Report from SWG6: Active Galactic Nuclei and Supermassive Black Holes


Massively multiplexed spectroscopy with MSE: Science, Project and Vision, Tucson, Feb 2019
AGN/SMBH Themes

Physics of BH growth

• SMBH seeds
• Reverberation mapping
• Variability
• Close SMBH binaries
• Nuclear outflows

The central engine (<~1-10 pc)

Coevolution with galaxies

• AGN host properties
• Type-2 (obscured AGN)
• The earliest SMBHs and their hosts
• AGN triggering and mergers
• AGN feedback

The host galaxy

As a cosmological probe

Beyond the galaxy

• Clustering and demography
• Gravitational lensed quasars
• Reionization with high-z quasars
• Intervening absorbers

Nomenclature: quasar=Quasi-Stellar Object(QSO)=luminous AGN
AGN/SMBH Themes

Physics of BH growth

Coevolution with galaxies

As a cosmological probe

Single-epoch
- SMBH seeds
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- AGN host properties
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- Reionization with high-z quasars
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Temporally resolved
- Reverberation mapping
- Variability
- Close SMBH binaries
- Nuclear outflows
Lots of information in the spectrum, not just a redshift!

SDSS

MSE

Observed Wavelength [µm]

Redshift

Typical spectrum of an unobscured (type 1) quasar at z=2

MSE advantages

- Sensitivity
- NIR coverage
- Multiplex
- Survey dedication
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<th>SMBH seeds</th>
<th>25</th>
<th>&lt;100?</th>
<th>LR/MR</th>
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<th>&lt;0.3</th>
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<td>LR/MR</td>
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**AGN census survey**  
**Dedicated RM program**  
**Ancillary fibers**
Traditional methods of SMBH mass estimation based on spatially-resolved gas/stellar kinematics don’t work for distant quasars

- BH sphere of influence too small to resolve at large distances
- AGN light makes it difficult to measure nuclear stellar/gas kinematics

**Time delay \( \mathcal{T} \)**

\[
M_{\text{BH}} = f \left( \frac{\Delta V^2 R}{G} \right)
\]

- Reverberation mapping: primary method to measure BH mass in distant quasars (z>0.3)
- But time consuming: only \(<100\) AGN/quasars measured RM lags (at z<1); mostly Hbeta
SRO-11 Mapping the Inner Parsec of Quasars with MSE

MSE will try to measure broad-line RM lags for ~2000-3000 quasars at z=0-5 (w/ ~100 epochs over 5 yrs)

- An order of magnitude more than current MOS-RM programs
- NIR arm to cover Hbeta at z~2.5

We will learn a lot from the SDSS-V Reverberation Mapping program (2020-2025). Now is a good time to get involved and get prepared.
The AGN census
Many AGN selected from near-future multi-wavelength missions (e.g., eROSITA X-ray, infrared, or radio selection) will be optically faint.

MSE will provide a complete census of these different types of AGN and measure their physical properties with optical-NIR spectroscopy.

Lacy et al. (2015)
Science highlight

Quasar host galaxies at high-z

Host properties from spectral decomposition: SFR, stellar velocity dispersion, stellar mass, age, etc.

Matsuoka et al. (2016)

Shen et al. (2016)
Summary

- MSE is **unique** in the combo of sensitivity, multiplex, spectral coverage, and survey dedication.
- It enables a broad range of topics ranging from fundamental physics of SMBH accretion to the larger context of galaxy formation and cosmology.

**Conclusion 1:** H-band coverage is a powerful advantage and a game changer for most AGN science cases.

**Conclusion 2:** Most SMBH science cases mesh well with leading survey programs, either as part of a galaxy redshift survey (e.g., AGN census), ancillary filler fibers (e.g., TDE, z>6 quasars, etc.), or get the science for free (e.g., ancillary science from the RM program).

**Conclusion 3:** We are happy with LR/MR for all programs. But we can also use HR for detailed quasar absorption line studies.

For discussion: any important AGN/SMBH science that we missed?