# The nature of very high redshift quasars and the rapid formation of super-massive black holes (SMBHs)

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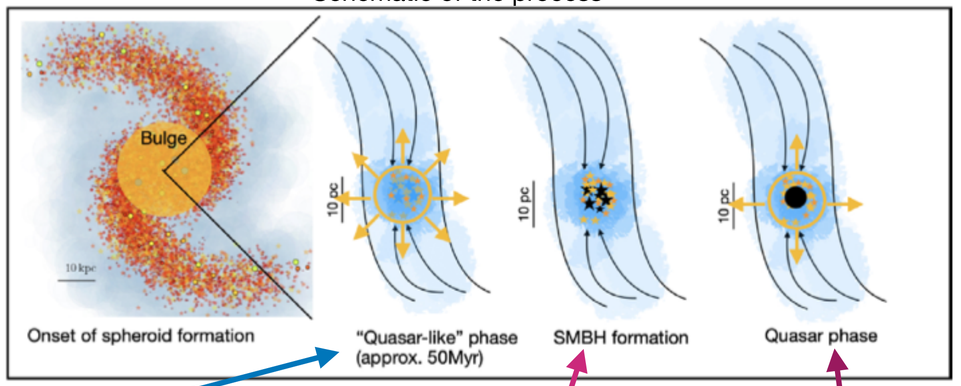
The development of a comprehensive understanding of how SMBHs form quickly and why they correlate with their hosts and what the very high-z quasars are.
Given the known baryonic physics and downsizing, quasars must appear at z near 10, SMBHs must thereafter form within a few 100 Myr and their masses must correlate with their host galaxy's.
[ for details see Kroupa, Subr, Jerabkova & Wang (2020, MNRAS 498, 5652) ]

Schematic of the process




## The solution to the very-high-z quasars, rapid SMBH formation and SMBH-host-galaxy correlation is actually simple :

The first post-Big-Bang gas clouds collapse under self-gravity. If massive enough, an extremely massive (>$10^9$Msun) hyper-luminous first star-cluster forms at the collapsing cloud's centre about 200 Myr after the Big Bang.

Ultra-low metallicity + very high density (the centre of collapsing proto-spheroid / proto elliptical galaxy or proto classical bulge)
===> **very top heavy stellar IMF** in this cluster (Marks et al. 2012)
===> hyperluminous (millions of O stars within 1-10 pc) **quasar-like object** 200 Myr after Big Bang) exists for 50Myr :
a *Jerabkova object* (see Jerabkova et al. 2017, A&A 608, 53)

Very top heavy stellar IMF in this cluster (Marks et al. 2012)
===> many stellar mass BHs after 50Myr (250 Myr after Big Bang).

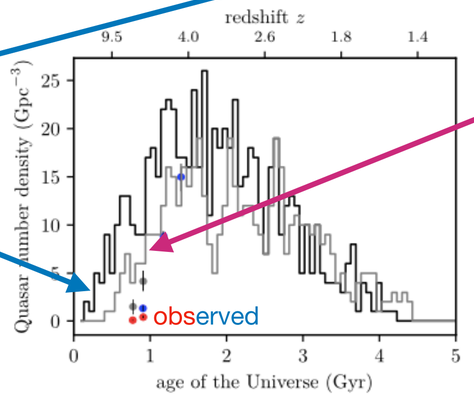
**The spheroid keeps forming** ===> high gas influx rate to centre
The gas influx compresses the BH cluster, gas drag slows BHs
(w/o gas the BH cluster persists in a state of balanced evolution through BH-BH binary heating).
If gas influx sufficiently high (for final spheroid mass >$10^{9.5}$ Msun)
===> Stellar-dynamical BH-BH binary heating of the BH cluster is overcome (i.e. balanced evolution is broken)
===> the BH cluster shrinks to a **relativistic state** within 100-300 Myr (350-650 Myr after Big Bang).

Once the BH cluster reaches the relativistic state it implodes essentially instantly (within a dozen Myr) due to the **emission of gravitational waves**.
===> formation of **seed SMBH** weighing >$10^5$ Msun.

**The spheroid keeps forming** ===> high gas influx rate to centre feeds growing SMBH ===> standard **quasar phase**.

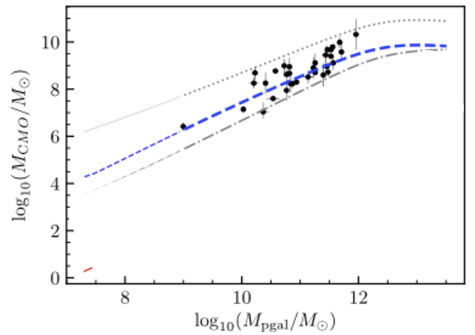
Massive elliptical galaxies form on shorter time than less massive ones (**downsizing**)
===> **SMBH--galaxy-mass correlation** as observed

The very first quasars are hyper-luminous star-burst clusters - *Jerabkova objects* - (top-heavy IMF, form within 200Myr of BigBang).




In these Jerabkova objects SMBH seeds form within 100-300Myr.

The seeds accrete gas from the forming spheroid and are the "classical quasars" (rapidly accreting SMBH seeds) until spheroid formation quenches after a downsizing time.




The SMBH mass ($M_{CMO}$) grows over the downsizing time to the observed correlation with the present baryonic mass of the hosting spheroid (E galaxy or bulge).