncover dozens of powerful obscured quasars which lack hard X-ray counterparts in NuSTAR survey and serendipitous fields. At the NuSTAR flux limits, a lack of detection indicates extremely heavy obscuration with hydrogen column densities beyond $10^{25}$ cm$^{-2}$. This points to a population of very deeply buried AGN.

Quasar Sample
Combining data from SDSS, UKIDSS, and WISE (XQSOz, DiPompeo et al. 2015; unWISE, Lang et al. 2016), our sample consists of ~8 million galaxies with redshift measurements. To address selection effects we make no prior selection to target AGN. Of our sample, 58 are detected by NuSTAR in the COSMOS field and Serendipitous Survey, while an additional ~4000 are undetected but within a NuSTAR pointing.

SED Modelling
We model our SEDs with a combination of galaxy+AGN templates from Assef et al. (2010) and Kirkpatrick et al. (2015). We simulate nuclear obscuration with an SMC-like extinction curve for $\lambda < 3300$ Å (Gordon & Clayton 1998), and a Galactic extinction curve at longer wavelengths (Cardelli et al. 1989). We calculate 6-micron AGN luminosities and find ~3 million candidate AGN with $L_{6\mu m} \geq 10^{43}$ erg s$^{-1}$.

X-ray Flux Limit and Luminosities
Using the $L_X$--$L_{\text{IR}}$ relation of Chen et al. (2017), we determine the X-ray flux detection threshold ($L_{\text{flux lim}}$) of NuSTAR and apply this upper limit to our undetected sources. We use the ratio of observed/expected $L_X$ as a proxy for obscuration and estimate the distribution of $N_H$ for our candidate AGN.

Forward Modeling the $N_H$ Distribution
We sample the observed $N_H$ distribution from Lansbury et al. (2017) and model an additional gaussian component representative of highly obscured sources ($N_H \geq 10^{24}$ cm$^{-2}$), which we convert to match to our observed/expected $L_X$ ratio. We find that a significant population of heavily obscured sources with $N_H \approx 10^{24}$--$10^{25}$ cm$^{-2}$ must exist to reproduce our results.

Conclusion
We model the SEDs of candidate AGN within the SDSS+UKIDSS+WISE footprint and obtain estimates of IR and X-ray luminosities. We compute the expected $L_X$ from Chen et al. (2017) and use the ratio of observed to expected $L_X$ as a proxy for nuclear obscuration. We forward model the $L_X$ ratio and determine that a significant population of X-ray undetected, heavily obscured AGN must exist with $N_H > 10^{24}$ cm$^{-2}$ to account for the observed AGN luminosities.

References

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