Projects for TPIV, specialisation term and master thesis

@Laboratory for galaxy evolution and spectral modelling

- High-redshift galaxies
- BHs and AGN
- Linking simulations to observations via spectral modelling

M. Hirschmann, 2024

Conducting and analysing cosmological and idealised simulations

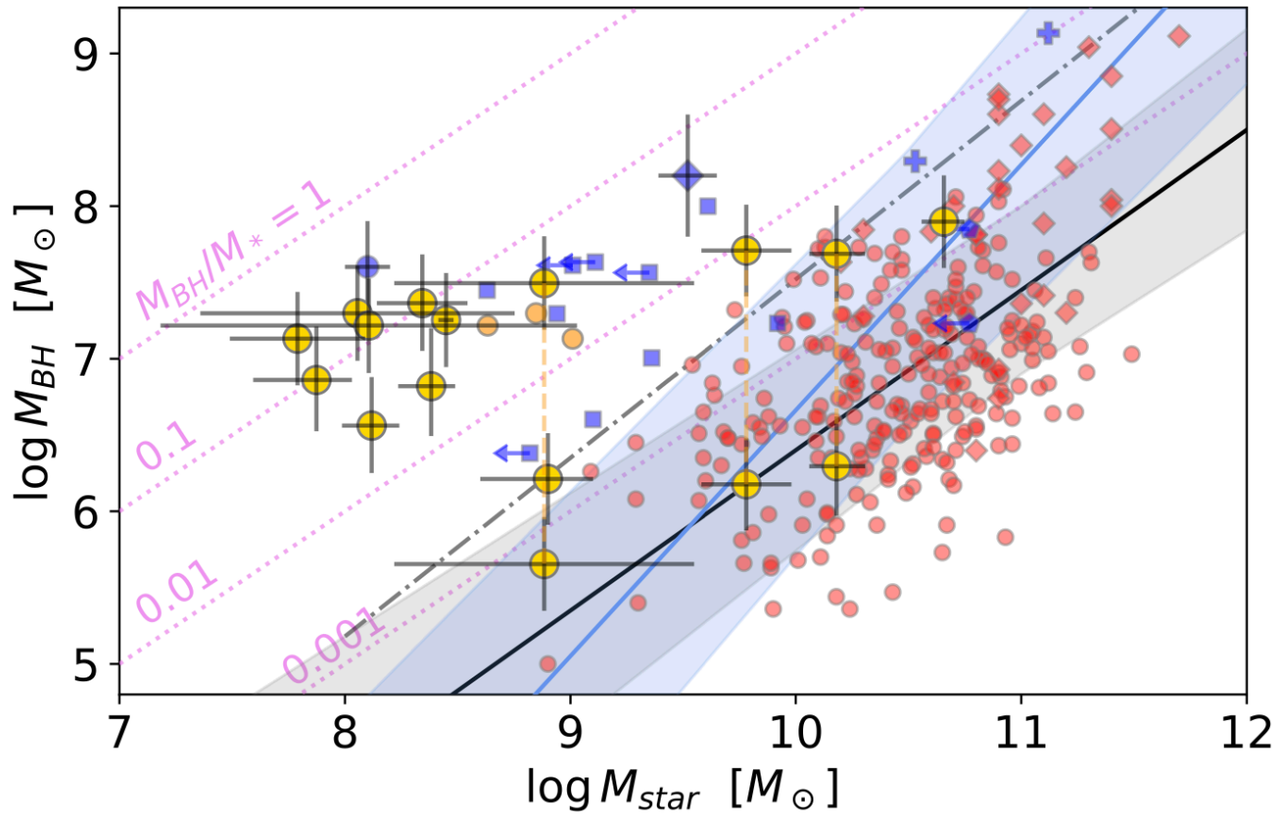
Origin of overly massive BHs at z > 4?

- **Motivation**: Current simulations models fail to re-produce the **overly massive BHs** at a given stellar mass at high redshift as observed with JWST

- **Work**: Explore the impact of BH seeding, growth and feedback models on the high-redshift BH-stellar mass relation

- **Method**: Conducting cosmological zoom simulations of high-redshift galaxies with different (existing) models

- **Useful expertise**:
  - Data analysis with python
  - HPC computing
  - Astro courses



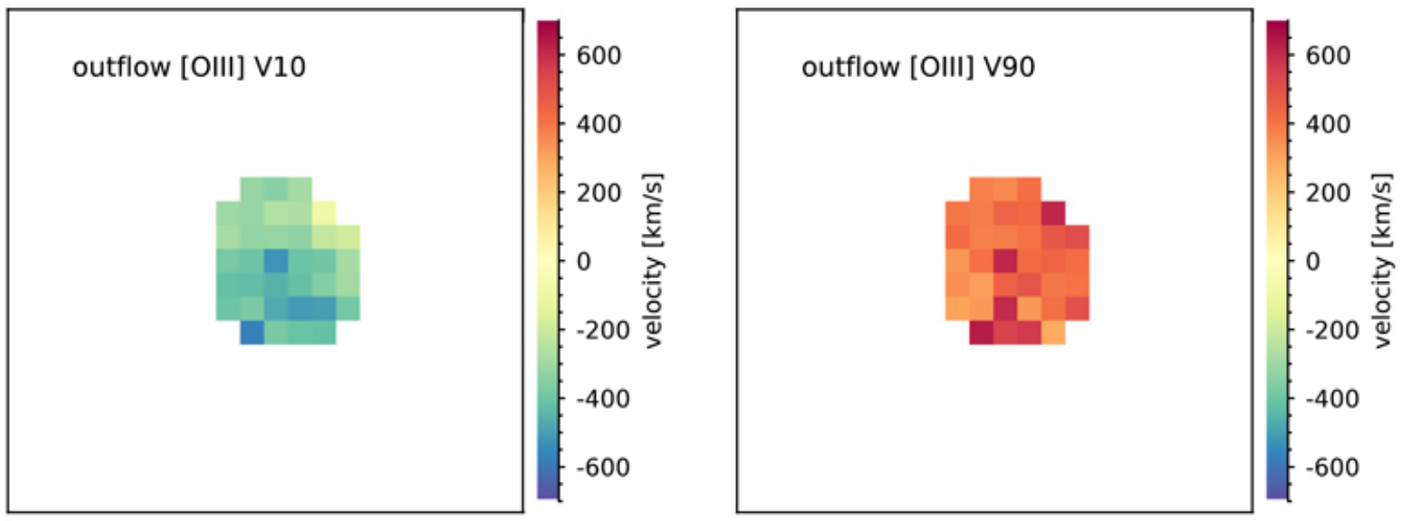
How do AGN winds shape high-z galaxies?

- **Motivation**: Observations show ***AGN-driven outflows from high-z galaxies***, yet it is unclear how galaxy properties are affected.

- **Work**: Analyse the impact of AGN-driven winds on different galaxy properties, such as stellar populations, stellar and gas kinematics, morphologies, sizes etc. and compare to new JWST data.

- **Method**: Take advantage of existing, new sets of cosmological zoom simulations of z > 3 galaxies, ran with different feedback models

- **Useful expertise**:
  - Data analysis with python
  - [HPC computing — if you want to run your own simulations]
  - Astro courses



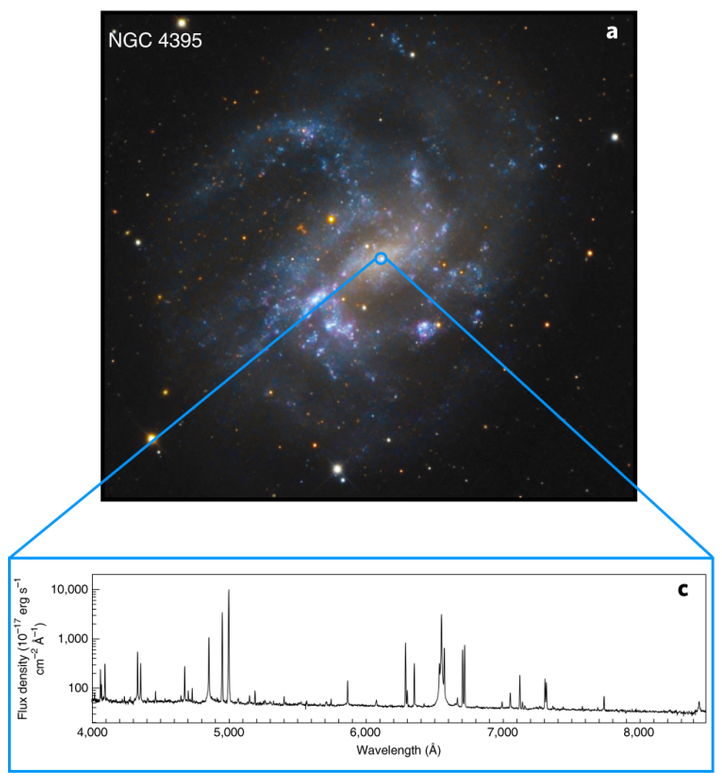
How do intermediate-mass BHs accrete their gas?

- **Motivation**: There is increasing observational evidence for intermediate-mass BHs (1e2-1e5$M_{sun,}$ likely tracing initial BH seeds) in low-mass galaxies both at low and high redshift. ***Big puzzle: how do they grow to become supermassive***?

- **Work**: Test the impact of different physical processes (e.g., stellar feedback, AGN radiation etc.) on gas accretion onto the BH

- **Method**: Conduct and analyse extremely high-resolution, idealised simulations of low-mass galaxies, resolving gas flows down to 0.1pc

- **Useful expertise**:
  - Data analysis with python
  - HPC computing
  - Astro courses



Interpretation of high-z galaxy spectra (e.g. from JWST): Creation and analysis of synthetic spectra with emission line of simulated galaxies

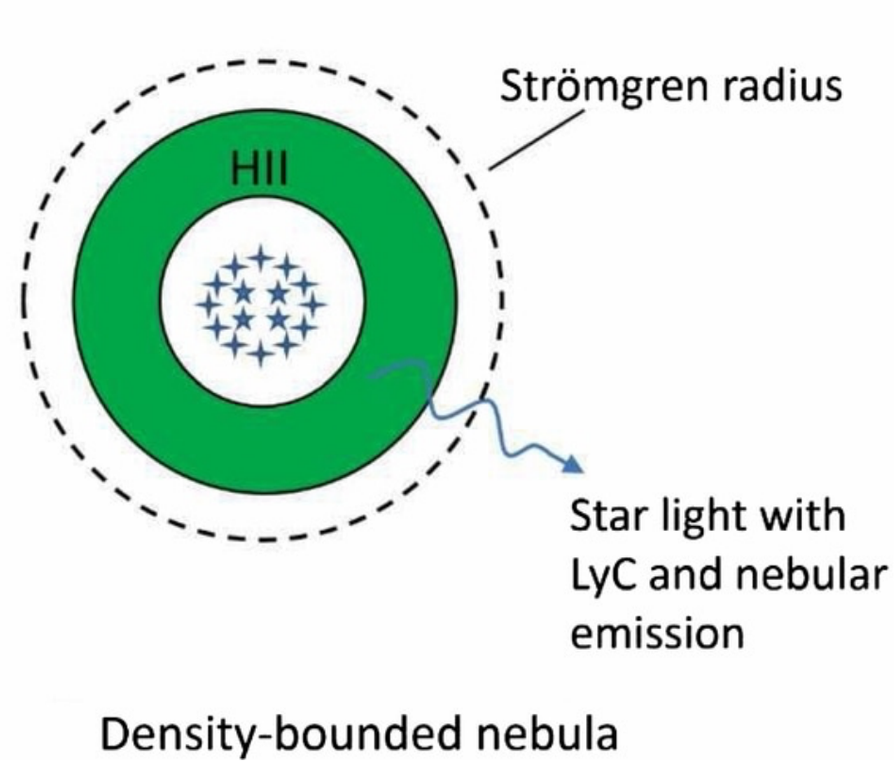
How is escaping ionising radiation from HII regions affecting line-ratio diagnostics at high redshifts?

- **Motivation**: We know that LyC ionising radiation can be escaping from HII regions, in particular at high redshift. How does this affect commonly used emission-line-ratio diagnostics to identify AGN or estimate gas properties at early epochs?

- **Work**: Analyse different emission-line catalogues of simulated simulations

- **Method**: Conduct photo-ionisation models of the ionised region around young star clusters, making different assumptions, link them to simulated galaxies

- **Useful expertise**:
  - Python coding
  - Astro lectures
  - Compiling and running codes remotely on compute clusters



How does the gas in high-z AGN get enriched with metals?

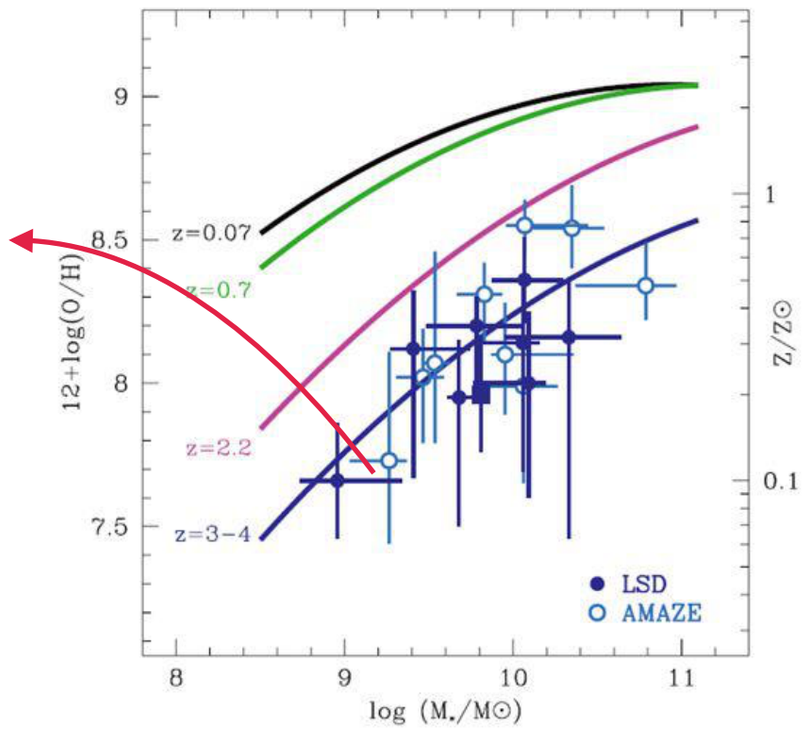
- **Motivation**: How is the ***gas enriched with metals in AGN*** early in the Universe? While we have "good" estimates for metallicities in high-z *star-forming* galaxies, this is less well understood for high-z *AGN* galaxies — might be sensitive to AGN-driven outflows

- **Work**: Model synthetic spectra and explore theoretically how well the "direct-T" method, applied to emission lines (calibrated against low-redshift data), works for high-z AGN

- **Method**: Conduct photo-ionisation models of the ionised region around AGN, to test "observational" methods how to best estimate metallicities from emission lines

- **Useful expertise**:
  - Python coding
  - Astro lectures
  - Compiling and running codes remotely on compute clusters

AGN at high z?

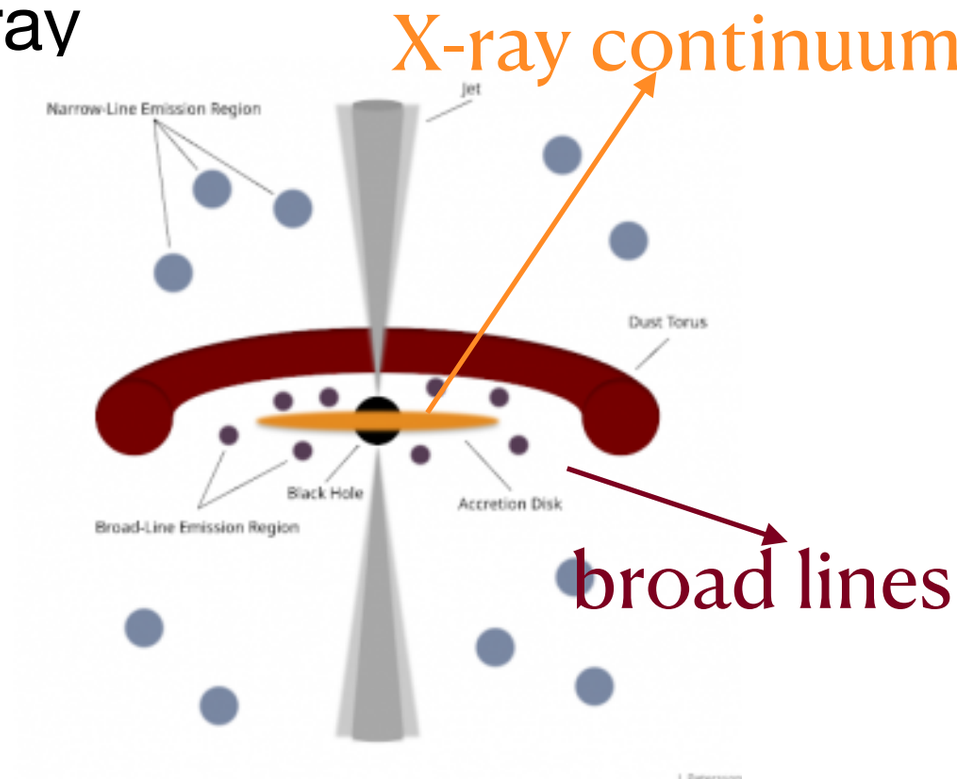


Why are most high-redshift type-1 AGN in JWST data not detected in X-ray as expected?

- **Motivation**: JWST discovered a new population of Type-1/ broad-line AGN above z~4. Yet, many of them are ***not observed in the X-ray as expected***. Why? Can accretion at the super-Eddington regime be the reason?

- **Work**: link theoretical models optical/UV emission lines with X-ray emission for simulated AGN, and explore detectability of X-ray luminosities

- **Method**: take advantage of broad-emission-line models and link them with AGN continuum spectra for X-ray
- **Useful expertise**:
    - Python coding
    - Astro lectures
    - Compiling and running codes remotely on compute clusters



Happy winter holidays!

And see you for the exam end of January…