Spectroscopy with the James Webb Space Telescope

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The James Webb Space Telescope (JWST)

Joint project of NASA, ESA and CSA

- 6.5m primary mirror
- Orbit at Sun-Earth Lagrange point L2
- Cold (T<50 K), infrared-optimised
- Wavelengths of operation 0.6-29 microns
- Launch scheduled for 2013 (Ariane 5)
The James Webb Space Telescope (JWST)

4 science instruments:

- NIRCam
- NIRSpec
- TFI / FGS

\{ \text{NIRCam, NIRSpec, TFI / FGS} \} < 5 \text{ microns}

- MIRI

MIRI > 5 \text{ microns}
NIRSpec uses microshutter arrays to create spectroscopic masks.
• 4 Microshutter arrays (MSA) - total of ~ 250,000 shutters
• Fixed slits
• IFU (3x3 arcsec)
• Imaging (for target acquisition only)
MSAs give NIRSpec a unique multi-object spectroscopy capability

NIRSpec optimized for low- and medium-spectral resolution due to very low background:

- R=100 prism covers 0.8-5 microns in one shot
- R=1000 grating - 3 settings: 0.8-1.8, 1.7-3, 2.9-5 microns
- R=2700 grating - 3 settings: 0.8-1.8, 1.7-3, 2.9-5 microns

Can get simultaneous spectra for over 100 objects over 3 x 3 arcmin field.

Long exposures (100ks) will enable spectra of ultra-faint (AB~29) objects.
Star formation and assembly of $z > 2$ galaxies

High quality spectra can be fit by population synthesis galaxy models to yield the star formation history, dust reddening, stellar mass and dynamical mass.

By measuring the ratios of emission lines for starbursts, NIRSpec can determine the metallicity evolution of distant galaxies.

Can also use line ratios to separate AGN from star formation.
Trace AGN and star formation activity back to early epochs.

At a flux limit of 15 $\mu$Jy (1.4 GHz), source counts show $\sim$50 radio sources per NIRSpec FOV.

EVLA will go deeper.

What are these sources?

30 $\mu$Jy sources have:

(i) flat(ter) spectral indices
(ii) optical/near-IR SEDs of starbursts
(iii) low X-ray flux for starbursts

Owen & Morrison (2008)
Deep Radio Surveys

NIRSpec spectroscopy can provide:

- redshifts (lines/continuum)
- AGN activity
- star formation rate (lines/continuum)
- dust reddening
- stellar mass
- metallicity

Need to combine with deep mm, FIR, X-ray to fully understand sources

100 microJy SXDS VLA survey

Simpson et al. (2006)
Radio-selected high-z proto-clusters

Powerful radio galaxies reside in high mass galaxies at all redshifts.

Some also have been found in overdensities, possible protoclusters.

NIRSpec could study ~ a hundred galaxy cluster candidates per observation.

Overzier et al. (2008)
High-resolution CO observation of z=6.42 SDSS quasar with the VLA

CO line width of 280 km/s

Dynamical mass within central 2 kpc: \( \sim 10^{10} \, M_\odot \)

Molecular gas mass \( \sim 10^{10} \, M_\odot \)

similar resolution to JWST

Use NIRSpec IFU, EVLA and ALMA to map the host galaxy properties to compare:

• stars
• ionized gas
• dust
• molecular gas (density)
Conclusions

JWST set for launch in 2013 - not long after completion of first large multi-frequency EVLA surveys.

NIRSpec will provide a huge gain in sensitivity for near-IR spectroscopy of small, faint sources.

Versatile instrument with MSA, fixed slits and IFU.

Multiplexing capability will allow for programs with hundreds (thousands) of spectroscopic redshifts of very faint sources.

High quality spectra to give not just redshifts, but information on galaxy star formation and AGN properties.