SMBH formation scenarios

▪BH seeds from PopIII stars:

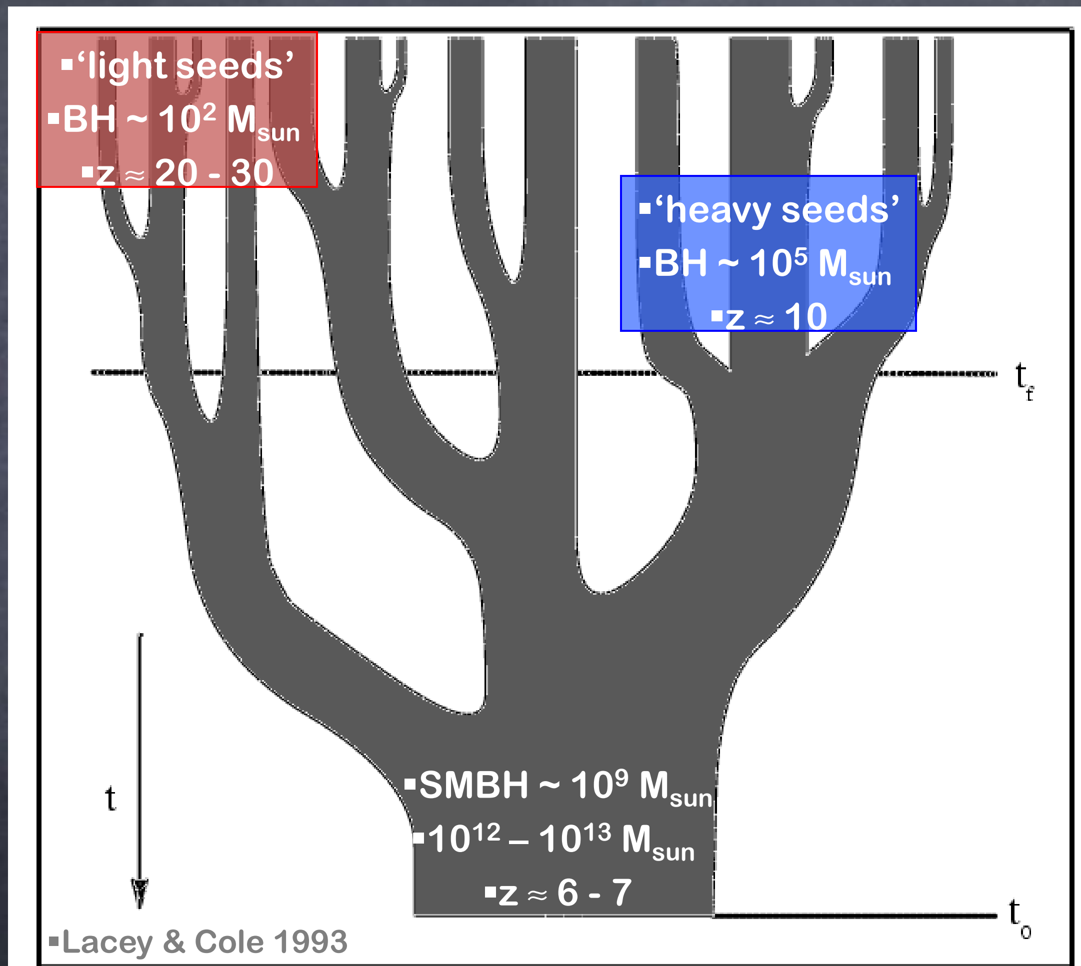
These would collapse from a metal-free gas leading to a top-heavy IMF, corresponding to very massive stars with masses >100 $M_\odot$. Stars with $M<300\ M_\odot$ will produce pair-instability SNae, and their stellar cores would be entirely disrupted leaving no remnants. Stars with $M>300M_\odot$ will produce BHs with 100-150 $M_\odot$. The primordial generation of stars could form at redshifts z~20 in DM haloes with $M>10^6\ M_\odot$, corresponding to populating the peaks above 2.5σ corresponding to a cosmic density of seed BHs: ρ_{BH}~100 $M_\odot$ Mpc^{-3}

▪BH seed from direct collapse of gas clouds

Gas clouds with $M=10^3$-$10^6\ M_\odot$ can directly collaps to BH if fragmentation of the gas cloud can be avoided i.e., high UV flux to avoid cooling and low-metallicities. The latter condition would be incompatible with the presence of nearby luminous galaxies. These seeds are rarer: a peak density of 0.1 Mpc^{-3} at $z \simeq 12$

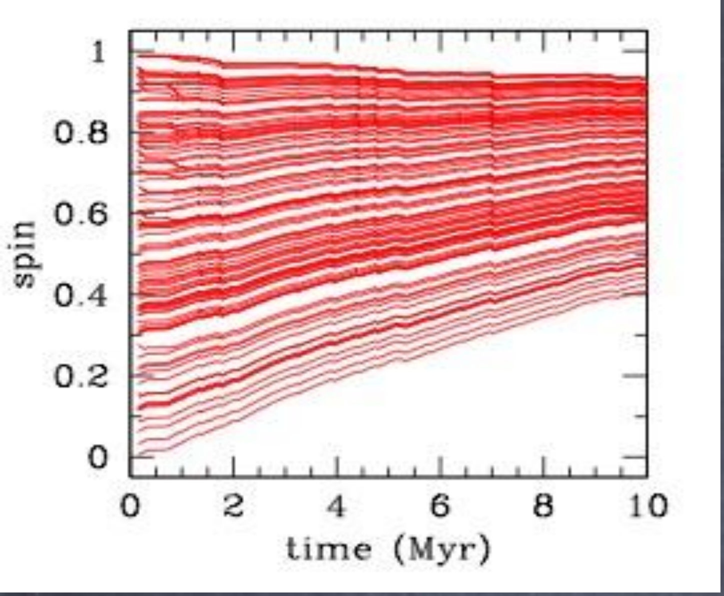
From the first BHs to the first QSOs: planting and growing seeds

growth by
gas accretion
limited by
feedback



growth by
BH-BH mergers
limited by gravitatioal recoil

collapse of overdense regions of DM primordial density field, followed by merging of DM haloes



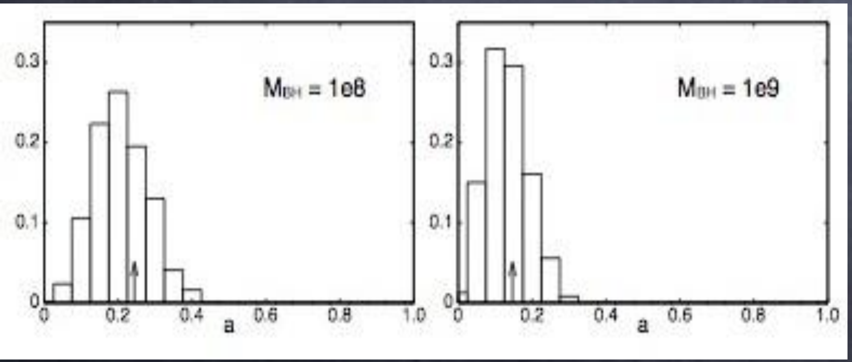
Physics of accretion

BH growth at z=6. λ=1; nearly continuous accretion from z~10 on ~100M_{Sun} seed BHs; ***LF and MF depend on: 1) accretion efficiency; 2) AGN accretion timescale; 3) cosmology.***

$$\frac{dM}{dt}=\frac{l(1-e)}{e}\frac{M}{t} \qquad l=\frac{L_{bol}}{L_{Edd}}=1 \qquad t\sim\frac{Mc^2}{L_{Edd}}$$

$$M(t)=M(0)\exp\left(\frac{1-e}{e}\frac{t}{t}\right)$$

Volonteri2010, Dotti+2010 Spin evolution in gas-rich merger remnants (also see Fanidakis+2010)



King+ 2006,2008 “chaotic accretion”

J(disk)<2J(BH)

M(disk)<M(BH)$(R_S/R_d)^{0.5}$