Supermassive black holes reside inside all massive galaxies

Active Galactic Nuclei (AGN) - growing supermassive BH
AGN required by galaxy evolution models to explain wide range of properties of massive galaxies and their central SMBH

Quasars – most powerful AGN

Do the winds from quasar/radiation couple with ISM?

Do they affect the global SF in galaxy positively or negatively?

What are the properties and drivers of multi-phase outflows?

Quasar Feedback Survey
Quasar Feedback Survey

https://blogs.ncl.ac.uk/quasarfeedbacksurvey/
Jarvis, Harrison +21

- Sample of 42 powerful quasars, $L_{\text{bol}}>10^{45}$ erg/s
- Mostly-radio quiet, $L_{1.4\text{GHz}} <10^{23}$
- Multi-wavelength data:
  - Radio imaging
    - Sub-mm interferometry
    - Integral field spectroscopy

  Gives sub-kpc spatial resolution for IFS observations

  High L-regime, equivalent to $L^*$-values at $z\sim1-2$, where outflows are prevalent
**Main Question:** What are the properties and drivers of the multiphase outflow?

**Data:**
- VLA radio images;
- MUSE-AO spectroscopy (ionised gas and stellar kinematics);
- ALMA (molecular gas kinematics)

**Galaxy on global scale:**
- **Large scale:** molecular and ionised gas follow galaxy dynamics
- **Central regions:** high velocity residuals and high velocity dispersions close to jet
- **Enhanced velocity dispersion for ionised gas in regions perpendicular to the jet**

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![MUSE - [OIII] - Ionised Gas](image1)

**Stellar Kinematics (GIST)**

![Stellar Velocity (V_*)](image2)

*GIST: Bittner+2019*

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**Textbook Case: J1316+1753**

*Girdhar+ in prep.*
**Conclusions**

- Ionised gas seen to be more disturbed than molecular gas, due to low density
- An enhanced velocity dispersion seen perpendicular to the jets in ionised gas
- Outflow component seen above the jet in molecular gas
- In agreement to simulations for inclined jets (~45°), which predicts, while jet is inside the disc, it increases dispersion

**References:** read more about our survey!

- Harrison+17, Harrison+18
- Jarvis,Harrison +19
- Jarvis,Harrison +20
- Jarvis,Harrison +21
- Molyneux, Harrison, Jarvis +19