Figure 5 compares the average $M*$ -MBH relation for the JWST AGNs in this analysis and those in the literature.

The MBH of the individual JWST AGNs has been measured based on the FWHM of broad Hα emission and the luminosity (e.g. Greene & Ho 2005; Reines et al. 2013; Reines & Volonteri 2015), and we use the median mass of 28 JWST AGNs to evaluate the median MBH /$M*$ in this study.

Figure 5 also displays the **local relation** (Reines & Volonteri 2015) and **high-z relation** (Pacucci et al. 2023), which is based on the JWST AGNs at $4 < z < 7$.

Basicamente aca nos da la pista de lo que se refiere con relacion local y a alto z. Entiendo , ademas por lo visto en el paper de Sun que con local se refiere a z<4.

While Maiolino et al. (2023) and Harikane et al. (2023) reported that JWST AGNs have highly overmassive SMBHs (grey circles in Figure 5), our estimate shows the trend is much less pronounced.

Our results fall between the JWST AGNs' relation (Pacucci et al. 2023) and the local AGN relation (Reines & Volonteri 2015). Our results are rather consistent with Sun et al. (2024), who insist that MBH /$M*$ shows no redshift evolution up to $z = 4$.

Hasta aca lo que dice es importante, dice que $M_{\rm BH}$ de los AGN individuales se ha medido basados en las lineas anchas de H_α. Una vez que se determina todas las masas se calcula la mediana de los 28 AGNs para evaluar la relacion $M_{\rm BH}/M*$

We also estimate a possible evolution of the $M*$ -MBH relation for JWST AGNs.

We adopt the *black hole accretion rate* (**BHAR**) of **TRINITY** (Zhang et al. 2023), which *provides* the *average BHAR* as a *function of redshift* and the *DMH mass*.

TRINITY utilises a *halo merger* [Average black hole accretion rates (BHARs) are calculated by comparing the average M• of the same halo population between two consecutive snapshots.(paper iv] tree and scaling relations among DMHs, galaxies, and SMBHs to predict the masses of DMHs, galaxies, and SMBHs at each redshift bin.

The BHAR can be obtained from the **time derivative** of the SMBH masses. We simply assume that the host galaxies of JWST AGNs have a constant star formation rate (SFR).

We estimate the total SFR by summing the SFRs derived by the Hα luminosity in the narrow line component (Matthee et al. 2024) and that from the IR luminosity (Casey et al. 2024).

Matthee et al. (2024) adopt Kennicutt & Evans (2012) to estimate SFR from the Hα luminosity as 15 M $\odot$ yr -1 .

Casey et al. (2024) inferred the mean IR luminosity of LRDs as $\langle L$ IR $\rangle = (7.9+2.9) \times 1010$ L $\odot$, which yields SFRIR ~ -4.7 -1 10 M $\odot$ yr by applying the empirical relation (Kennicutt & Evans 2012).

Finally, we assume the SFR of JWST AGNs as time-invariant with 25 M $\odot$ yr -1 . Please note that there is a great deal of uncertainty involved in estimating SFR. If we stand on the model of Hopkins et al. (2008) mentioned in Section 3.3, JWST AGN may undergo a starburst in the future, so this assumption may be an underestimate.

Figure 6 shows the evolution paths of MBH /$M*$. We confirm that most of the JWST AGNs will follow the low-z relation (Sun et al. 2024) at $z \lesssim 3$, which supports the hypothesis that the JWST AGNs at $5 < z < 6$ are the ancestors of quasars at $z \lesssim 3$.

TRINITY predicts that AGNs residing in DMHs with Mhalo,z=0 = 1013 h -1 M $\odot$ will remain low in BHAR from $z \sim 5$ to $z \sim 3$, which helps mitigate the offset to the local relation at $z < 3$.

In addition, TRINITY also **predicts** that the BHAR *will start to increase* at $z \sim 3$, which implies that the AGNs become active at $z \sim 3$.

Furthermore, recent JWST observation (Kokorev et al. 2024b) for an LRD at $z = 4.13$ shows a consistent MBH -$M*$ relation with local one (Kormendy & Ho 2013; Greene et al. 2016, 2020).

They suggest that a starburst may occur after forming an overmassive SMBH at high-z and the MBH /$M*$ gets closer to the local relation. Although this differs from the assumed star formation history, the final fate of JWST AGNs is the same as the conclusion of this study.

The above assessment assumes that all JWST AGNs have an average DMH mass; however, individual JWST AGNs should have different DMH masses and therefore different BHARs.

Zhang et al. (2024) also predicts the redshift evolution of MBH /$M*$ of JWST AGNs at $z \gtrsim 4$. Their calculation shows that MBH /$M*$ will keep almost constant or slightly increase toward $z = 0$, which suggests that JWST AGNs are still overmassive even at $z = 0$, though no such population has been found.

The result may be due to the fact that they assume mathematically that all SMBHs with the same host stellar mass share the same average Eddington ratio distribution. As such, the prediction of MBH /$M*$ of JWST AGNs has a large variation among individual studies with different assumptions.

1 Trinity

Introduccion del Paper: Esta buena para lo que necesito contar:

It is widely accepted that supermassive black holes (SMBHs) exist in the centres of most galaxies. SMBHs are called active galactic nuclei (AGNs) during phases when they are accreting matter and releasing tremendous amounts of energy.

With their potential for high-energy output, SMBHs are leading candidates to regulate both the star formation of their host galaxies and their own mass accretion.

At the same time, galaxies may also influence SMBH growth via the physics of how gas reaches the central SMBH as well as via galaxy mergers.

Hence, it is possible for both SMBHs and their host galaxies to influence each others' growth, also known as 'coevolution'.

The coevolution scenario is consistent with two key observations. First, relatively tight scaling relations (∼0.3 dex scatter) exist between SMBH masses, M●, and host galaxy dynamical properties (e.g. velocity dispersion, σ, or bulge mass, Mbulge, at z ∼ 0.

Second, the cosmic SMBH accretion rate (CBHAR) density tracks the cosmic star formation rate (CSFR) density over 0.

Que es Trinity?:

We present TRINITY, a flexible empirical model that self-consistently ***infers the statistical connection between dark matter haloes***, ***galaxies***, and ***supermassive black holes***(SMBHs). TRINITY **is constrained** by ***galaxy observables*** from 0 < z < 10 [galaxies'stellar mass functions, specific and cosmic star formation rates (SFRs), quenched fractions, and UV luminosity functions] and **SMBH** observables from 0 < z < 6.5 (quasar luminosity functions, quasar probability distribution functions, active black hole mass functions, local SMBH mass–bulge mass relations, and the observed SMBH mass distributions of high-redshift bright quasars).

The model includes **full treatment of observational systematics** [e.g. active galactic nucleus (AGN) obscuration and errors in stellar masses]. From these data, TRINITY **infers** the **average SMBH mass**, **SMBH accretion rate**, **merger rate**, and Eddington ratio distribution as functions of **halo mass**, **galaxy stellar mass**, and **redshift**.

Average black hole accretion rates (BHARs) are calculated by comparing the average M● of the same halo population between two consecutive snapshots.

Todo lo mencionado en el Paper Sobre el uso de Trinity:

- Se utiliza Trinity para poder estimar una evolcuion posible de la relacion $M^* - M_{BH}$. En el trabajo se atoma de trinity el BHAR (Black Hole Acretion Rate) que da el BHAR promerdio en funcion del redshift y la masa del DMH.

- Trinity utiliza un halo merger y relaciones de escala entre DMHs, galaxias y SMBH para poder predecir las masas de DMHs, las masa de las galaxias y SMBH en cada bin de redshift. En particular el BHAR puede ser obtenido de la derivada temporal de las masas de los SMBH.

- TRINITY Predice que los AGN que residen en los halos de Materia Oscura y que tengan una masa del Halo de 10^{13} mantendran una baja tasa de Black Hole Acretion Rate entre los redshift $z = 5$ a $z = 3$. Esto ayudaria a mitigar el desajuste con la relacion local a $z < 3$.

- TRINITY por otro lado predice que los BHAR comenzara a crecer a $z = 3$, esto implicaria que los BH empezarian a estar activos a $z = 3$

- Las predicciones hechas anteriormente por TRINITY , donde se asume el BHAR dado por trinity y una tasa constante de SFR y se encuentra que hay concordancia, a z<=3 con la relacion local de Sun mientras que el AGN sera supermasivo a 5 < z < 6.

- En Sun se examinan los cocientes entre la masa del halo y la masa del BH y so evolucion en redshift. Teniendo en cuenta su dispersion los resultados estarian en acuerdo.

2 Paper de Sun

Over the past two decades, tight correlations between black hole masses (M•) and their host galaxy properties have been firmly established for massive galaxies (log(M∗/M⊙) $\gtrsim$ 10) at low-z (z<1) indicating coevolution of supermassive black holes and galaxies.

However, the situation at high-z, especially beyond cosmic noon (z $\gtrsim$ 2.5), is controversial.

With a combination of JWST NIRCam/wide field slitless spectroscopy (WFSS) from FRESCO, CONGRESS and deep multi-band NIRCam/image data from JADES in the GOODS fields, we study the black hole to galaxy mass relation at z∼1–4.

Taking account of the observational biases, the intrinsic scatter of the M• − M∗ relation, and the errors in mass measurements, we find no significant difference in the M•/M∗ ratio for 2.5<z<4 , suggesting no evolution of the M• −M∗ relation at log(M∗/M⊙) $\gtrsim$ 10 up to z∼4.

En lineas generales utilizan una base de datos espectroscopica similar para estudiar la relacion log(M∗/M⊙) a alto redshift (1 a 4). Lo que encuentran es que no hay evolucion de la relacion hasta z=4. En el paper que estamos examinando, se hace referencia a esto indicando que los del paper de SUn no ven evolcuion hasta z=4. Tienen un grafico tambien.

3 Duty Cicle:

Deacuerdo el paper el duty cicle se define como la fraccion de tiempo en que el AGN se encuentra en fasae activa.

Dice que para conocer el duty cicle hay que asumir varias cosas, aca se deriva por clustering analisis de los AGN del JWST.

Se asume que la masaa del halo se encuentra en un rango de masas [Mmin,Mmax], que la misma hostea un AGN y que la misma brilla aleatoriamente en tel tiempo. Asumiendo esto, puede calcularse el f duty con la formula dada.

Esta formula depende [Lmin,Lmax] que son las luminosidades maximas y minimas utilizadas en el analisis de clustering. Los otros elementos son la funcion de luminosidad y n representa la funcion de masa del AGN.

Se discute cual es la funcion de luminosidad correcta para saber cual es la luminosidad del agn ellos utilizan la funcion de luminosidad dada por: Matthee et al. (2024) <Revise el paper y esta bastante oscura como es es funcion.

Brevemente mencionan este paper: Eftekharzadeh et al. 2015 esta bueno para estudiar las funciones de correlacion. Lo que dicen sobre este paper es basicamente sobre la definicion de $f_{\rm duty}$ que va hasta infinito, pero que basicamente cambiarlo por un limite de magnitud maxima no cambia mucho.

Que obtienen?

Obtienen lo siguiente: $f_{\rm duty} = 0.36$ mas menos sus errores. Esto implica un tiempo de vida de $4{\cdot}10^6$ yr para los AGN a $5<z<6$. Esto es comparable a los quasars de tipo1 a $z<3$ lo cual aporta evidencia a que estos pudieran ser sus ancestros.