Some general Very high-z quasar and JWST Science notes

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Salpeter time

The Salpeter timescale (or Salpeter time) is the timescale for black hole growth, based upon the Eddington limit: a growing black hole heats accretion material, which glows and is subject to the luminosity limit. The timescale is $\approx 5 \times 10^7$ years.

$$t_{\rm Sal} = M/\dot{M} = 4.5 \times 10^7 \left(\frac{\epsilon}{0.1}\right) \left(\frac{L}{L_{\rm Edd}}\right)^{-1} \quad (1)$$

where $\epsilon = L/\dot{M}c^2$ is the radiative efficiency for a QSO radiating at a fraction $L/L_{\rm Edd}$ of the Eddington luminosity. Commonly accepted values of these two key parameters for luminous QSOs are $\epsilon = 0.1$ and $L/LEdd = 1$. Martini, P. (QSO Lifetimes; http://adsabs.harvard.edu/abs/2004cbhg.symp..169M).

This critical accretion rate, [the Eddington mass accretion rate], is proportional to the mass of the accreting object, which implies that the mass of an object that is growing at the maximal (Eddington) accretion grows exponentially on a timescale known as the Salpeter time,

$$\begin{aligned} t_{\rm Sal} &= \frac{\epsilon \sigma_T c}{4\pi G m_p} & (2)\\ &= \frac{\epsilon \cdot 6.65 \times 10^{-29} \cdot 3 \times 10^8}{4\pi \cdot 6.674 \times 10^{-11} \cdot 1.6726 \times 10^{-27}} \text{ seconds} & (3)\\ &= 1.4\epsilon \times 10^{16} \text{ seconds} & (4)\\ &\approx 45\epsilon \times 10^7 \,\text{years} & (5)\\ &\approx 45\epsilon_{0.1} \times 10^6 \,\text{years} & (6) \end{aligned}$$

where $\epsilon_{0.1}$ is the efficiency at which accreting gas rest mass energy is converted in radiation expressed in units of 10%, the standard value for an

accreting Schwarzchild black hole. (In terms of this efficiency, the accretion luminosity is $L_{\rm acc} = \epsilon \dot{M}_{rmBH} c^2$, where $\dot{M}_{\rm BH}$ is the black hole accretion rate.) From (Coppi, 2003).

Salpeter (1964).

References

Coppi P., 2003, in Centrella J. M., ed., The Astrophysics of Gravitational Wave Sources Vol. 686 of American Institute of Physics Conference Series, Massive Black Hole Growth and Formation. pp 141–150

Salpeter E. E., 1964, ApJ, 140, 796