

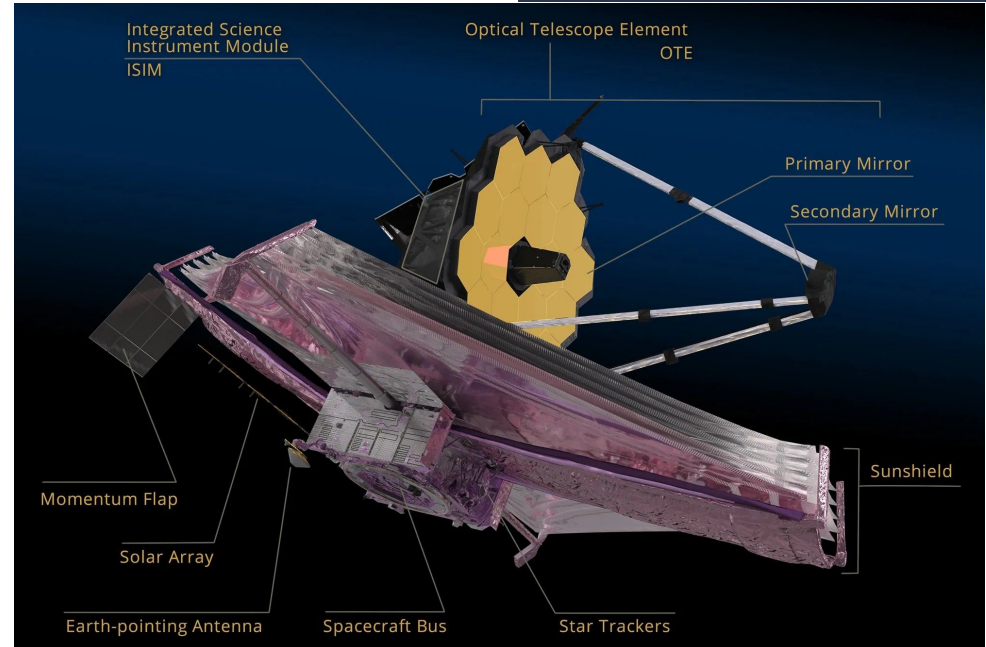
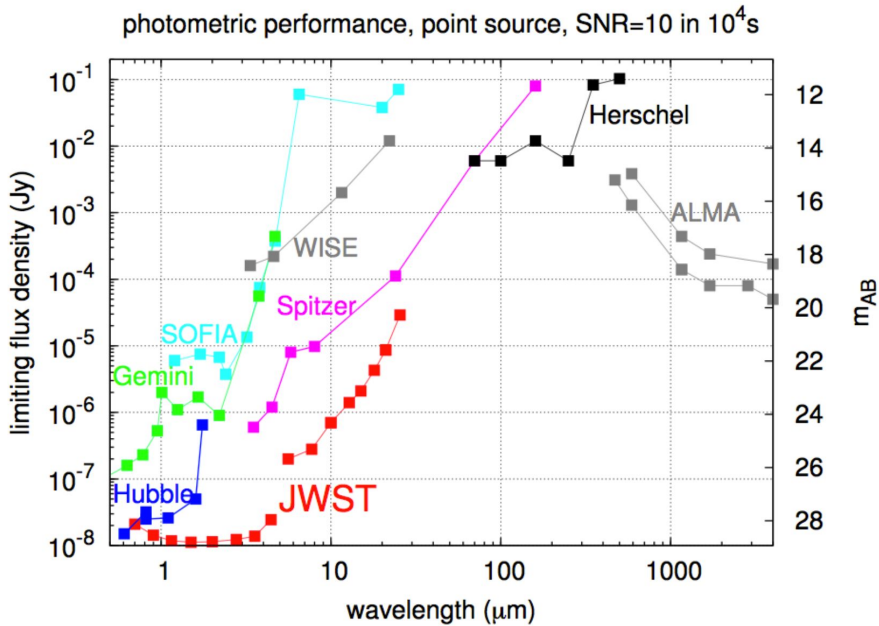
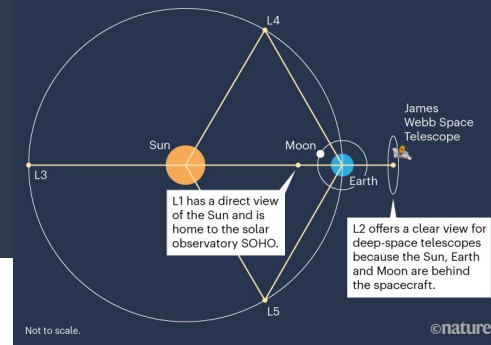
A gas-enshrouded and gas-reddened black hole at cosmic dawn

Summary of “**Little Red Dots**” to **Mirage of Miracles Black Hole*** - 1
Chaitanya Priyadarshi

Overview of MoM-BH*-1

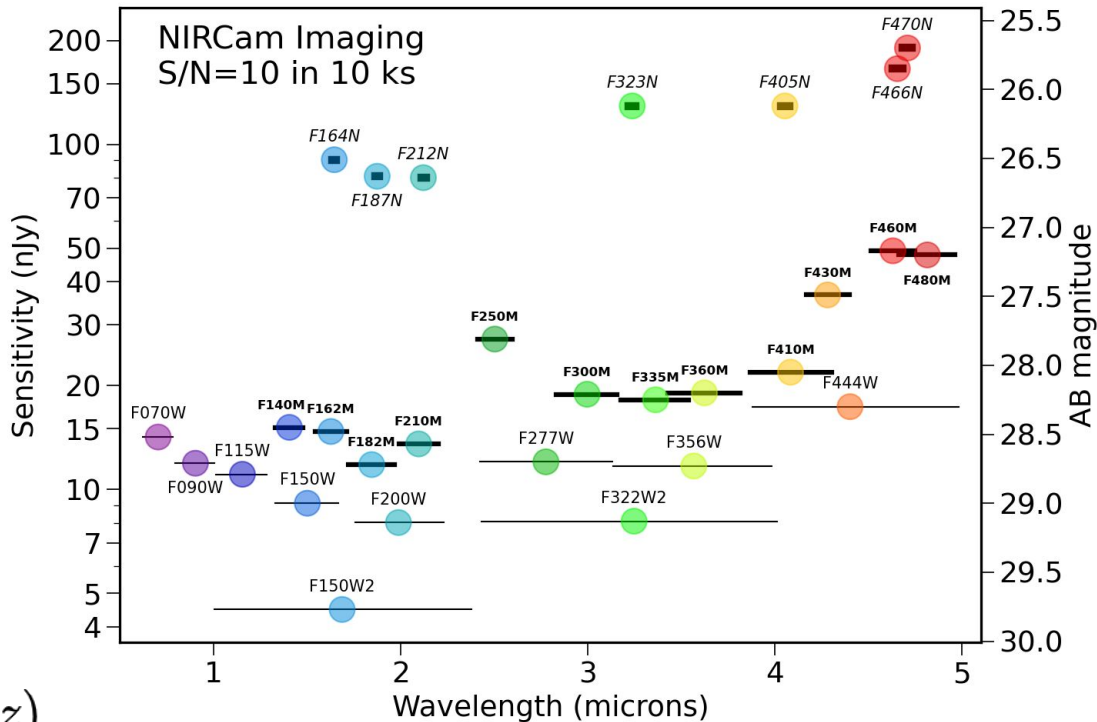
- Source at time **660 million years** after the Big Bang ($z = 7.7569$)
- Amongst the **largest Hydrogen Balmer breaks $7.7_{-1.4}^{+2.3}$** (highest for dust-free stellar case is 5)
- Broad multi-peaked H β emission and **Balmer line absorption** in several transitions
- **Modelling** on the structure resulting in the above measurements
- May support theory of “**rapidly growing black holes with Super-Eddington accretion**”
- Radiation from the Black Hole ($M \sim 10^{6.3} M_{\odot}$) dominates all light coming from host galaxy ($M < 10^{8.8} M_{\odot}$)
- **Red spots** seen by JWST’s NIRSpec in its **Ultra Deep Survey (UDS)** extragalactic field
- Part of the “**Mirage of Miracle**” program by JWST
- Redness due to **gas** and not dust. **Scattering** not kinematics

JWST



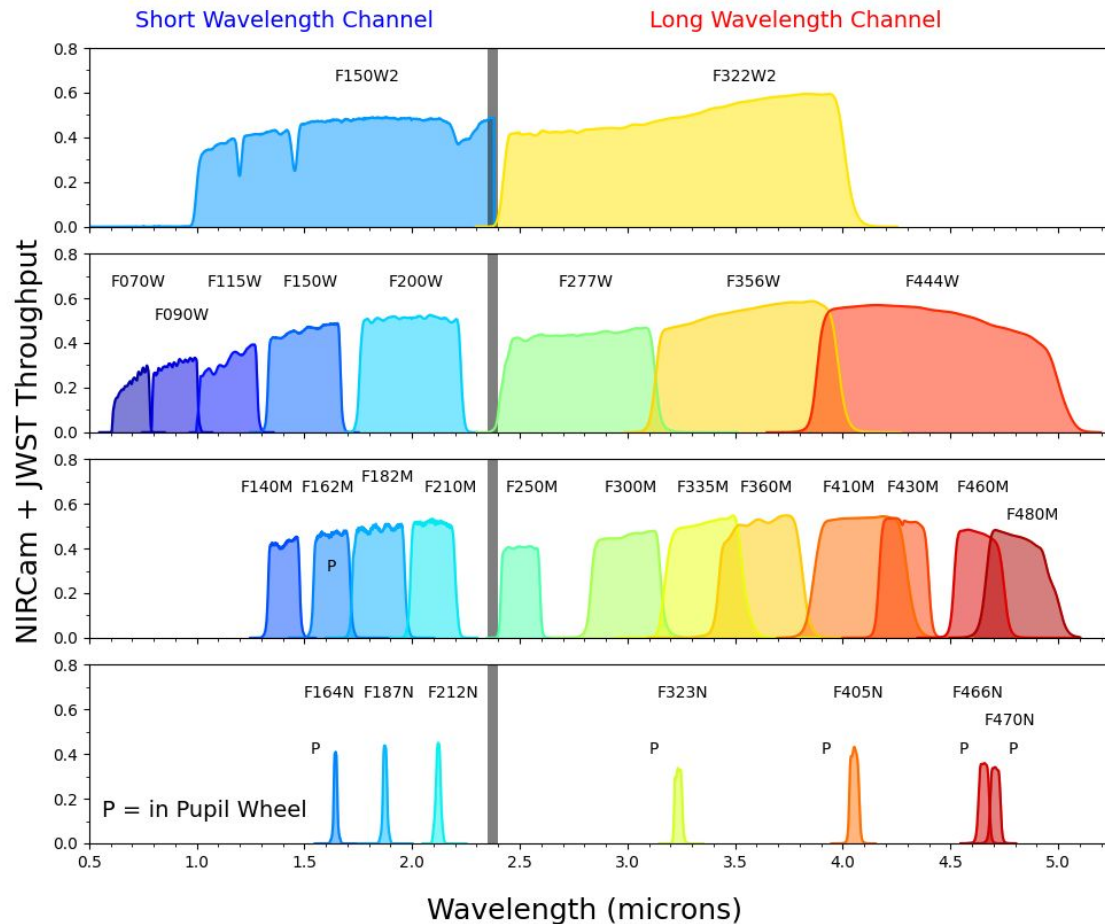
Observations

- **Observation field:** 250 arcmin², F277W-F356W > 2.5 mag
- **Source Luminosity:** F444W = 25.4 mag
- Observed in 2 prior survey programs (**PRIMER**, **EXCELS**) of JWST, **MoM** data was prioritized
- No complementary **radio** data, but Chandra observed in **X-ray**, but no detection

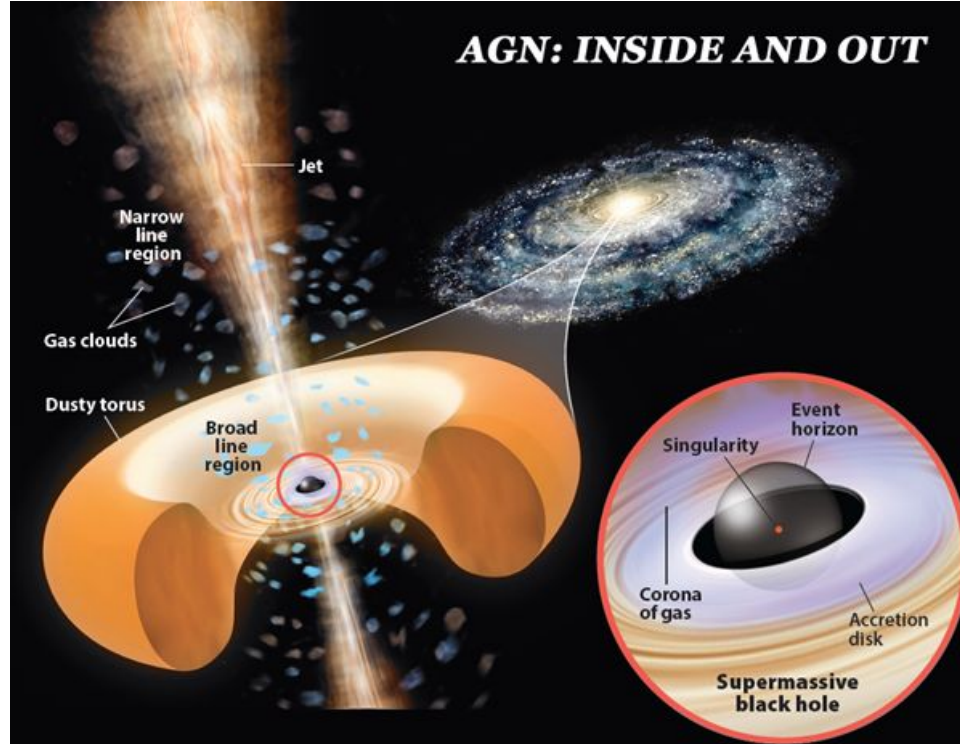


$$1\text{nJy} = 10^{-32} \text{erg}/(\text{cm}^2 \cdot \text{s} \cdot \text{Hz})$$

NIRCam Filters



General features of an AGN



Modelling

- Strong support for **presence of SuperMassive Black Hole** and **strong Balmer absorption**, led to the application of **Cloudy spectral synthesis models**.
- Start with **intrinsic AGN continuum spectra**, pass it through **gas surrounding**.
- The gas have **large turbulent velocities** due to the width of the absorption lines
- Post-processing: Application of a **uniform dust screen** is applied

List of parameters used:

1. Temperature
2. Optical to X-ray index
3. UB slope
4. X-ray slope
5. Ionization parameter
6. Gas density (n_H)
7. Column density (N_H)
8. Turbulence
9. Metallicity (Fe/H)
10. Dust (post-processing)

Inference from modelling

Selected model **matches many parameters** of interest, based on the **limited grid of parameters**

Some features remain unknown, like intrinsic SEDs of early AGN with effects like photon trapping

- **Extreme N_{H} column density** $\sim 10^{25.8} \text{cm}^{-2}$ -> similar to most enshrouded regions
- High n_{H} gas density 10^{11}cm^{-2} -> conducive to Balmer absorption
- Turbulent velocity $\sim 500 \text{kms}^{-1}$ <- width of central $\text{H}\beta$ absorber
- Metal-poor gas -> expected of a dwarf galaxy at $z \sim 8$
- Dust $A_{\text{V}} = 0.15 \text{mag}$ -> **Dust free**
- UV-weakness due to extreme H opacity -> **unlike classic AGN** modelling feature

Conclusions

- Naively applying local scaling features under standard assumptions, the accreting radiation does not exceed Eddington limit
- However, accounting for the **extreme observed conditions**, favours a **super-Eddington process**
- Neighbouring galaxy ($M \sim 10^{9.5} M_{\odot}$), 60 kpc away, with an **expected merger in 100 Myr**
- Theories of direct collapse BHs that form out of **primordial gas** predict that this **proximity to an ionizing source** may be the key to **suppressing the formation of molecular hydrogen** thereby aiding **direct collapse**
- Propose to treat MoM-BH*-1 as an **effectively pure template** for the **AGN component** of **LRDs** and combining it with a **star-forming galaxy** of **matched UV-brightness** accounts for the puzzling LRD properties