The Beast

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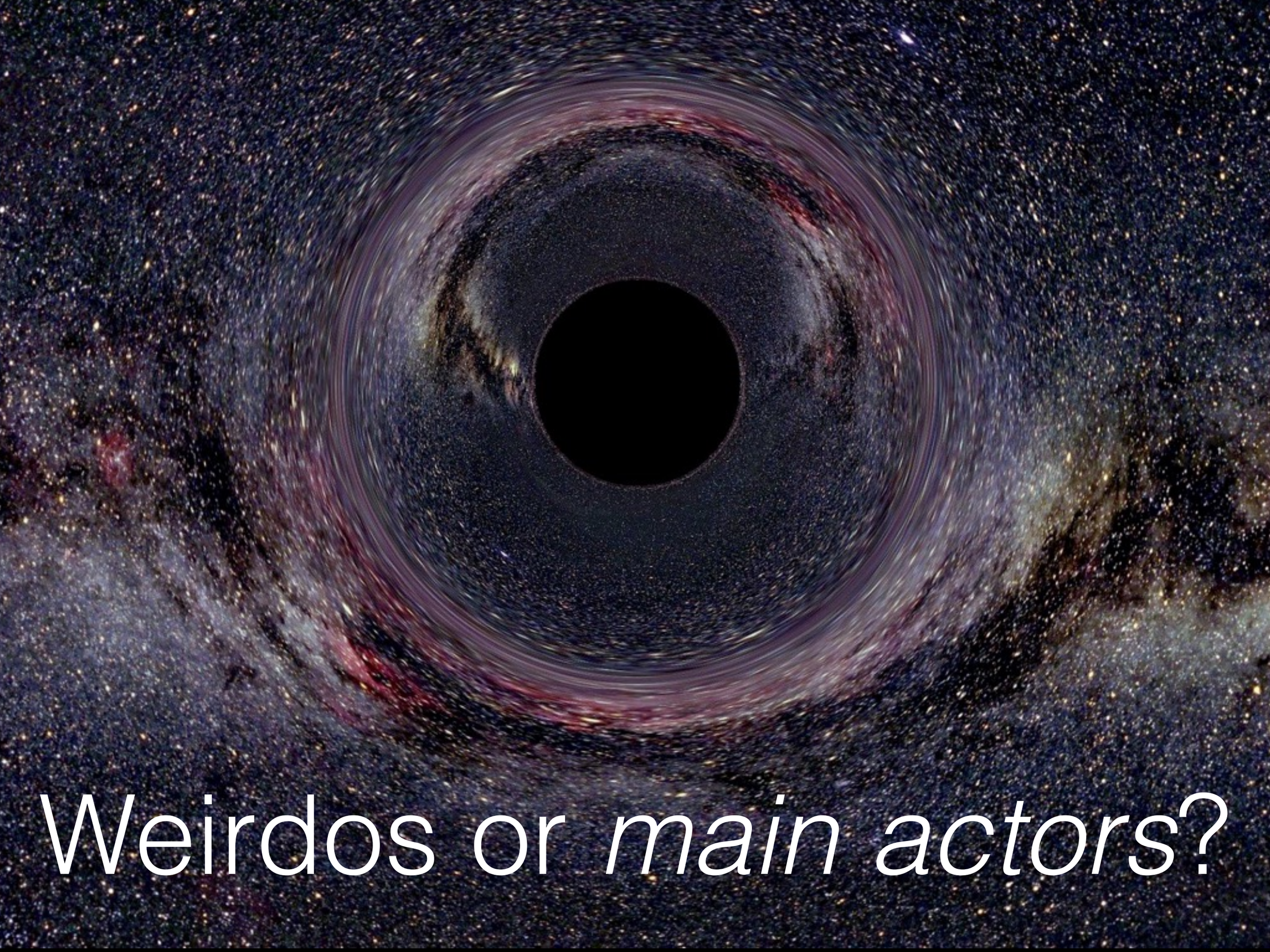
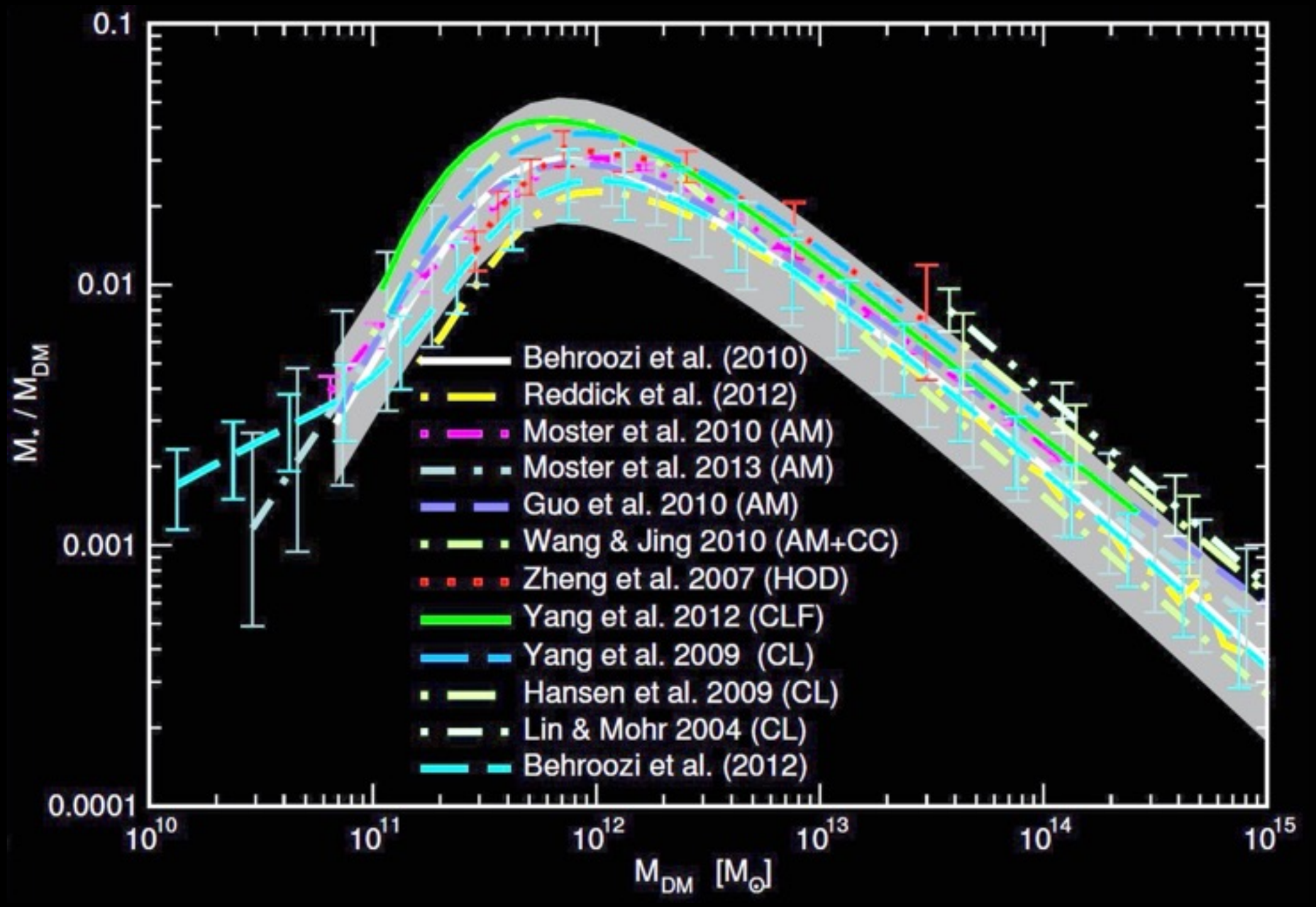


Weirdos or *main actors*?

Two *movies*

Baryon cooling highly inefficient



Adapted from Nesvadba, Sesto 2018

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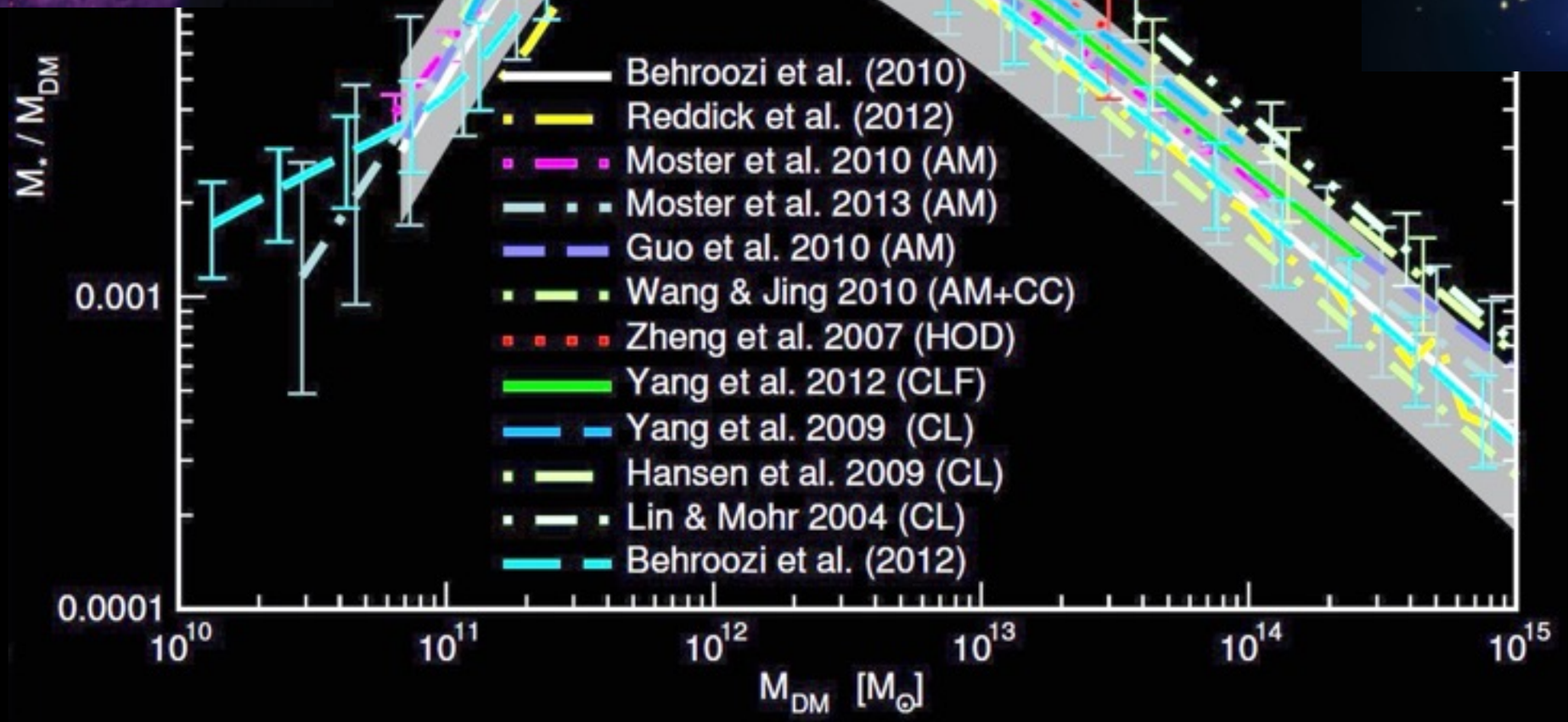

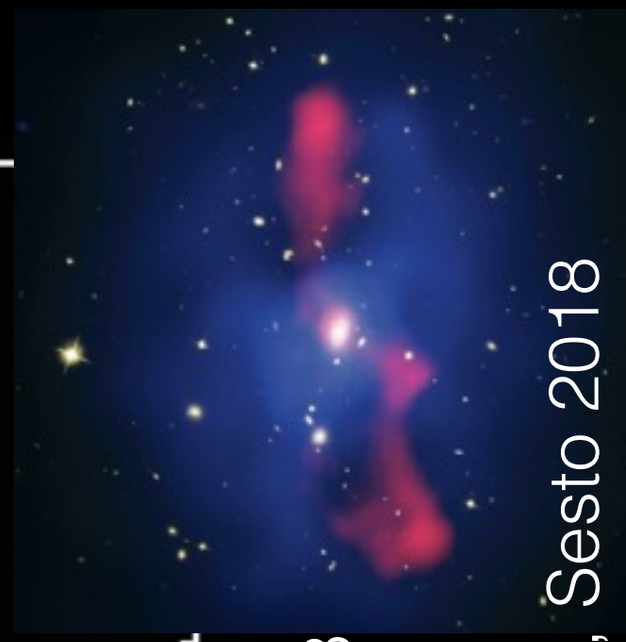

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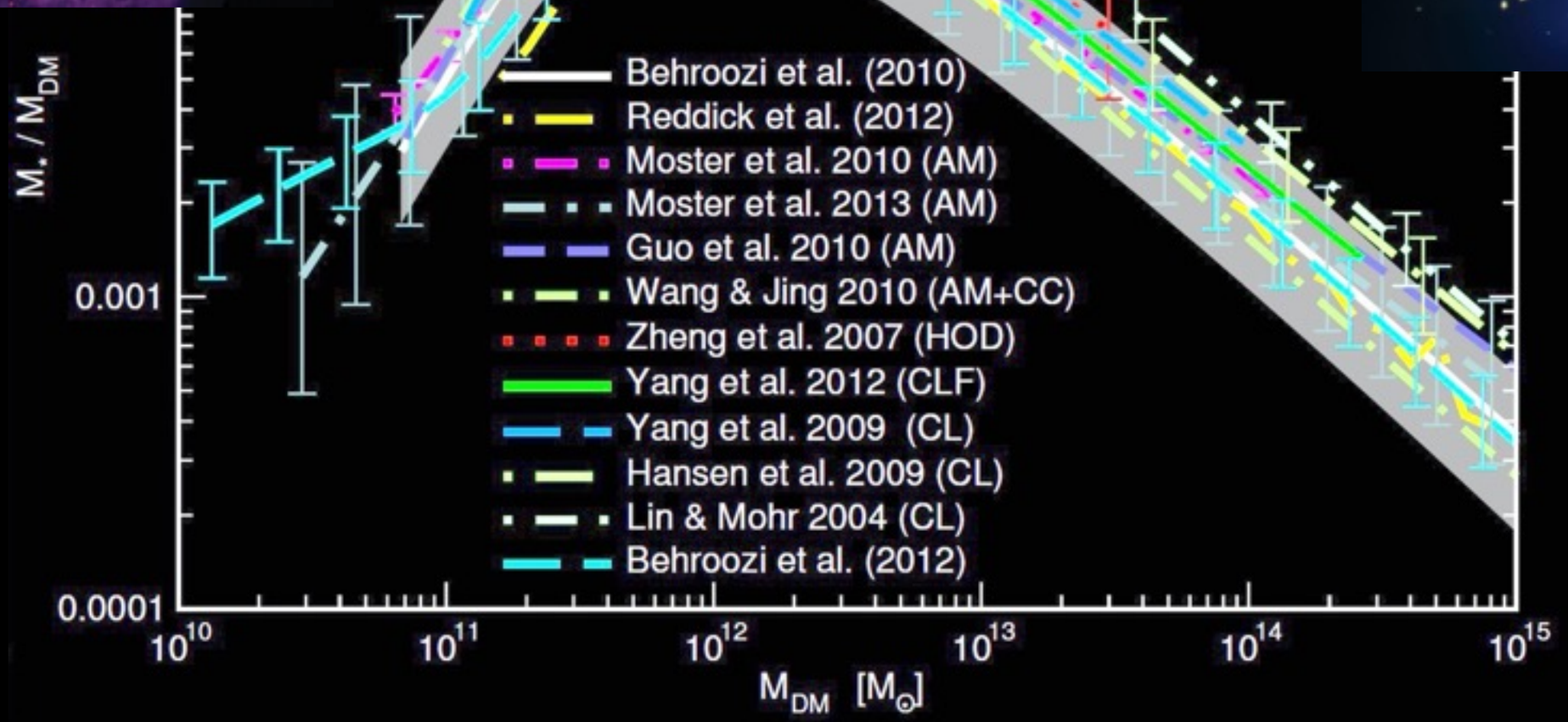

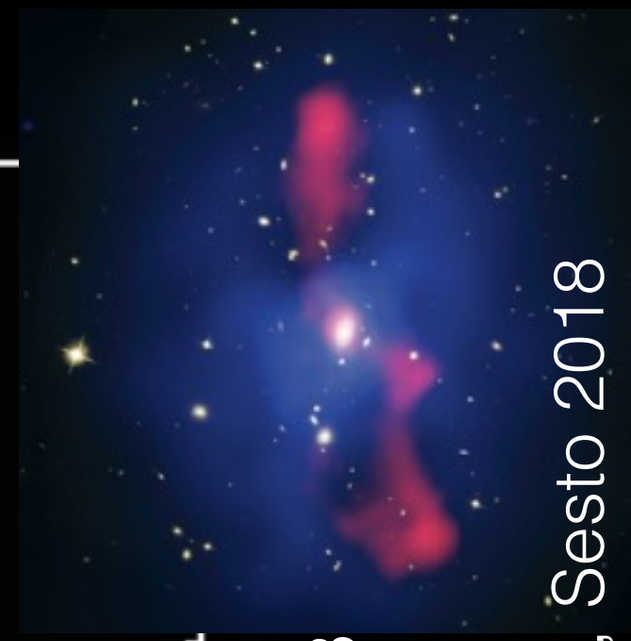

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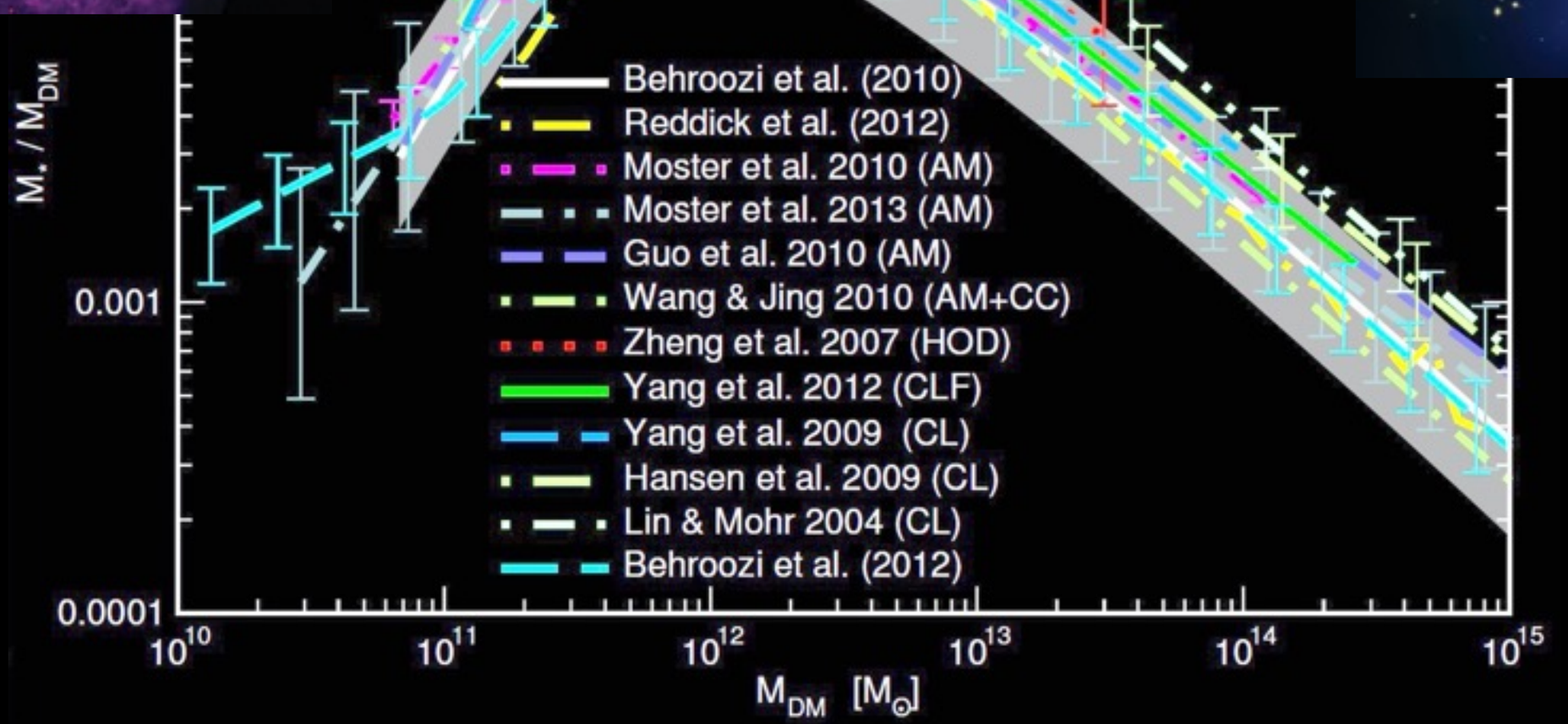
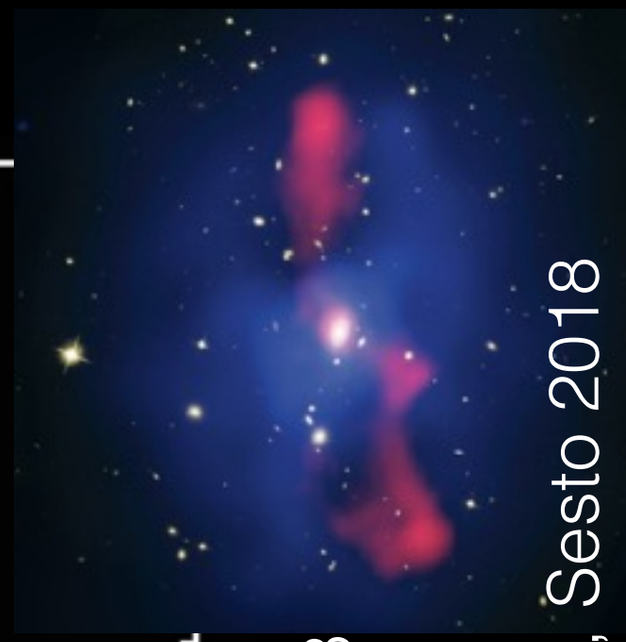


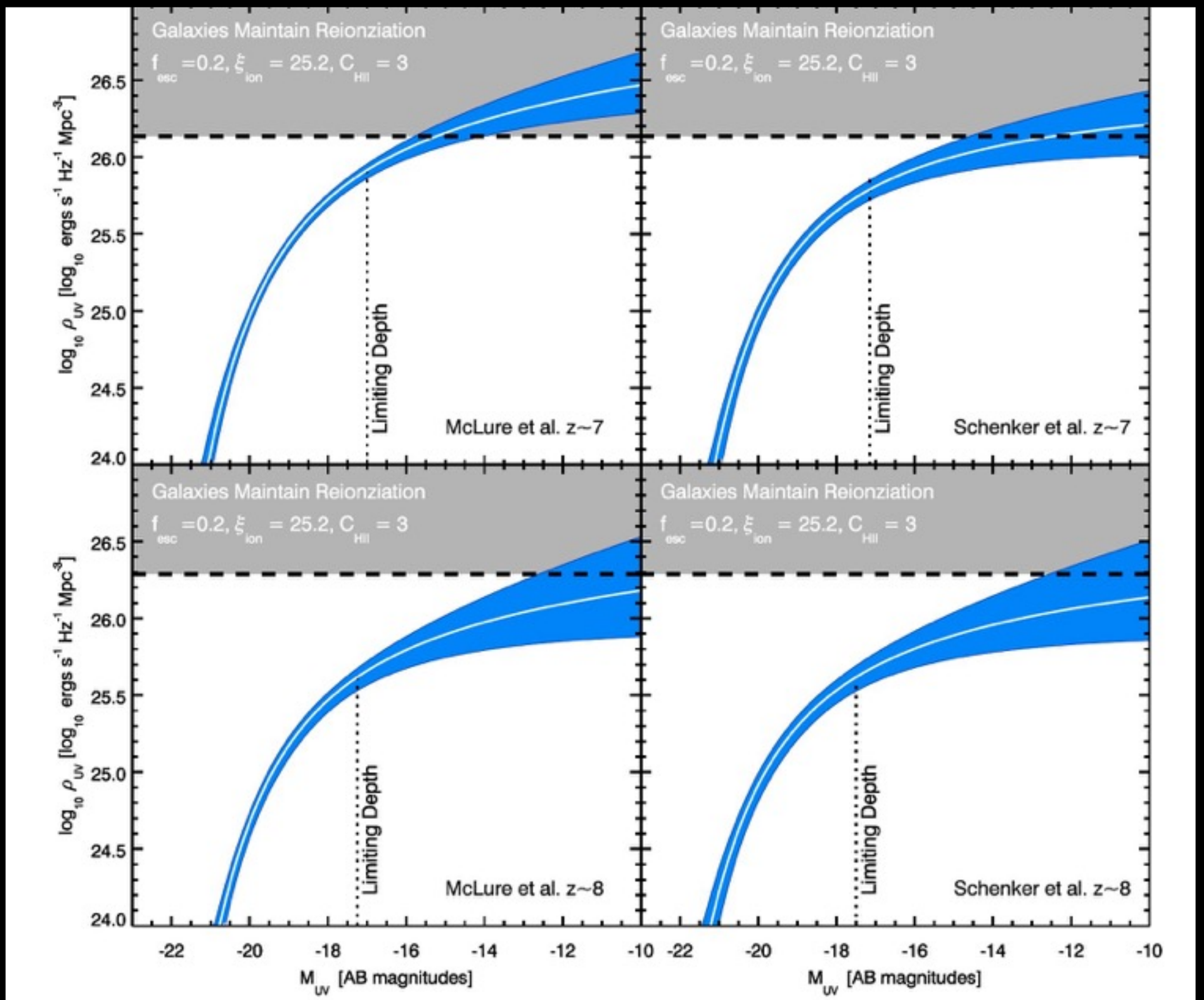


Kormendy & Ho 2013

Adapted from Nesvadba, Sesto 2018

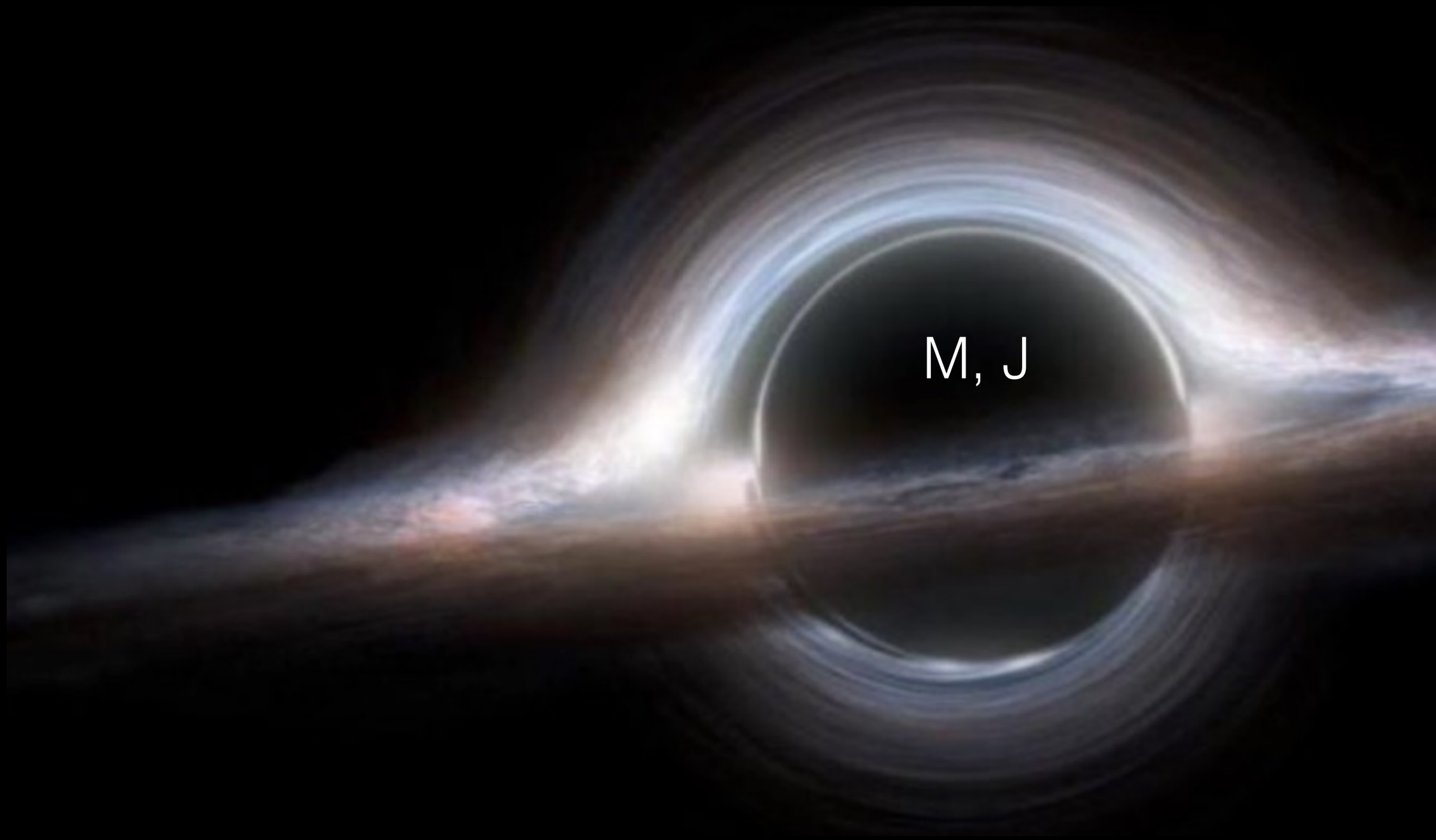
??? = AGN winds?

Reionization



Robertson+2013

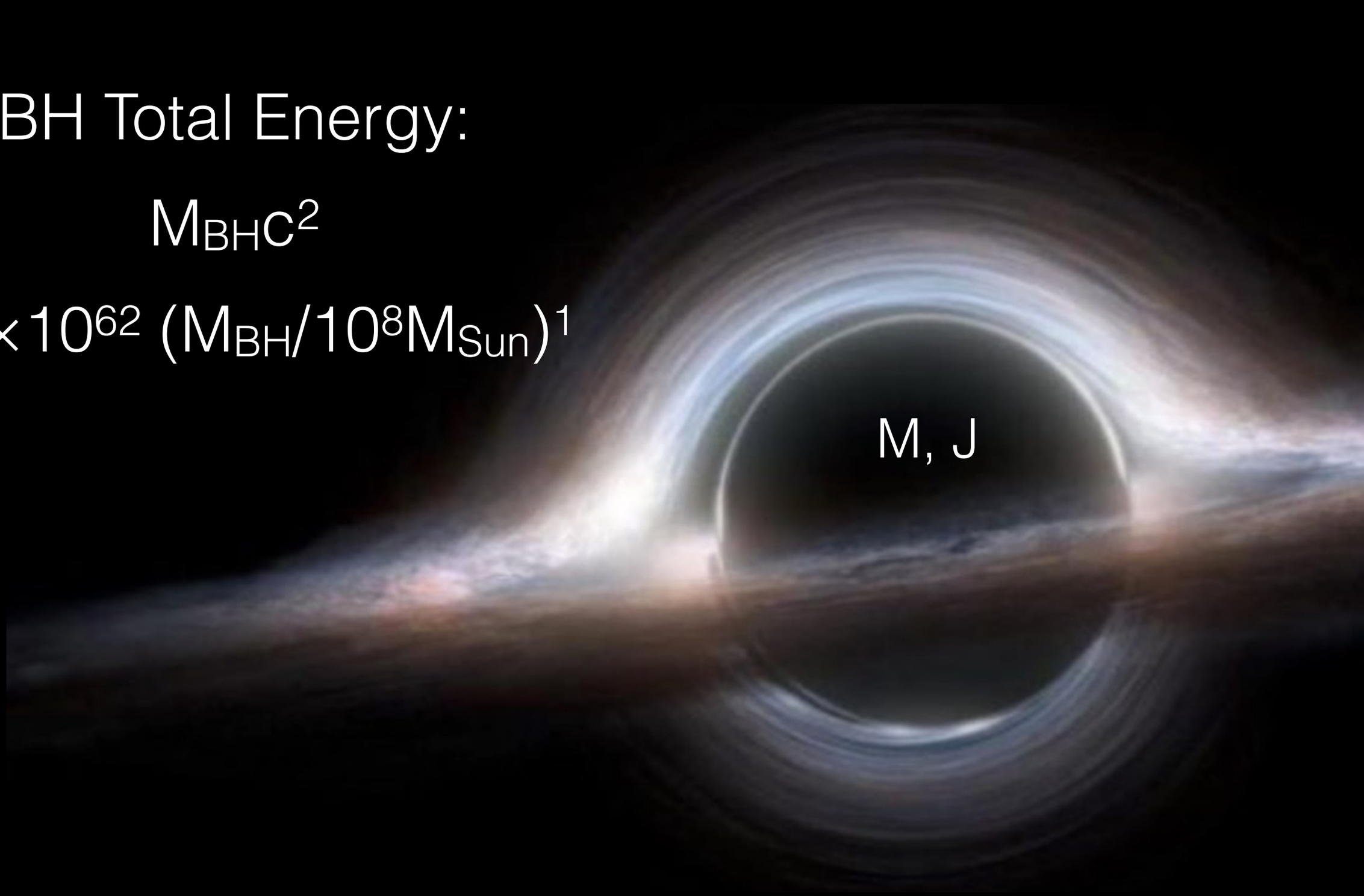
- General considerations
- Observation motivated AGN wind models


M, J

BH Total Energy:

$M_{BH}c^2$

$1.8\times10^{62}\ (M_{BH}/10^8 M_{Sun})^1$



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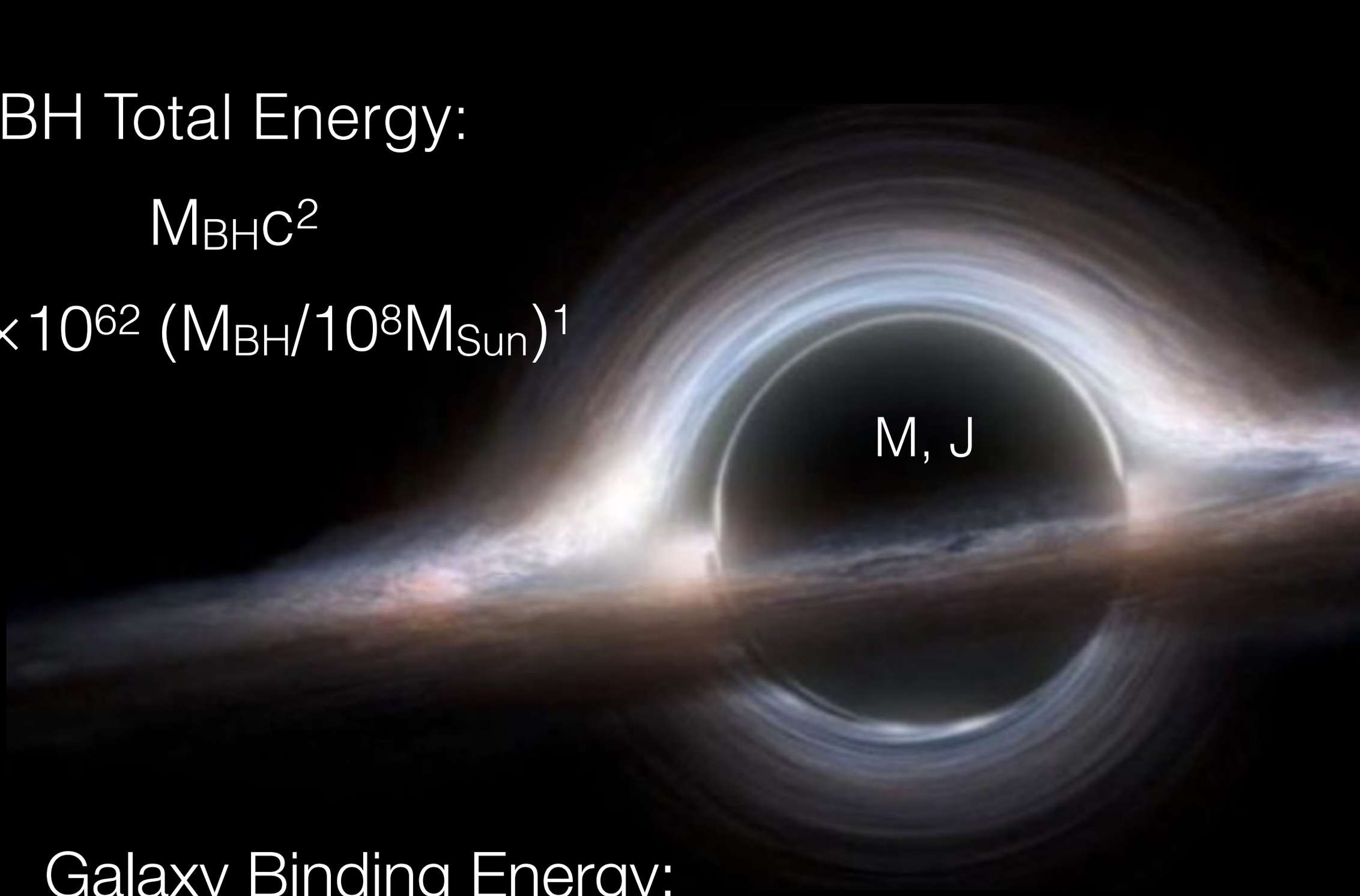

Galaxy Binding Energy:

$3/5\ GM_{Gal}^2/R$

$5.2\times10^{59}\ (M_{Gal}/10^{11}M_{Sun})^2\ (R/1kpc)^{-1}$

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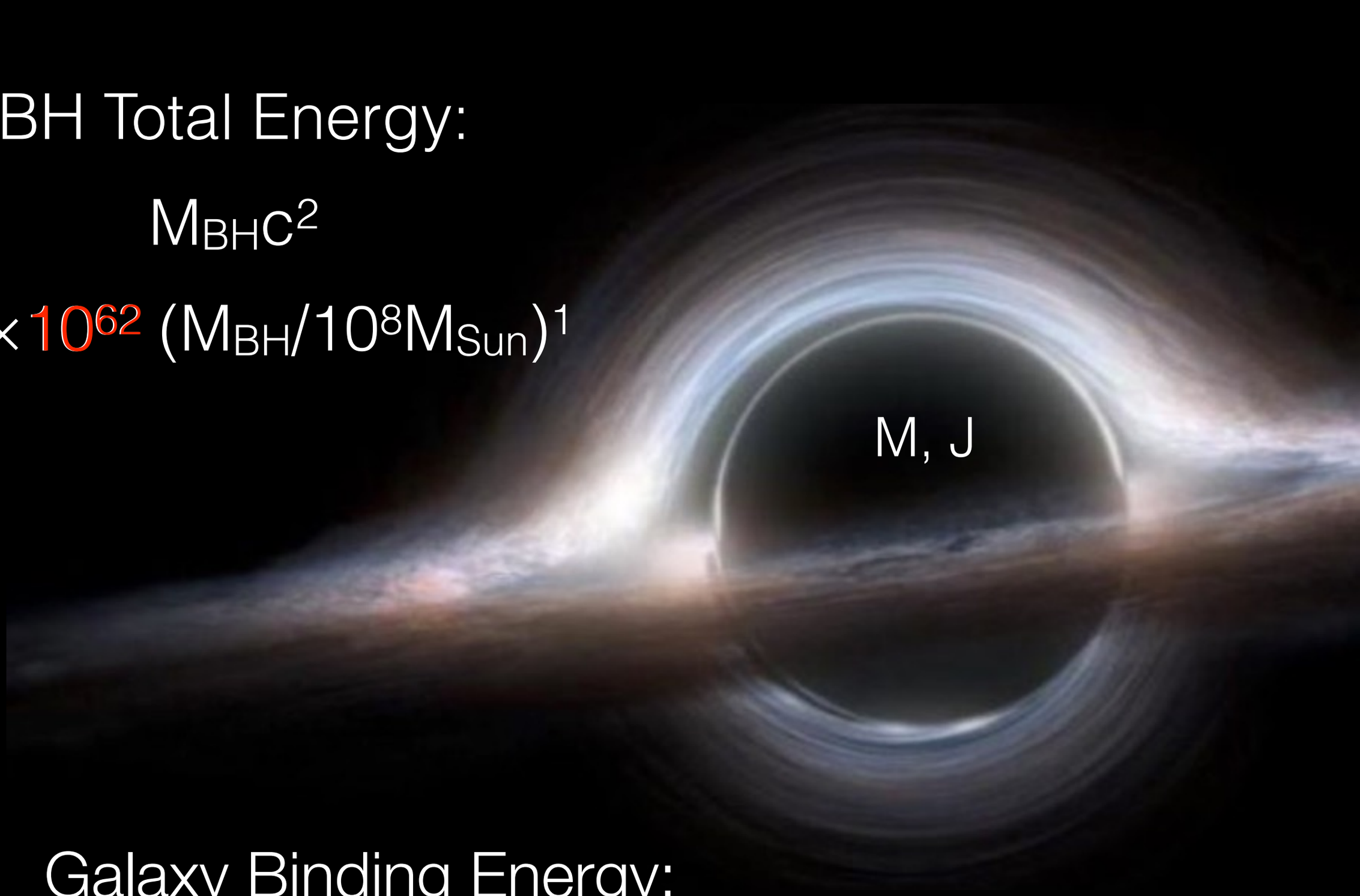

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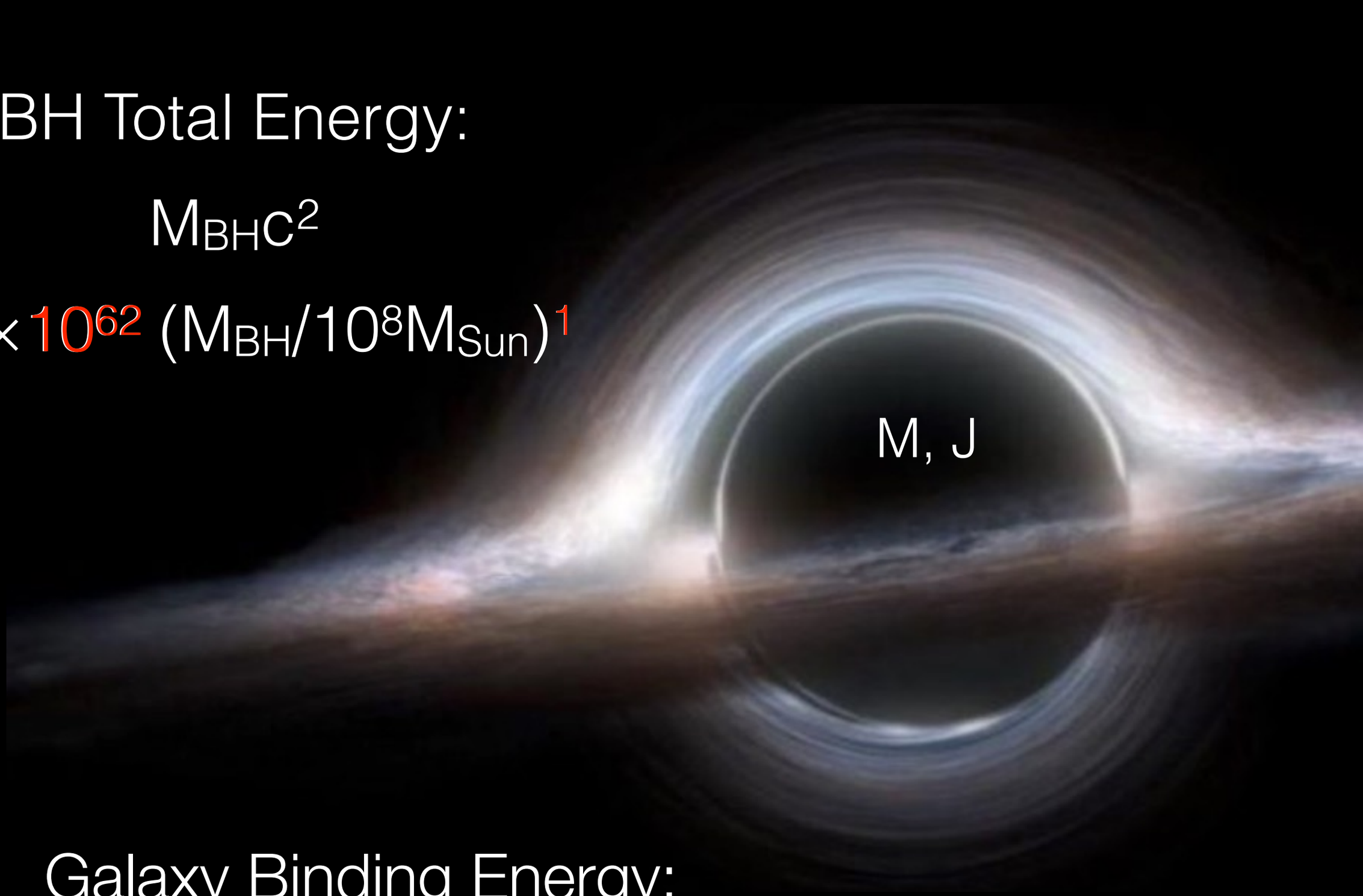

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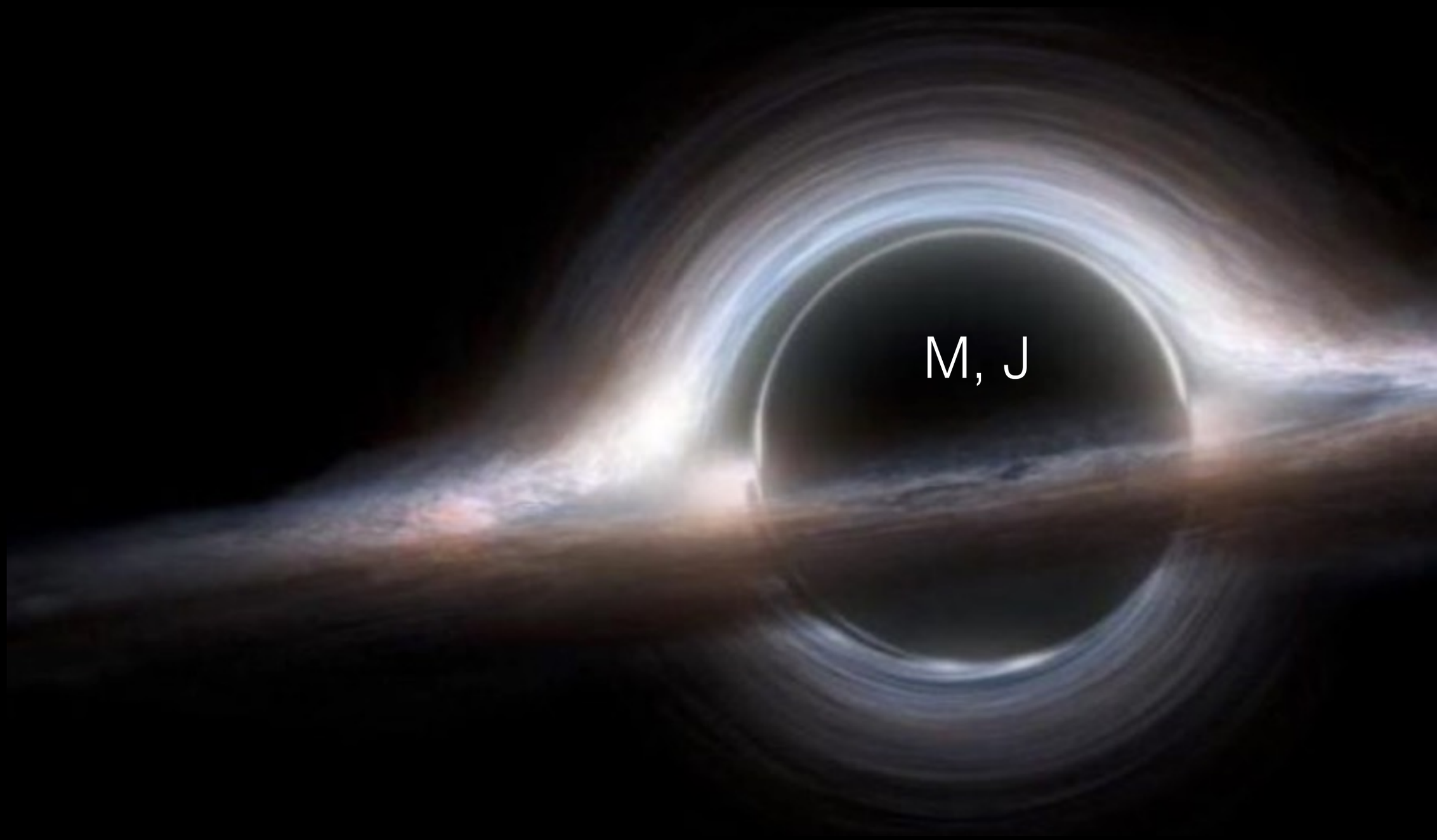
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$k_B A/4l_P^2$

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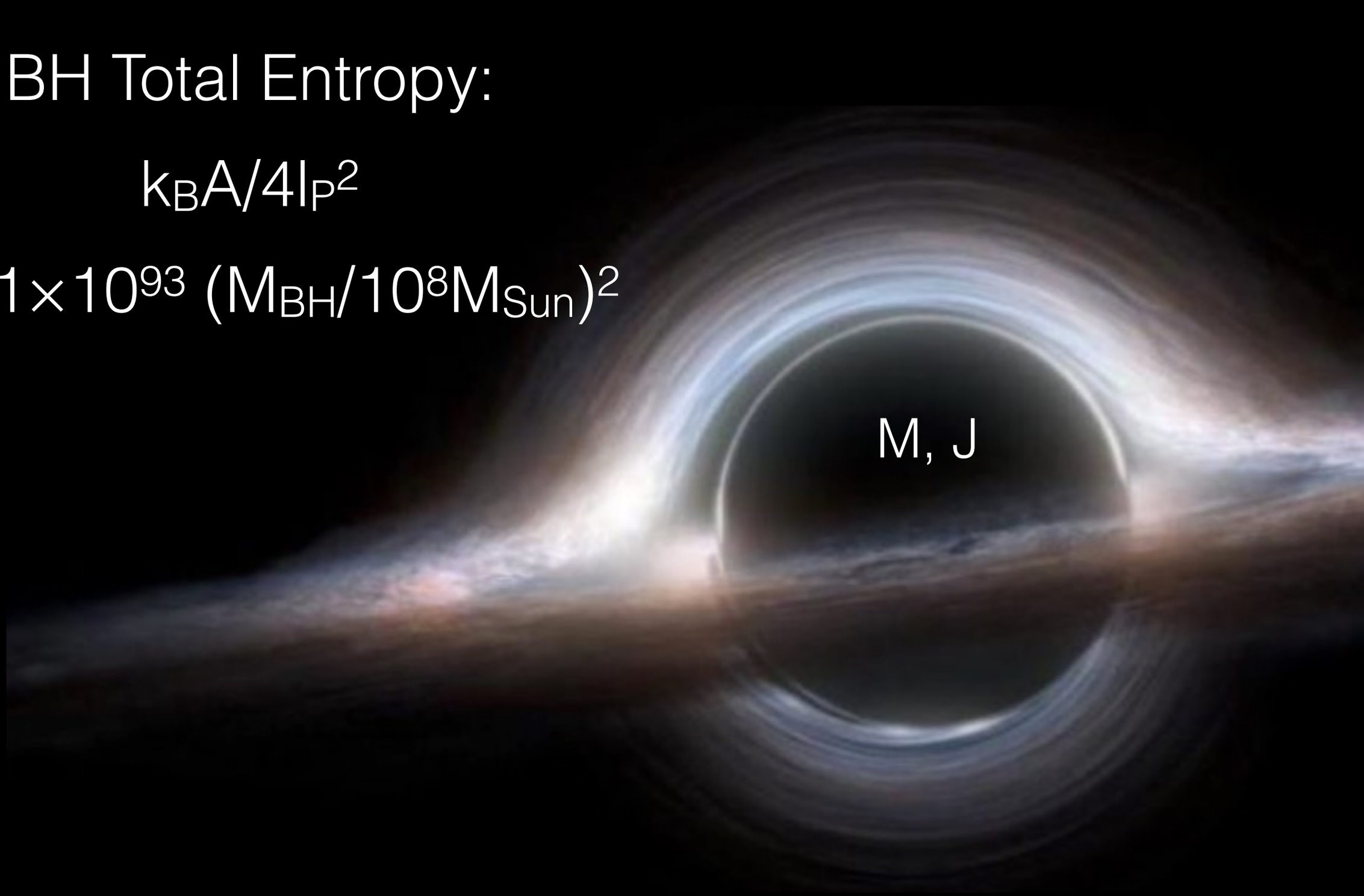

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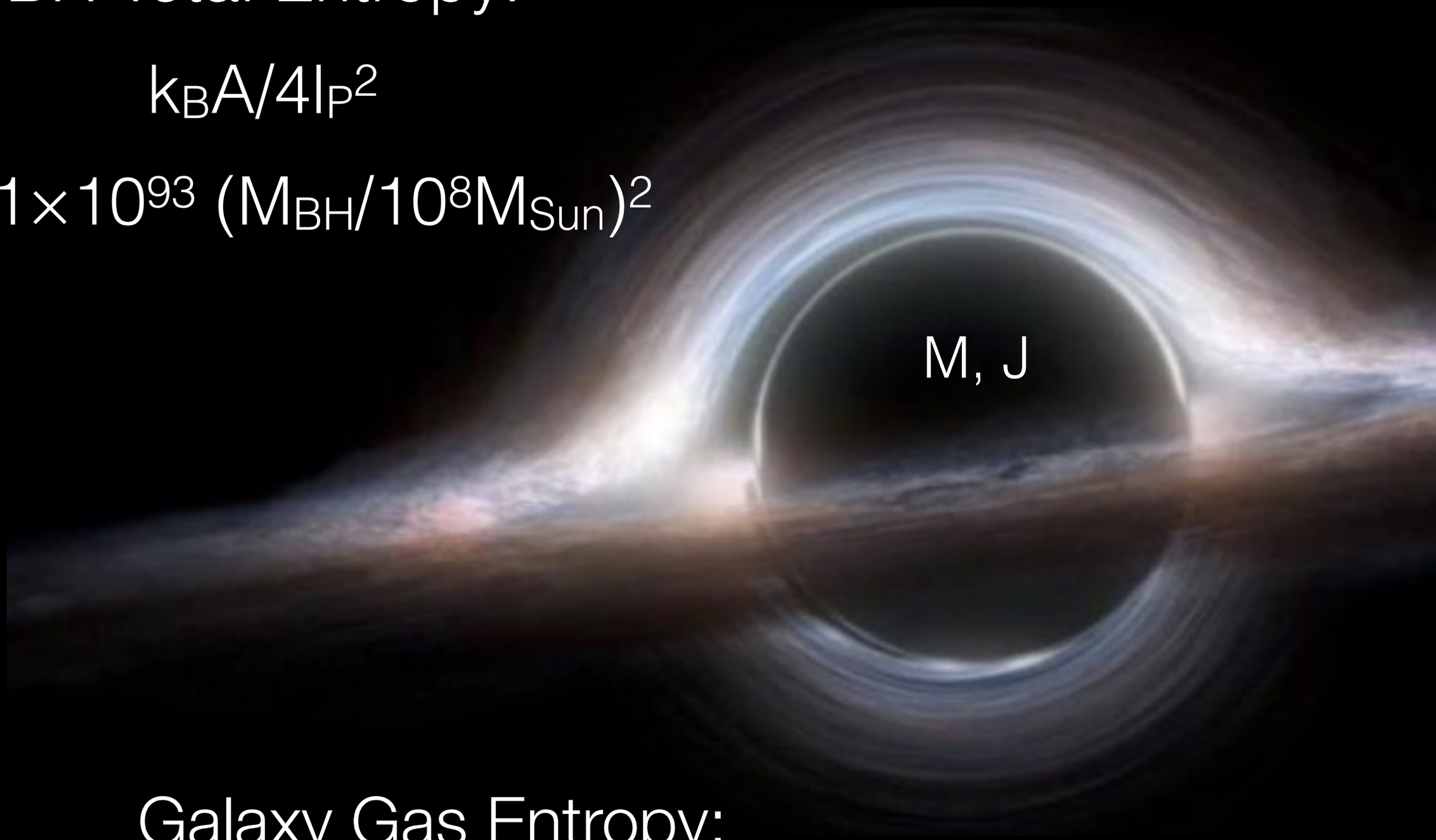

Galaxy Gas Entropy:

$k_B\ N\ \ln(K_B T/\mu m_p \rho^{2/3})^{3/2} \sim k_B\ N\ \ln(V+Vp)$

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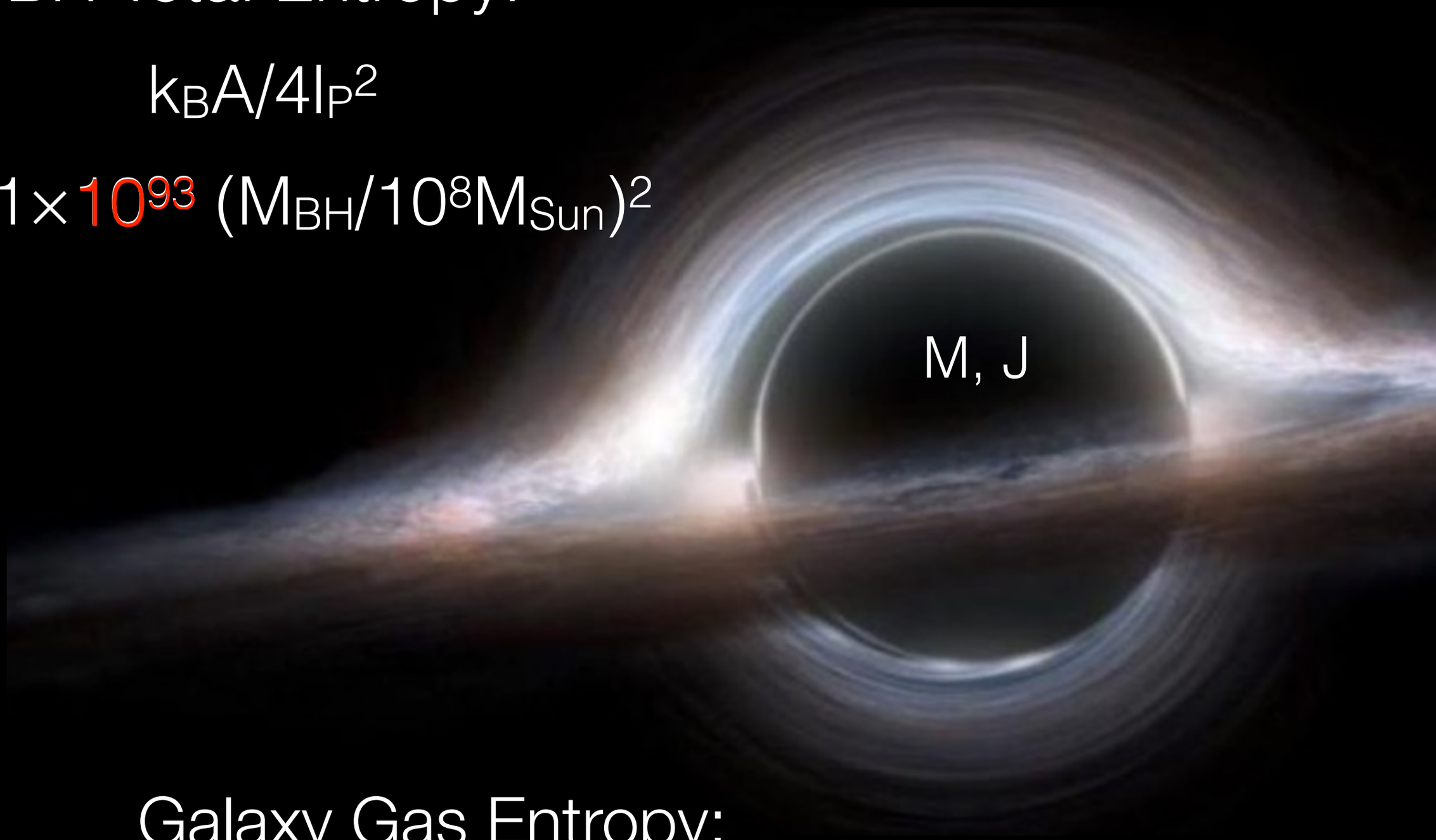

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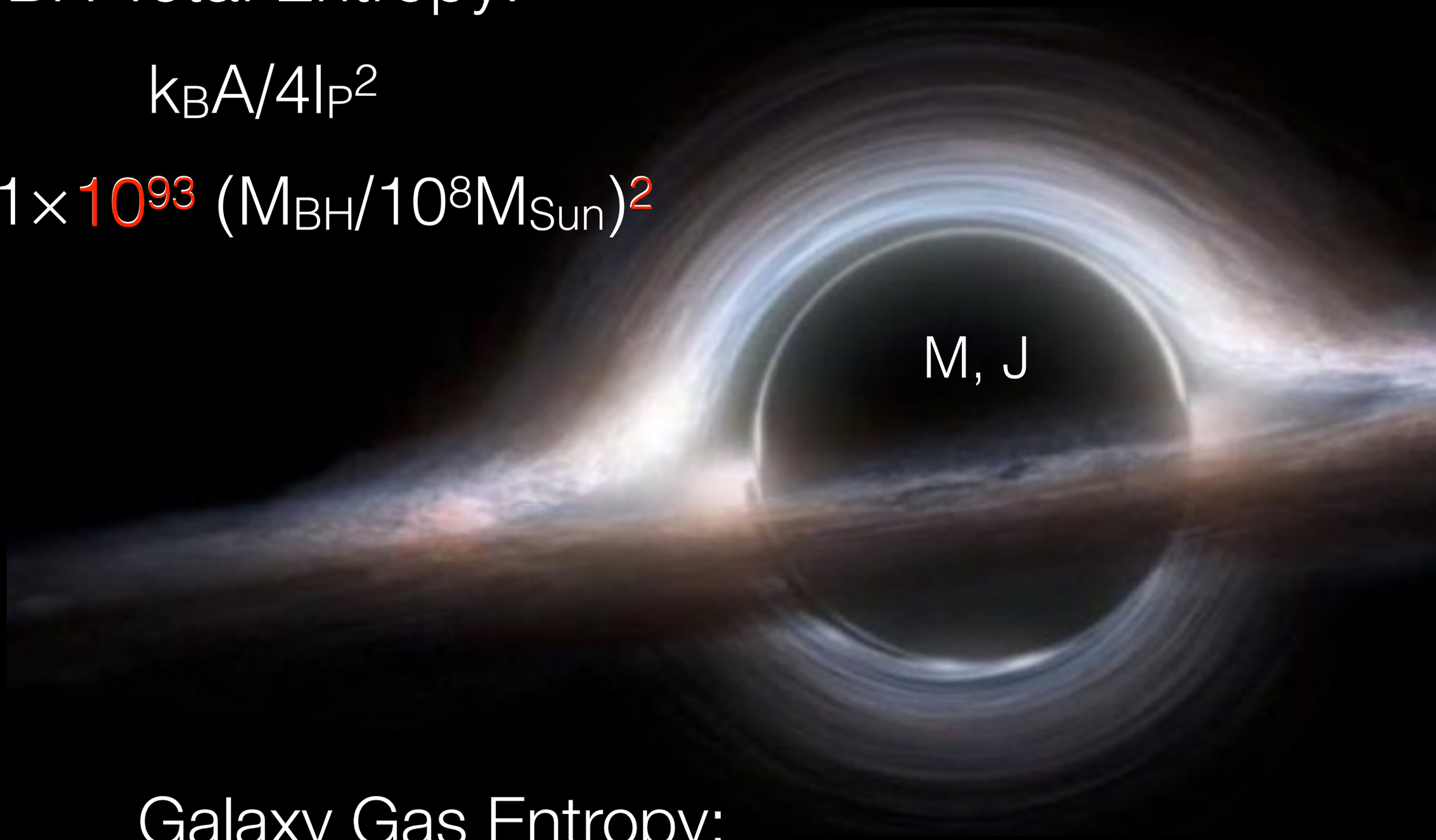

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Entropy is associated to irreversible processess on all scales:

- Gravitational clustering
- Star Formation
- Accretion disks
- Terrestrial weather
- Biological processes

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Processes occur if systems are *not* close to their maximum entropy

Gas collapse and star-formation

$E_{kin}=1/2mv^2=1/2p^2/m=3/2KT$

$p=(3mKT)^{1/2}$

$S=\log(V \times V_p)^N=N(\log(V)+\log(V_p))$

$V_p=4/3(3mKT)^{3/2}$

$S=N(\log(V)+3/2\lg(T))+const$

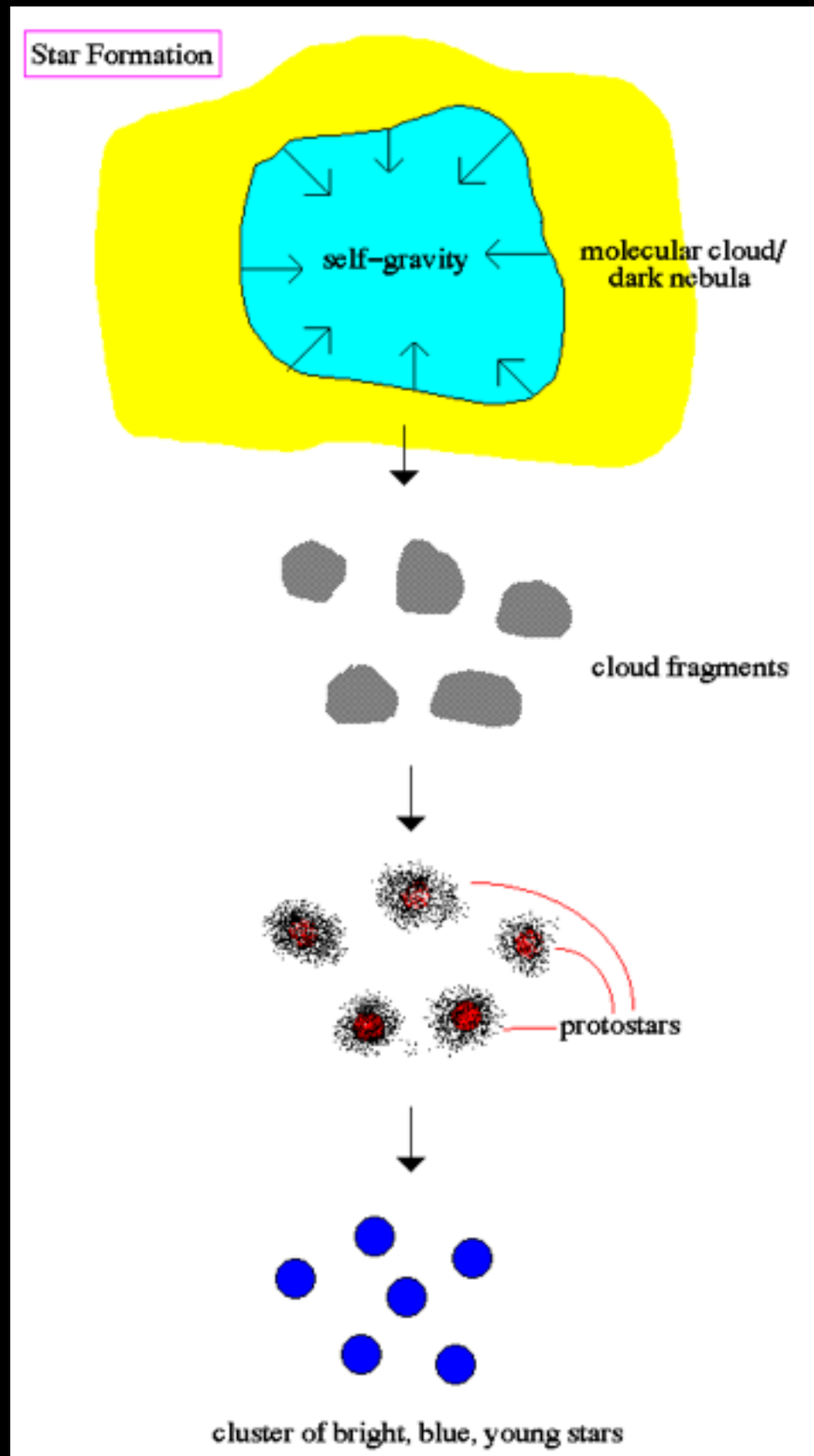
Gas collapse from R~10^{18} to 10^{11} cm

V ↓ 10^{21} factor

T ↑ from tens to thousands K

V_p ↑ by ~$100^{3/2}$ -> S ↓

To collapse a cloud must efficiently radiate the heat generated by the collapse, carring out entropy



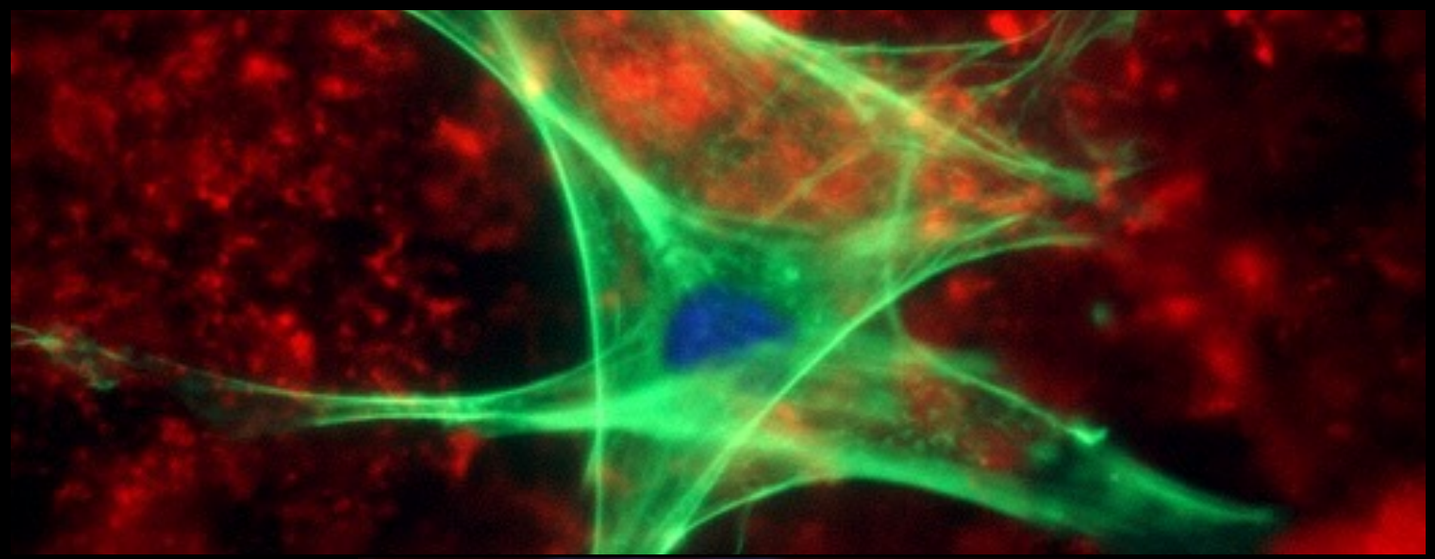
A change in perspective

A change in perspective

Universe island →

A change in perspective

Universe island → Bio cells



Organisms exchanging matter, energy and entropy with the environment throughout a network of interactions:

The life cycle of galaxies

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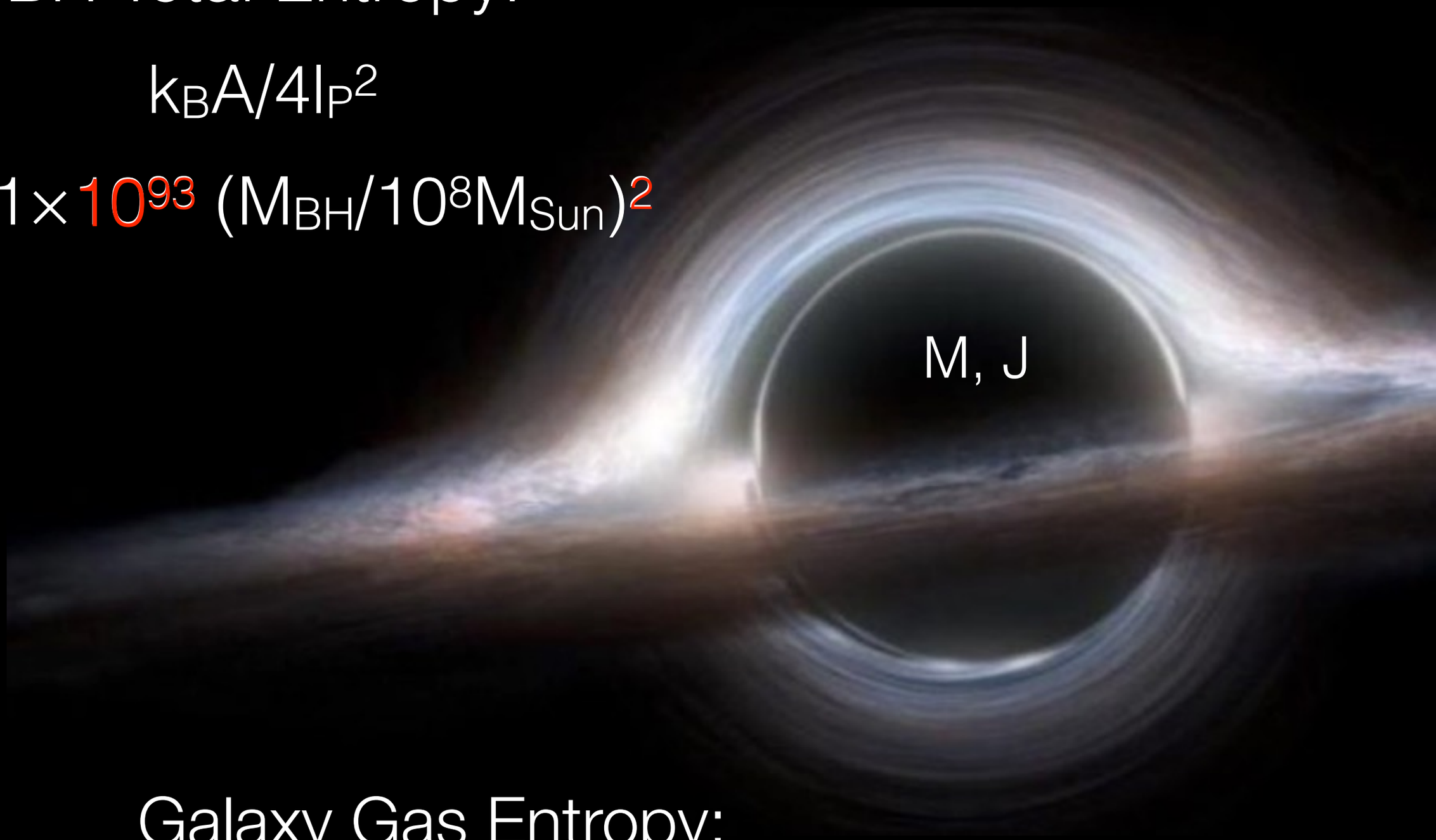

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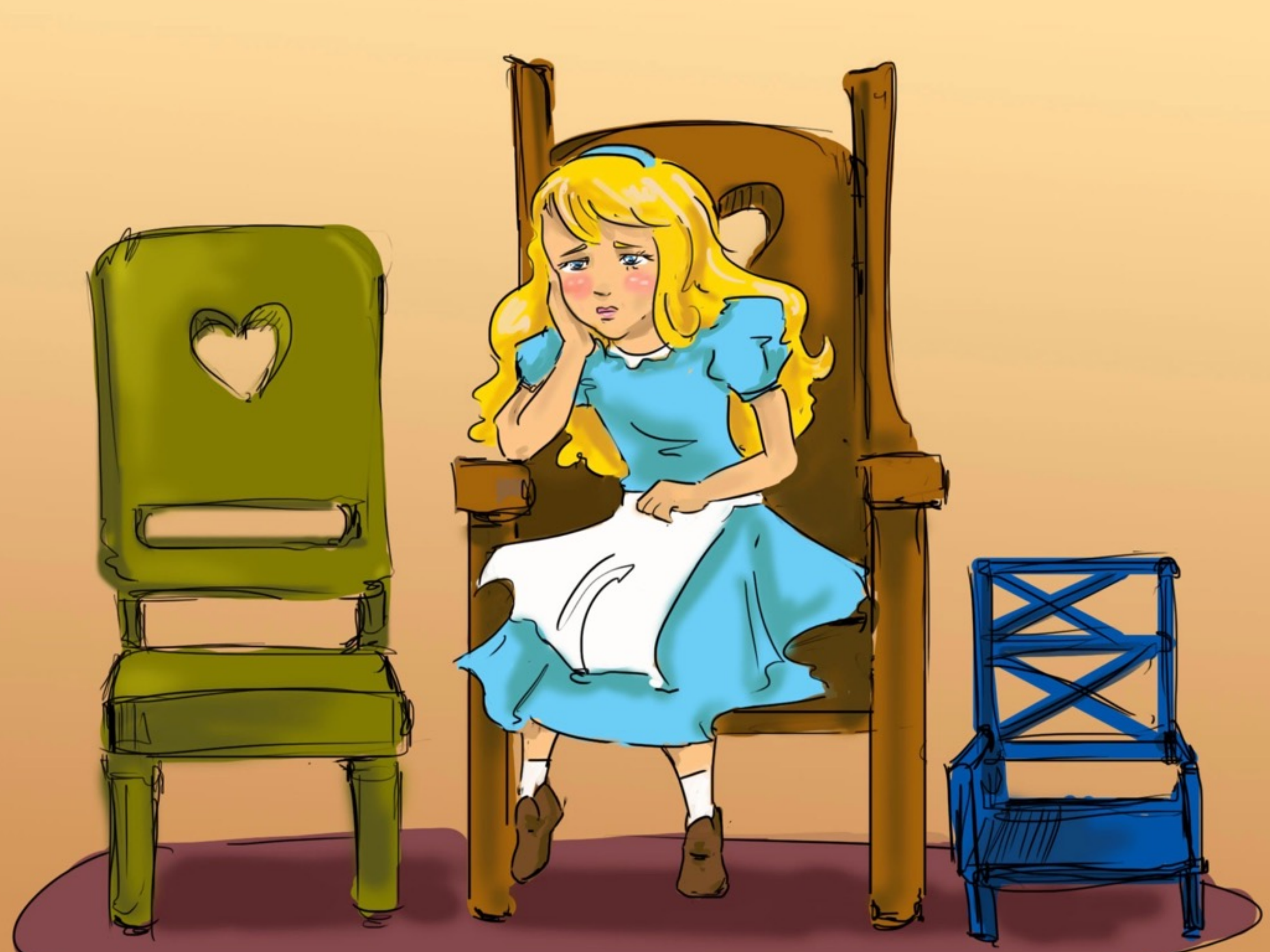
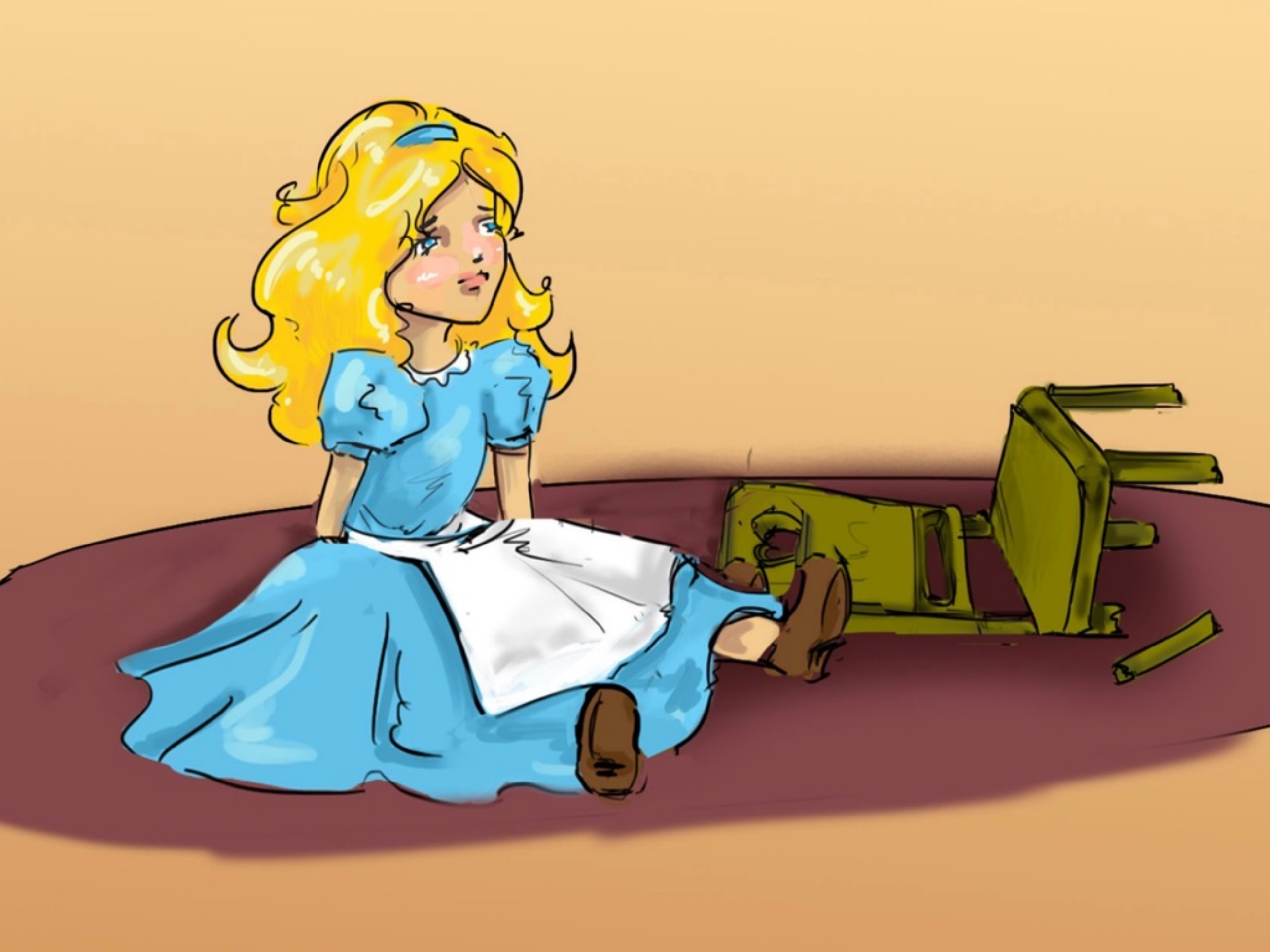
A Goldilocks problem?

or

autoregulation?

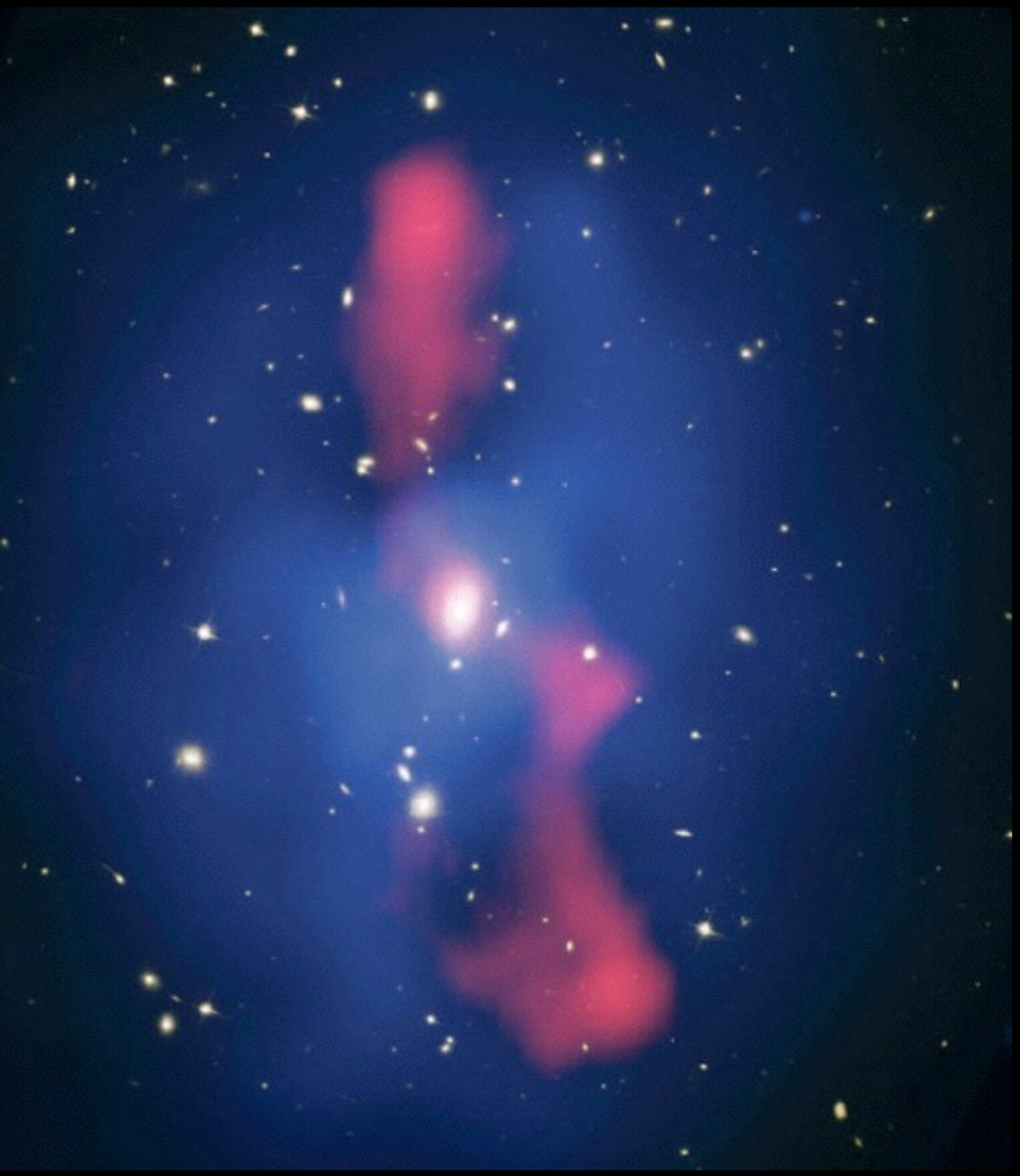
Goldilocks and the three bears





Autoregulation

Radio-mode feedback



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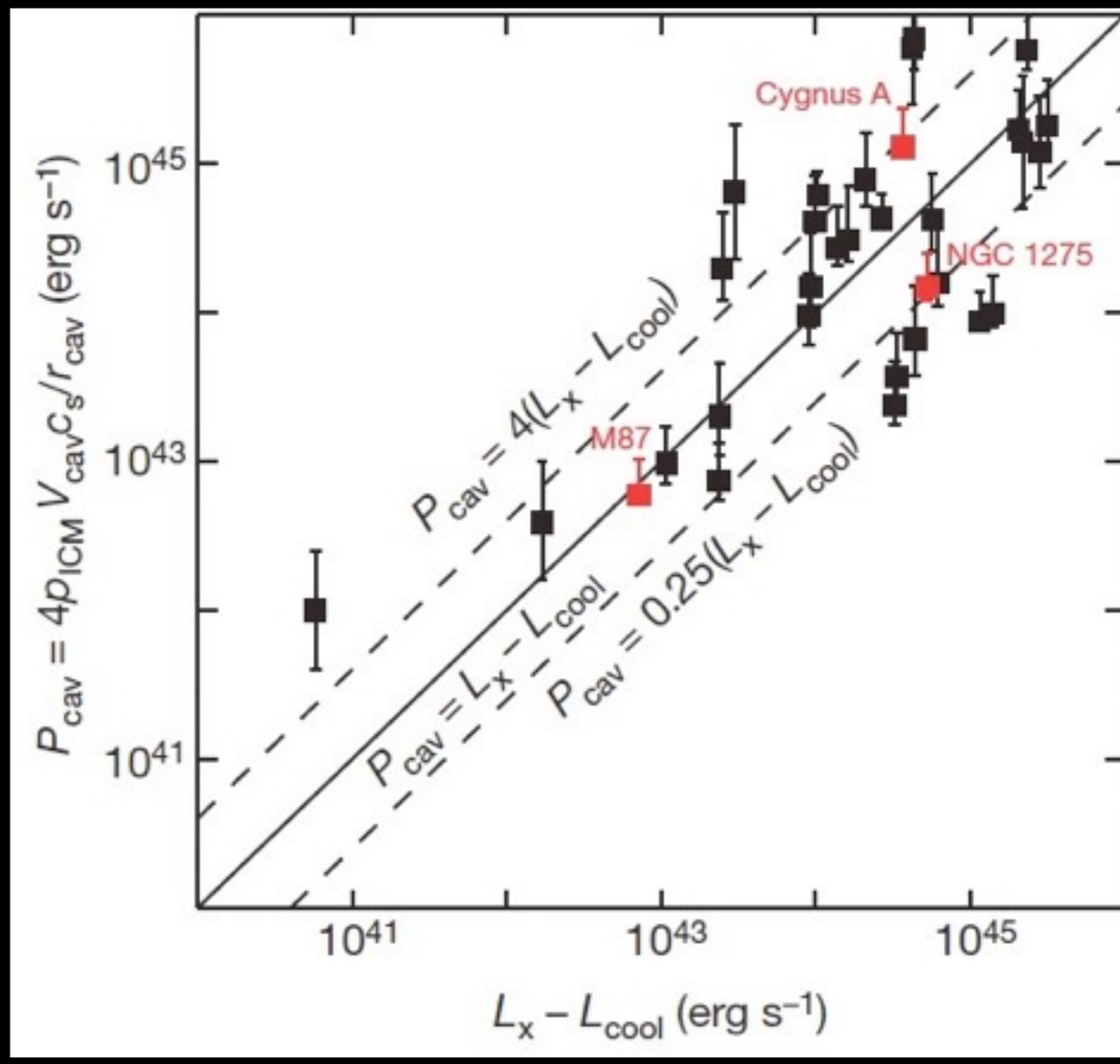

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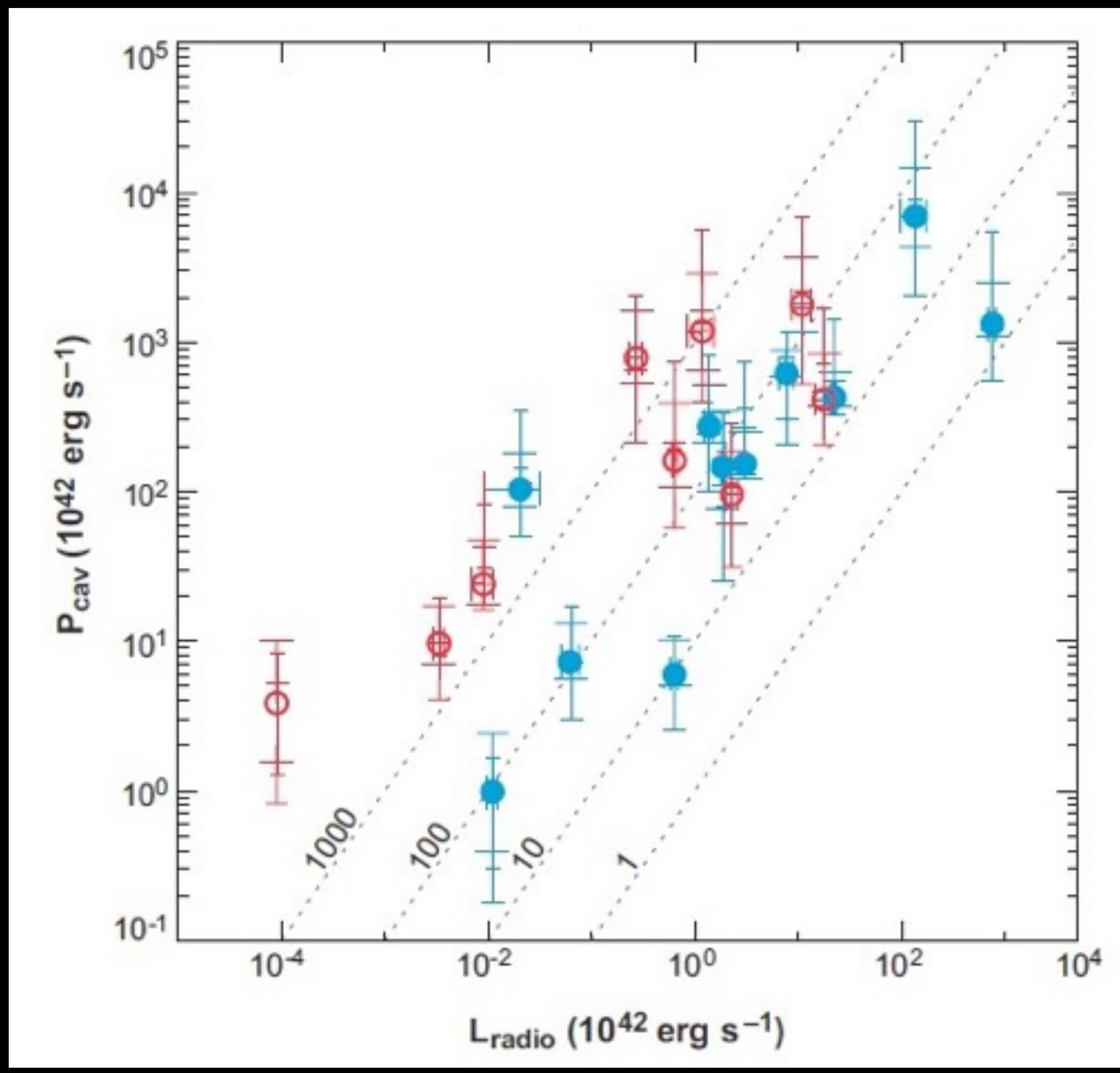
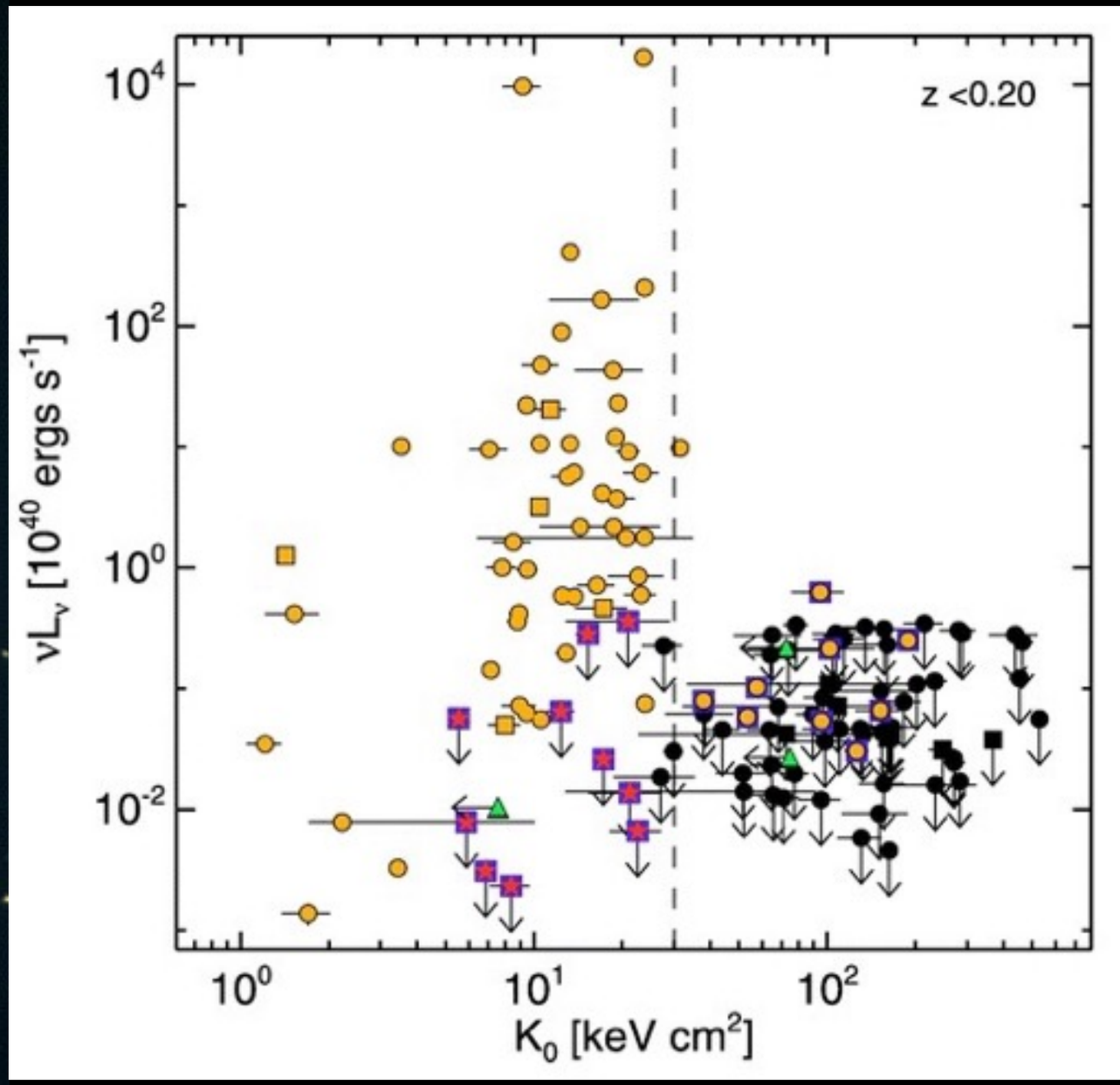


Radio-mode feedback

Power to excavate cavities ∝ L_X

Power in cavities ∝ L_R

AGN only in BCGs with *low inner entropy:* **cold accretion**



Radio-mode feedback

Power to excavate cavities ∝ L_X

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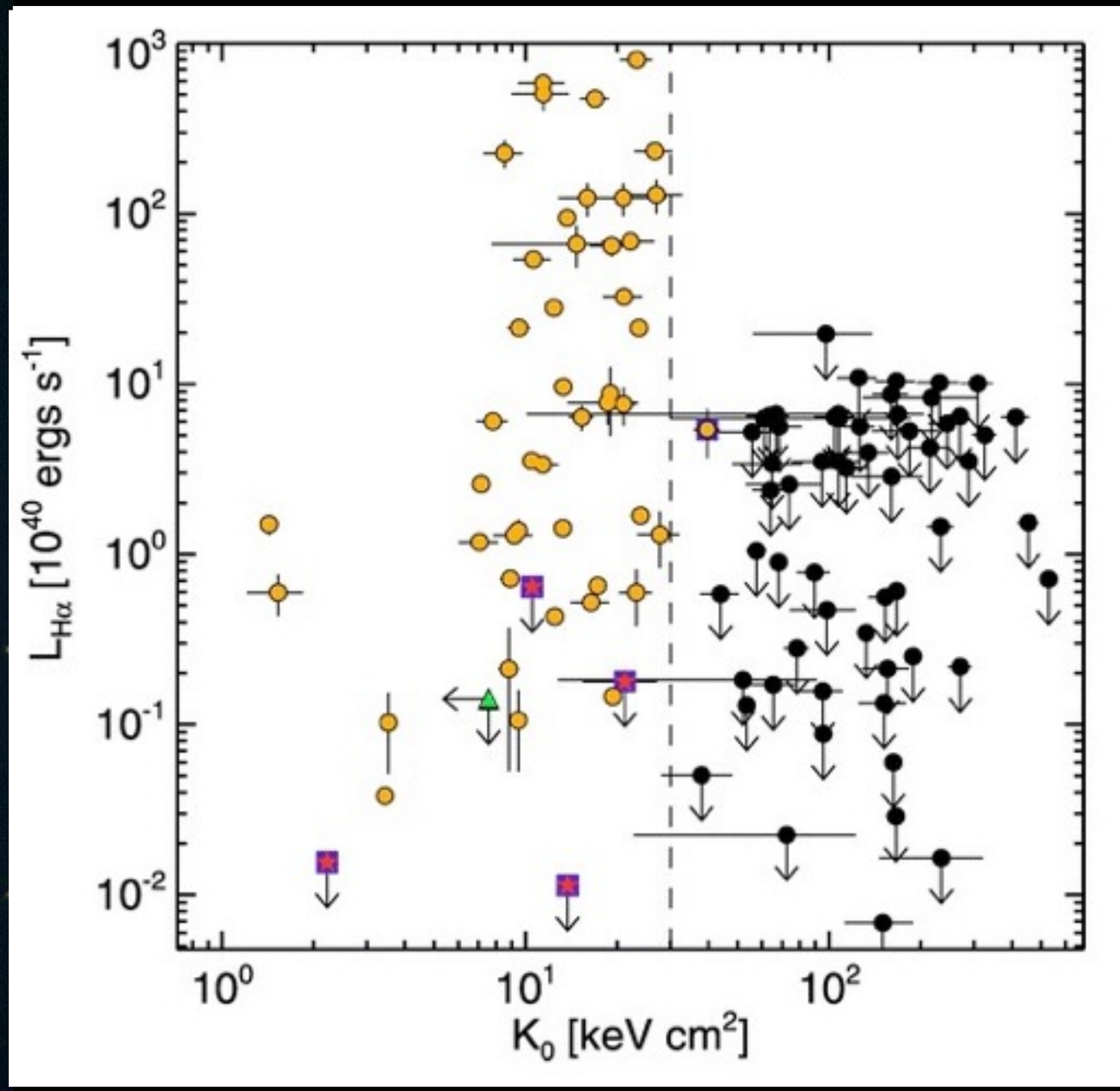
AGN only in BCGs with *low inner entropy:* **cold accretion**

BCGs with low inner entropy & AGN are **forming stars**

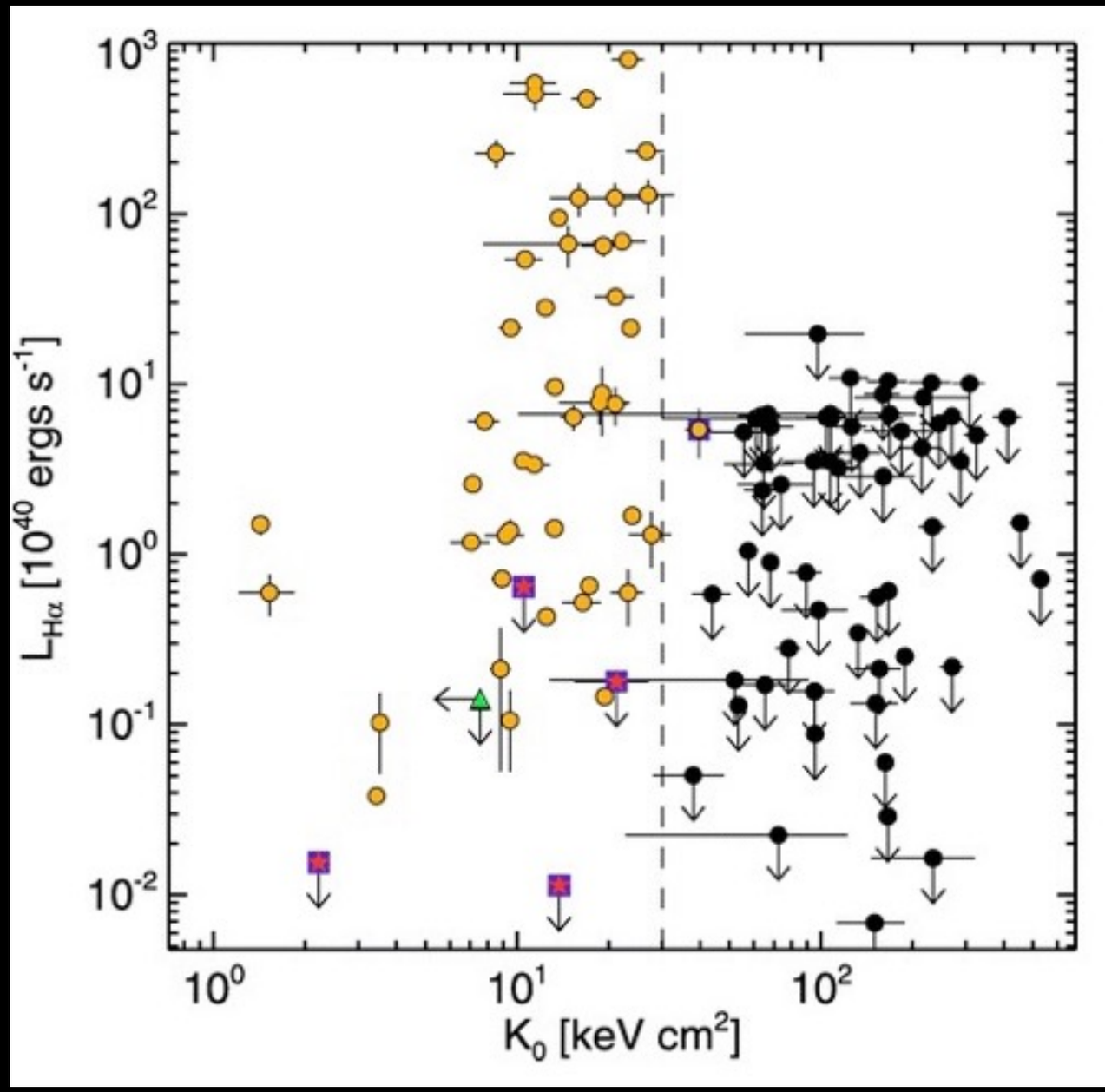


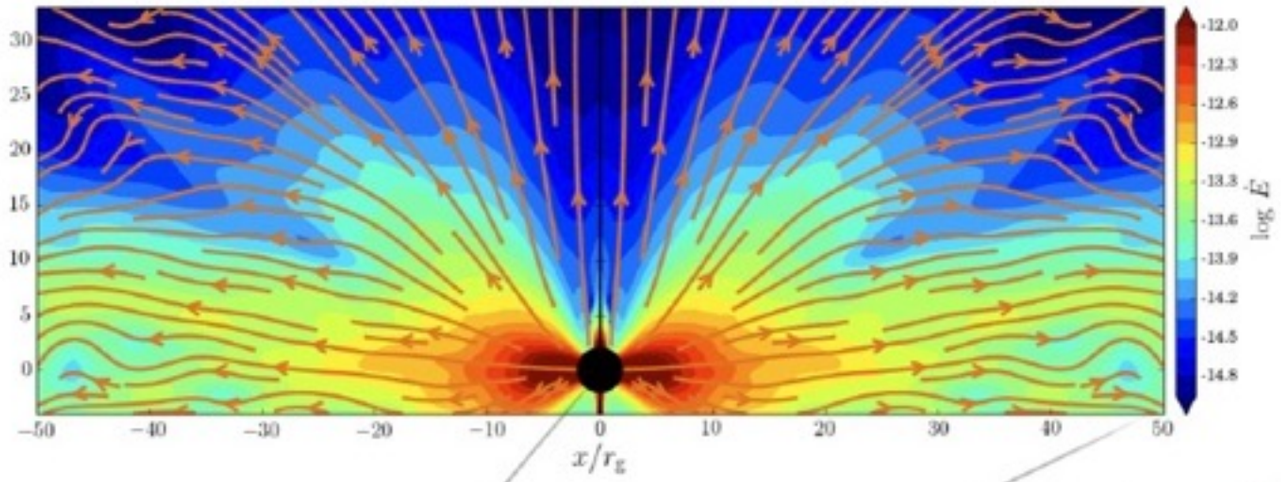
Radio-mode feedback

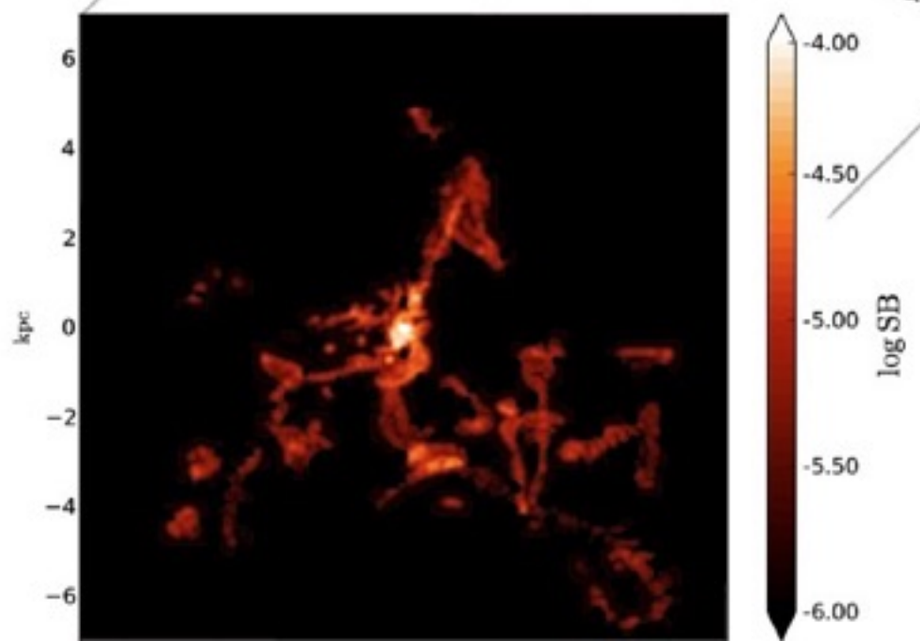
A delicate feedback mechanism:

"*AGN input energy regulates the gas entropy and, in turn, further gas accretion and SF (stars can form from low entropy, cold and dense gas only).*"

Voit & Donahue 2014







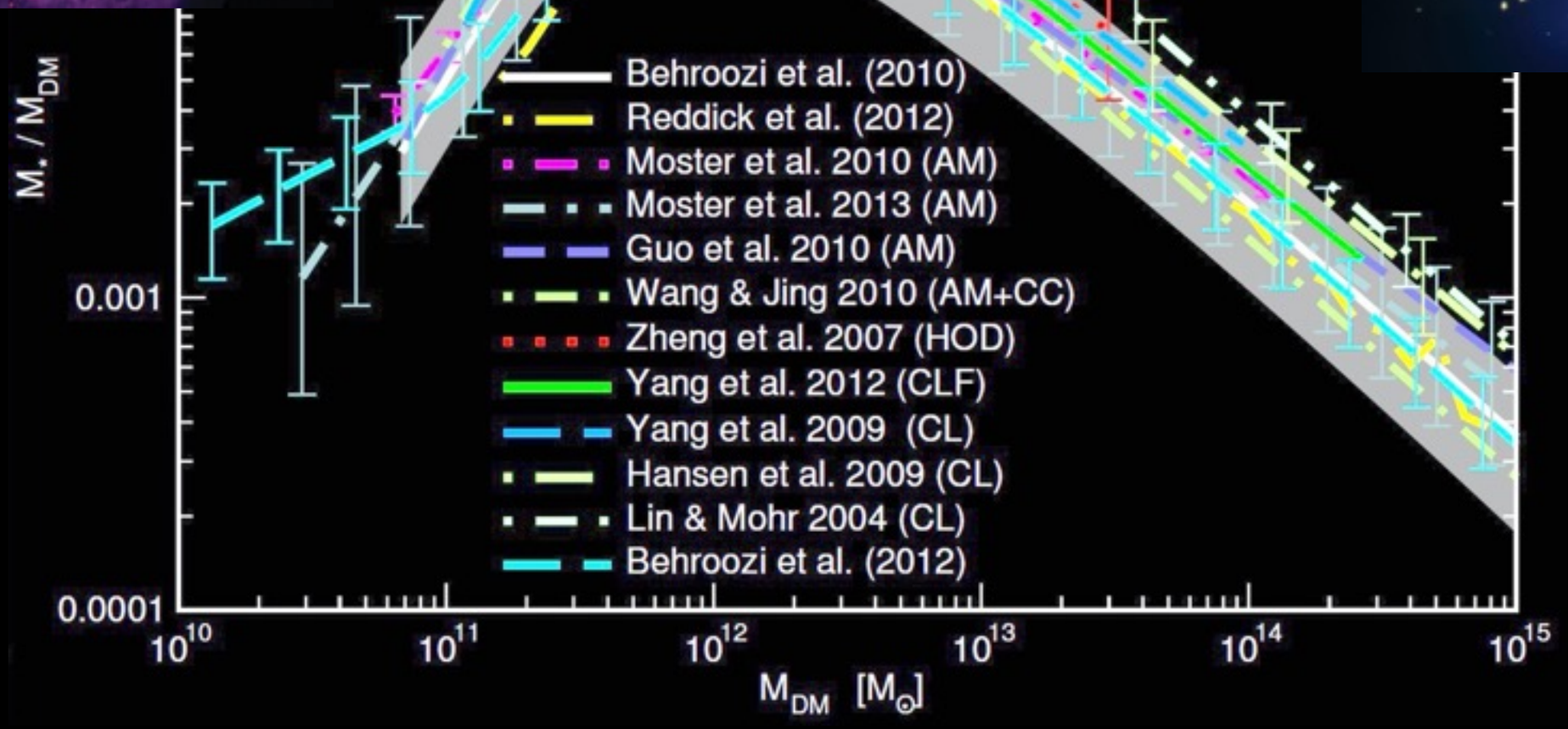
Caotic Cold Accretion

Gaspari+2013-2017

Precipitation

Voit+2014-2018

Baryon cooling highly inefficient



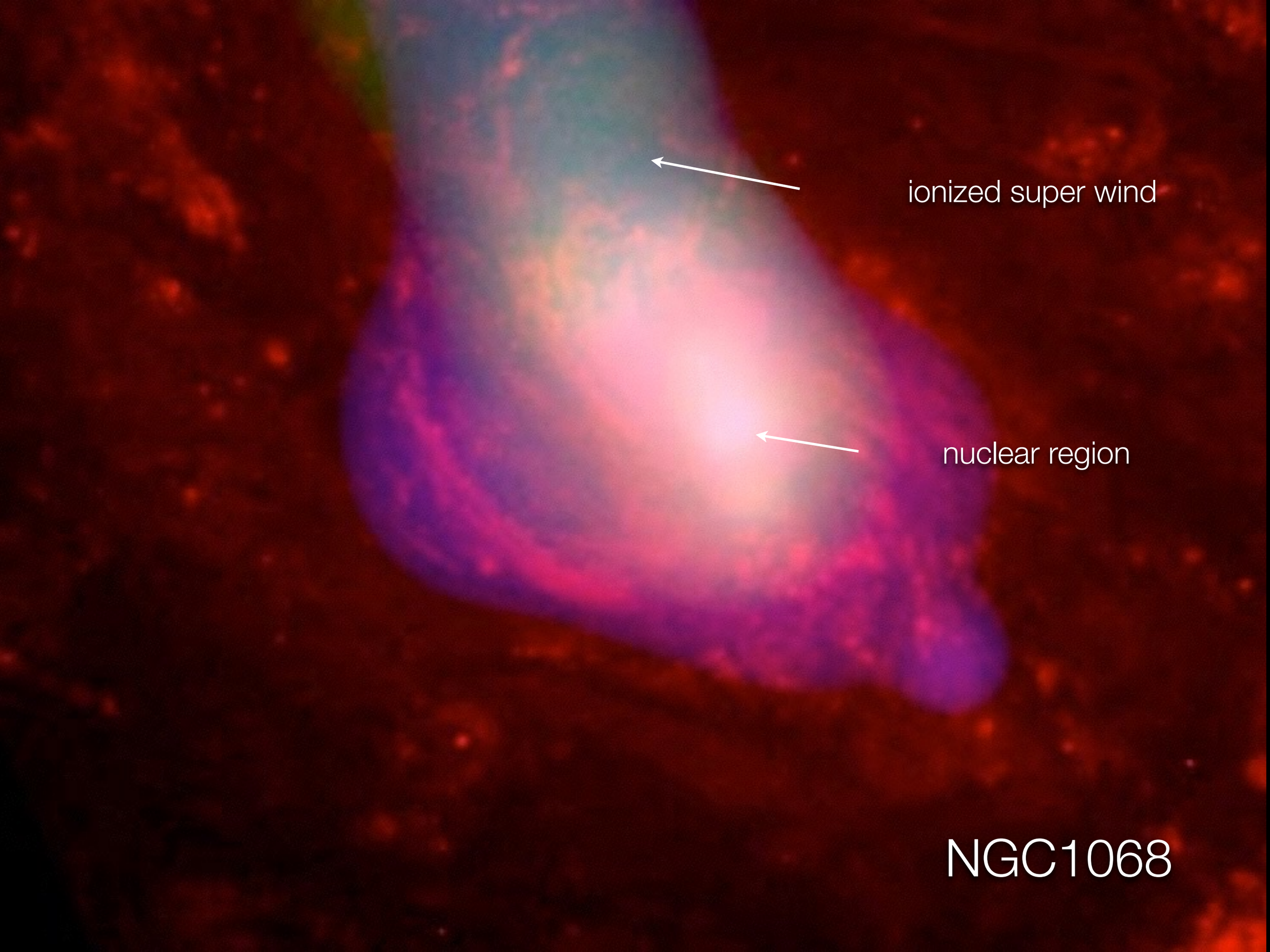
Kormendy & Ho 2013

??? = AGN winds?

Alternatives

- AGN winds/radiation
- Heating through cosmological accretion (Birnboim & Dekel 2006)
- Starvation (Peng & Maiolino 2015)
- Mass/gravitational quenching (Genzel+2014)
- …

AGN winds are ubiquitous


ionized super wind
nuclear region
NGC1068

X-ray winds,
semirelativistic

Ionized gas winds,
v~0.003-0.03 km/s

Atomic gas winds
v~100-1000 km/s

Molecular winds
v~100-2000 km/s

ionized super wind

nuclear region

NGC1068

X-ray winds,
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Ionized gas winds,
v~0.003-0.03 km/s

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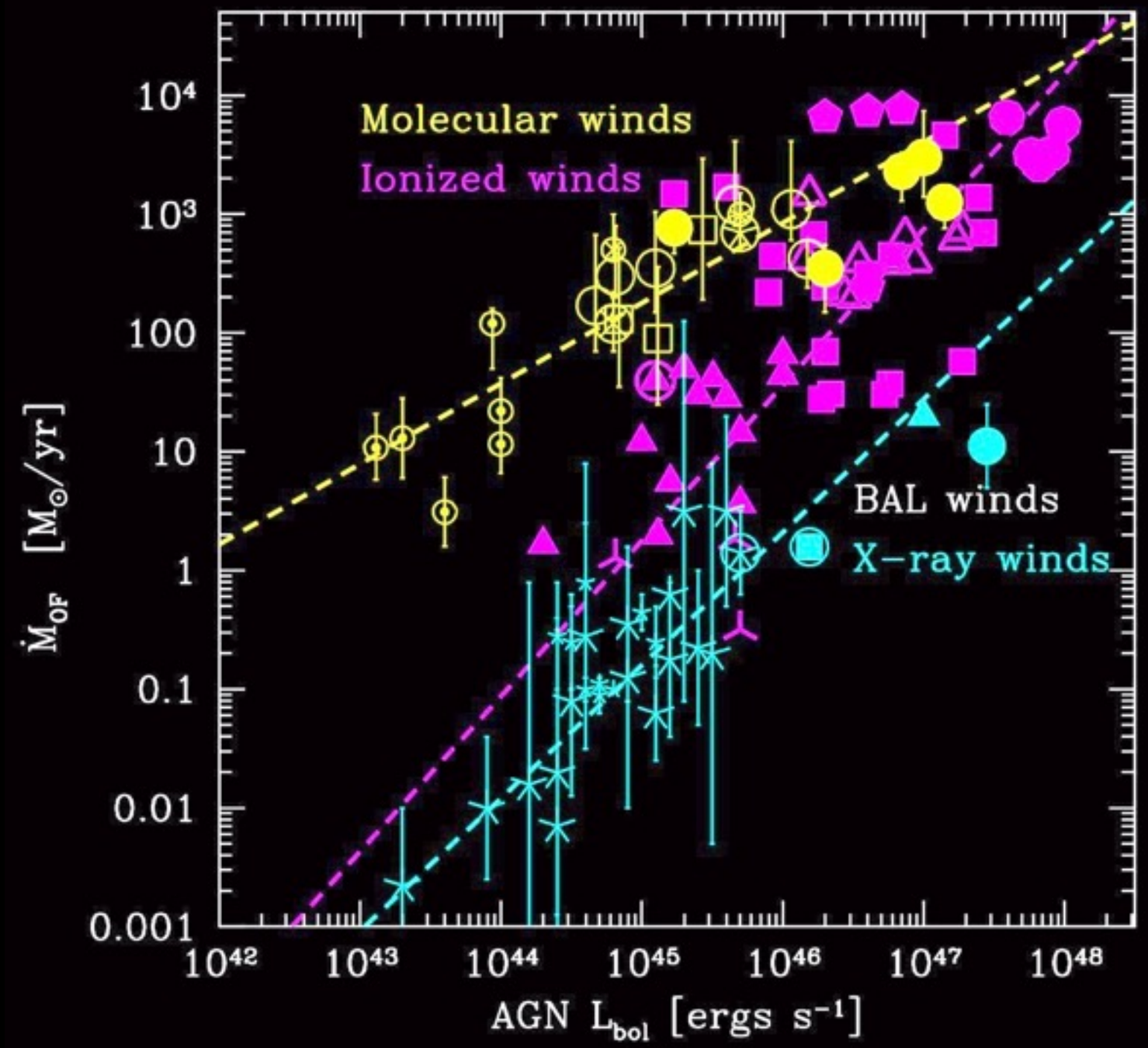
All carry significant amount of AGN L_{bol} ie~a few%

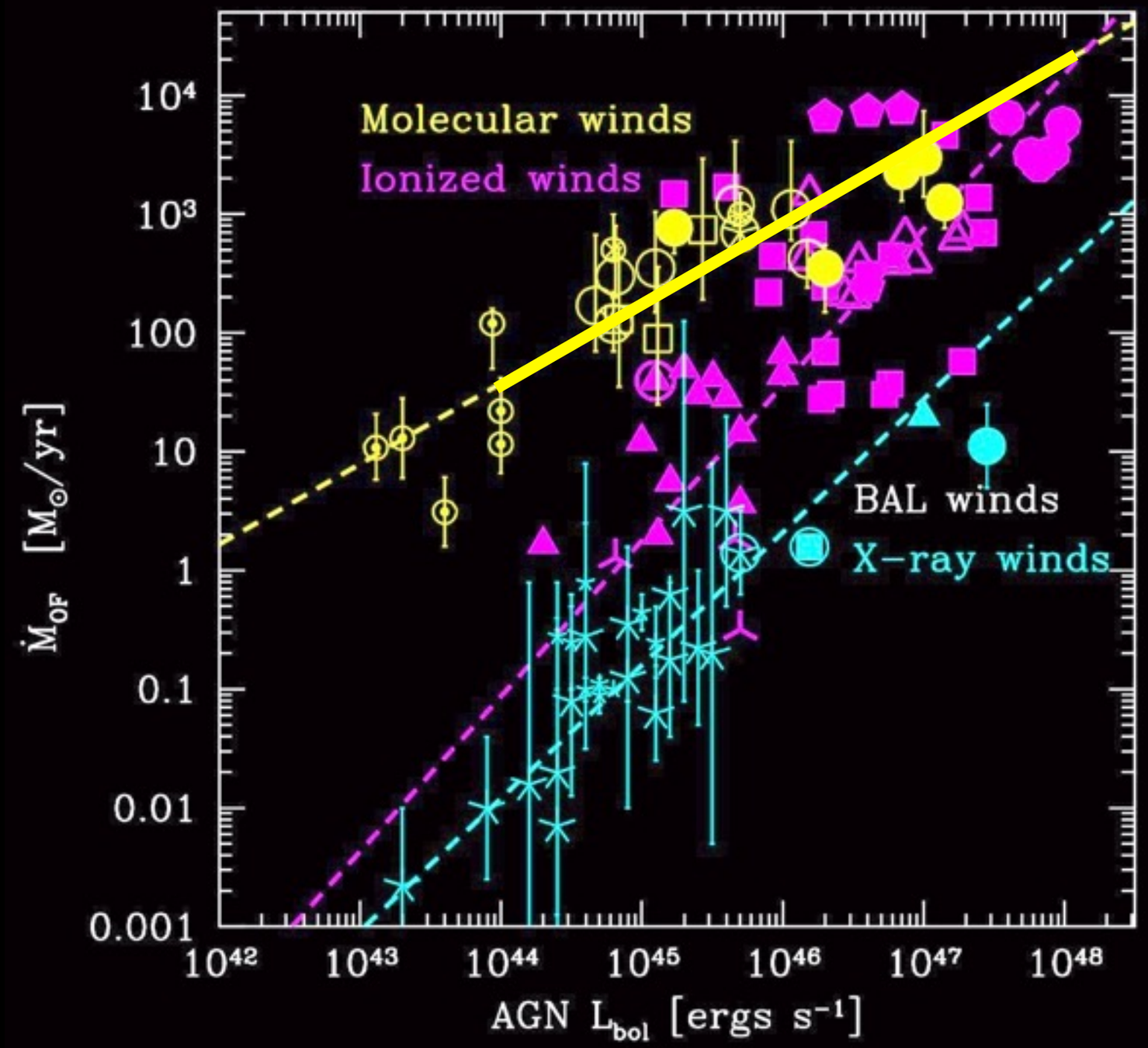
NGC1068

Large Mass outflow rates



Large Mass outflow rates

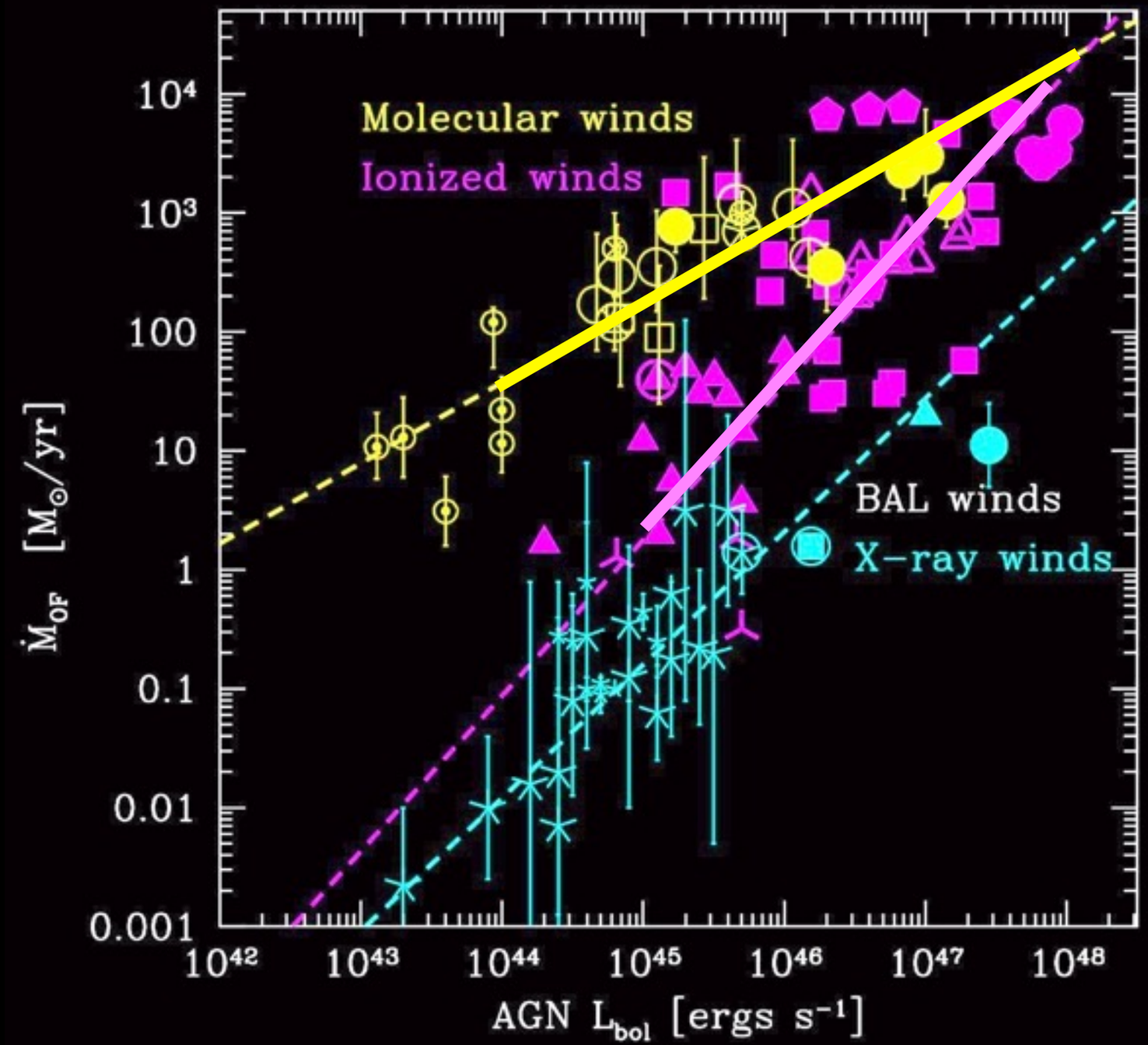
Molecular
$dM_{OF}/dt \sim L_{bol}^{0.66}$



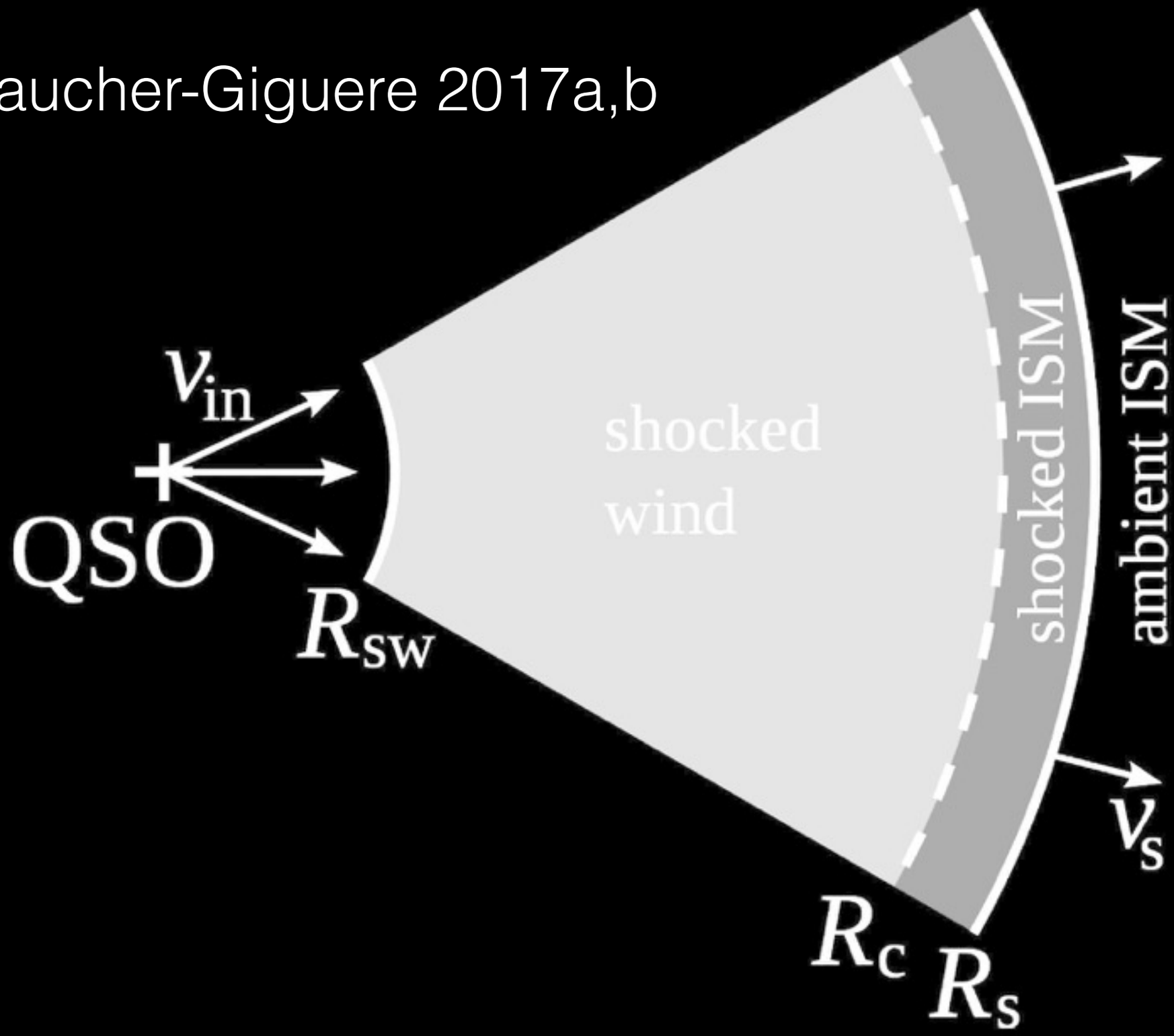
Large Mass outflow rates

Molecular
$dM_{OF}/dt \sim L_{bol}^{0.66}$

Ionized
$dM_{OF}/dt \sim L_{bol}^{1.3}$



Richings & Faucher-Giguere 2017a,b



Molecular outflows -> molecular reformation after shock passage

AGN wind models

Menci, FF, CF+ 2018

AGN wind models

Follow the approach of Richings & F-G 2017

Menci, FF, CF+ 2018

AGN wind models

Follow the approach of Richings & F-G 2017
Adopt an exponential density profile

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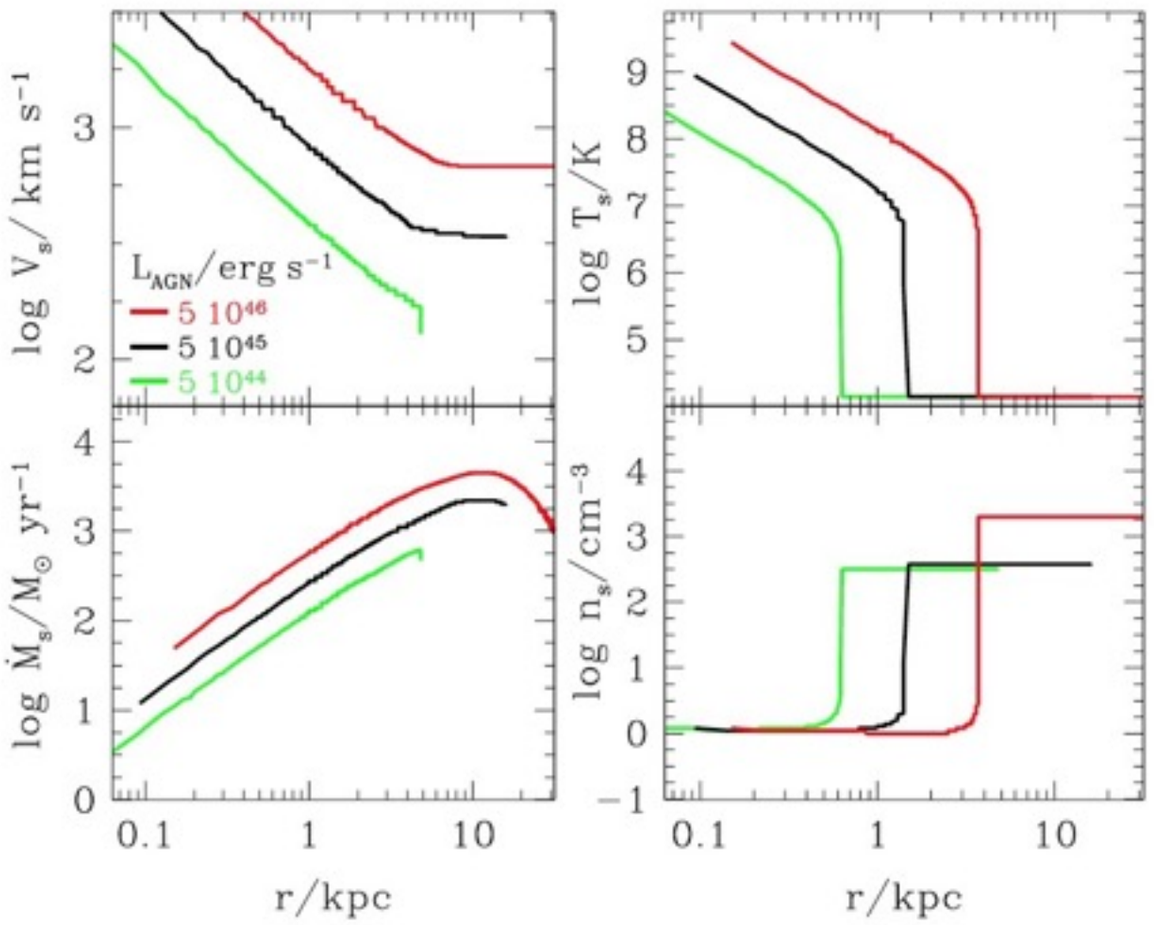

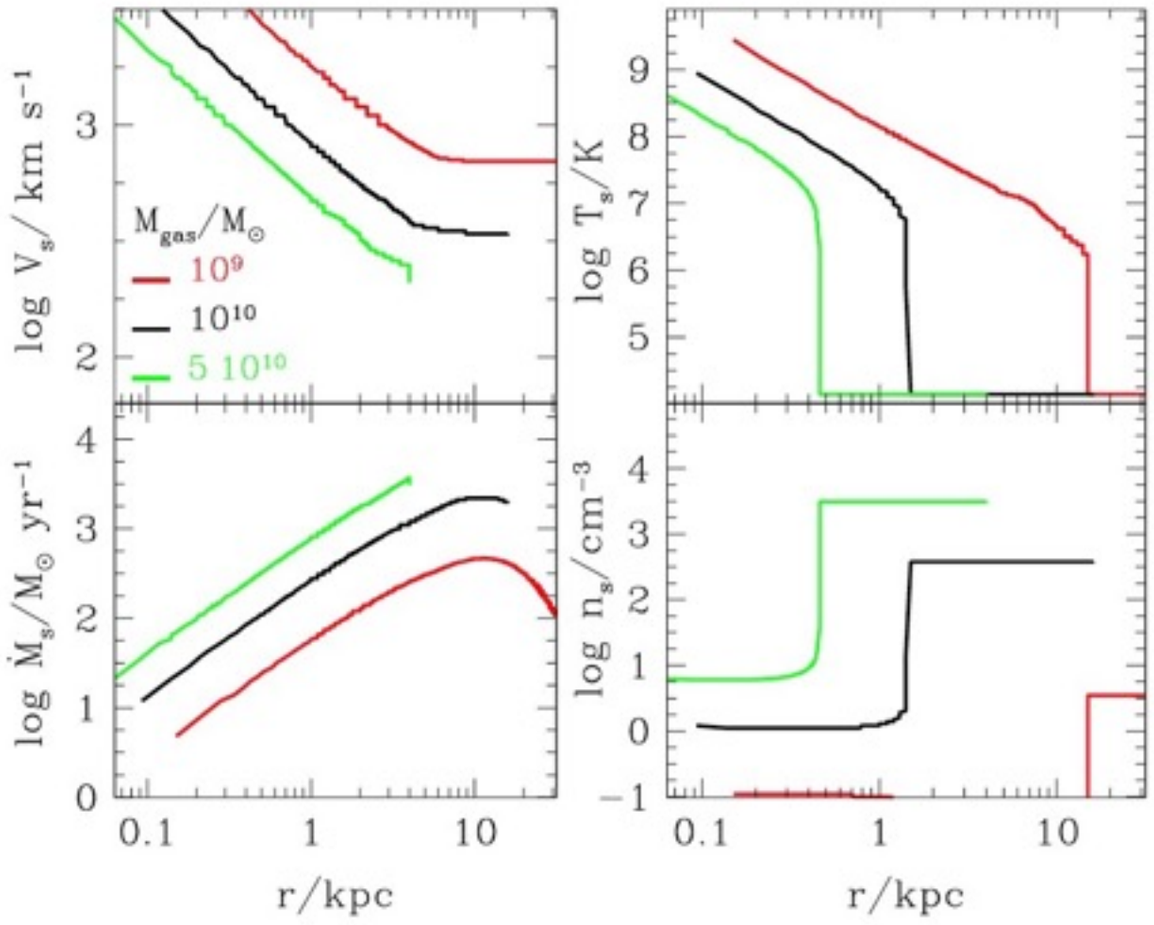

Menci, FF, CF+ 2018

AGN wind models

Follow the approach of Richings & F-G 2017
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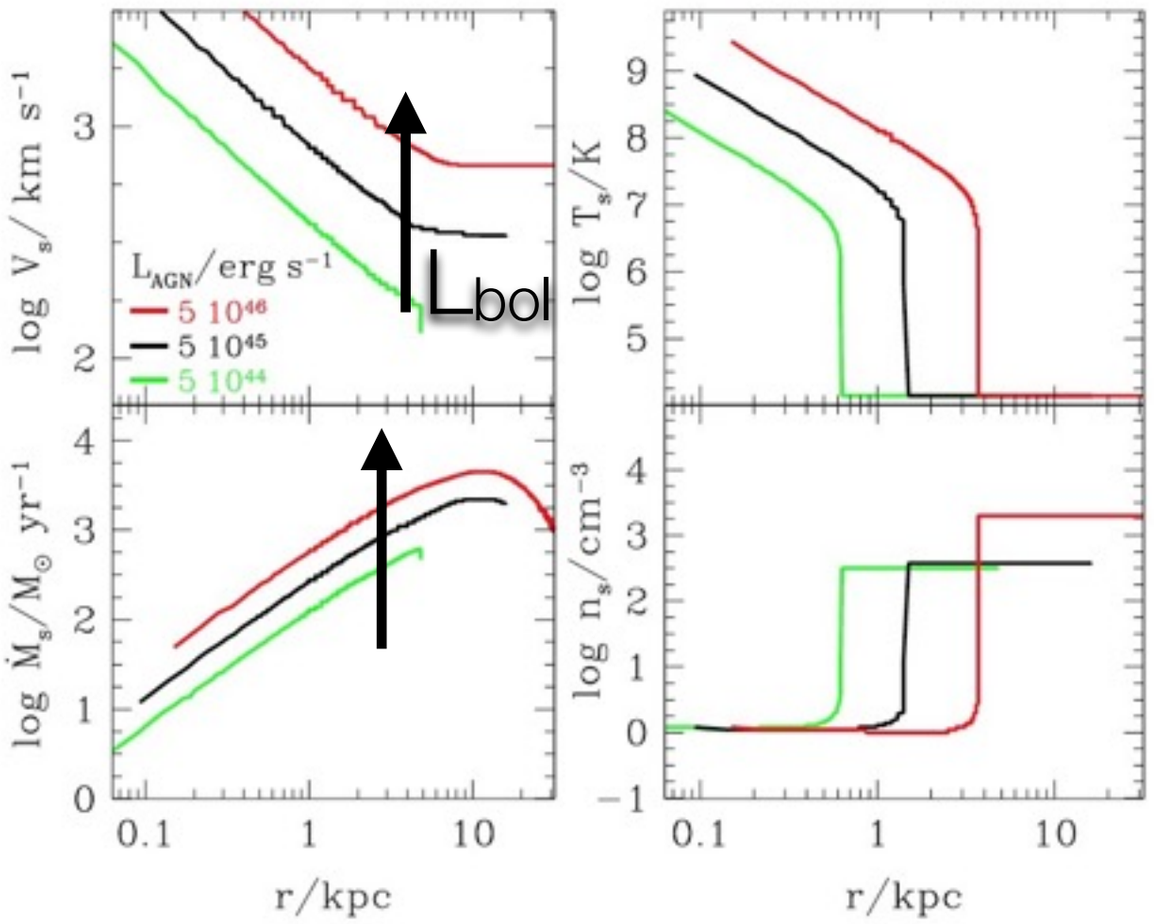

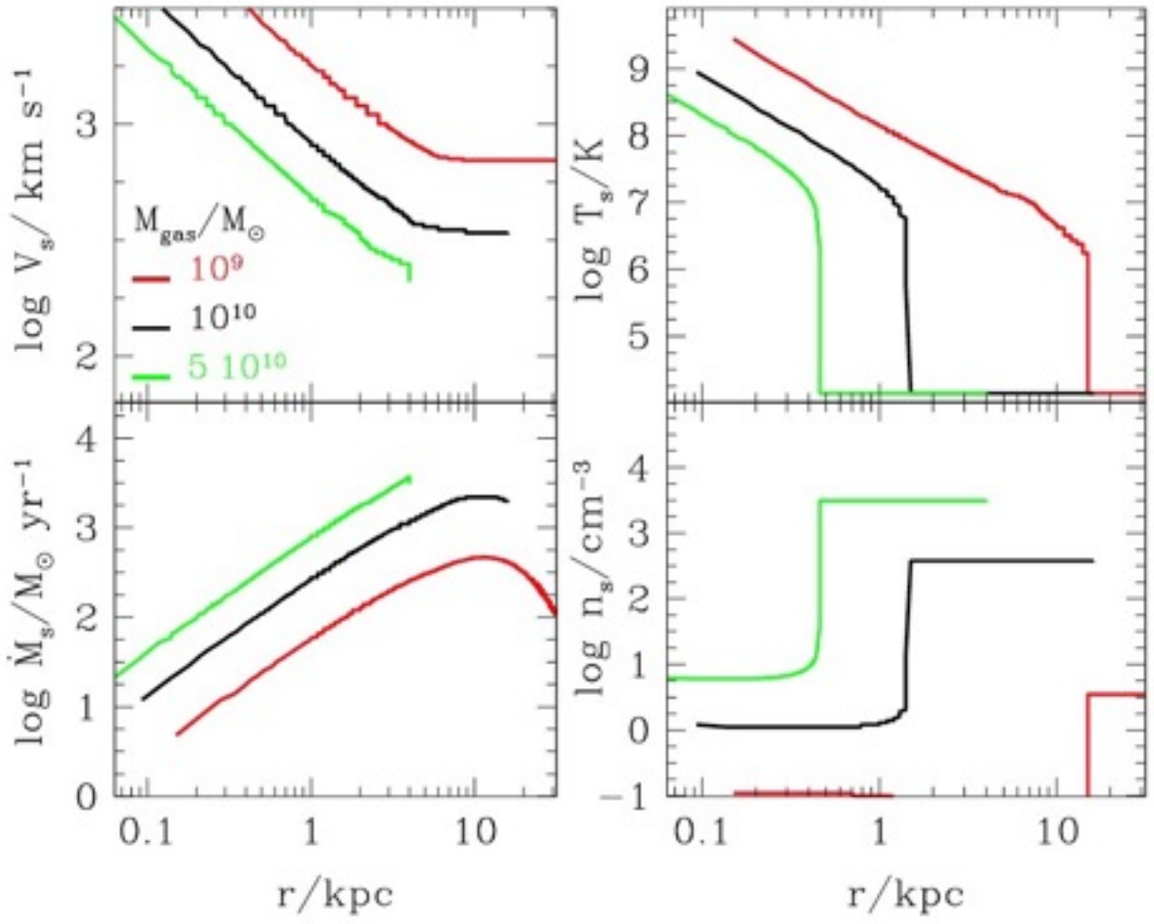

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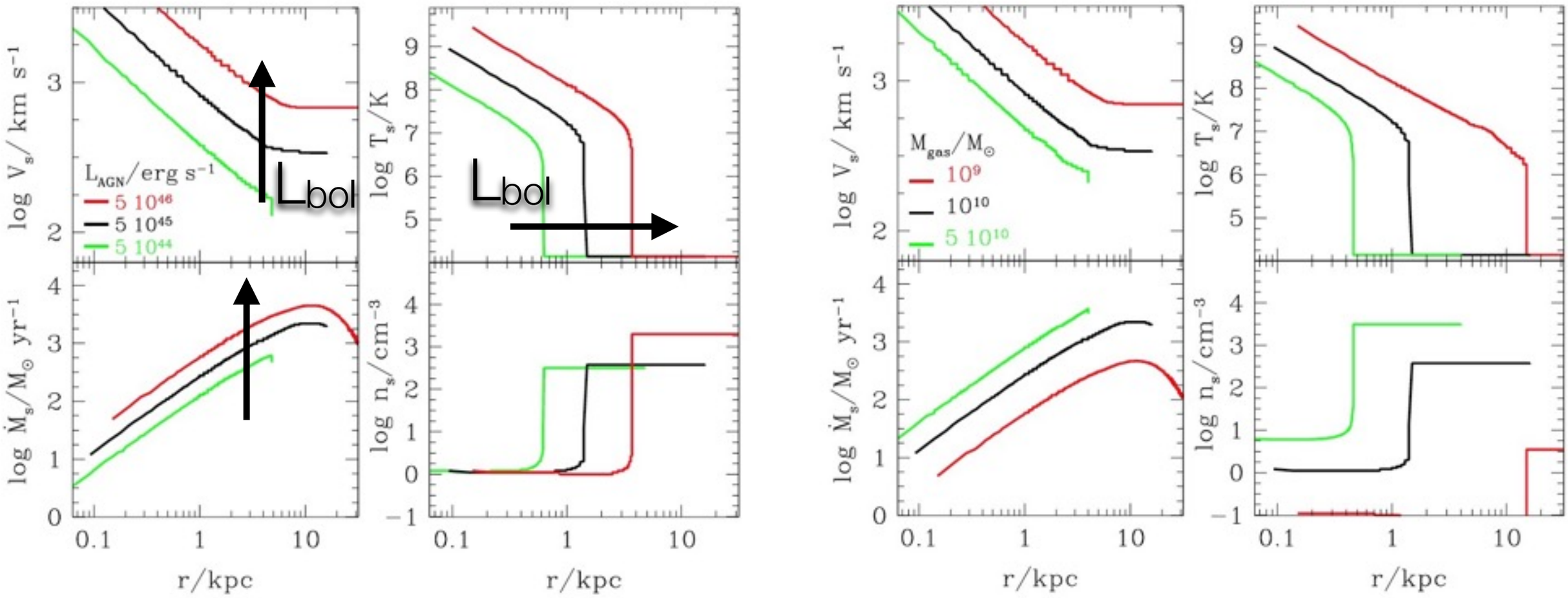

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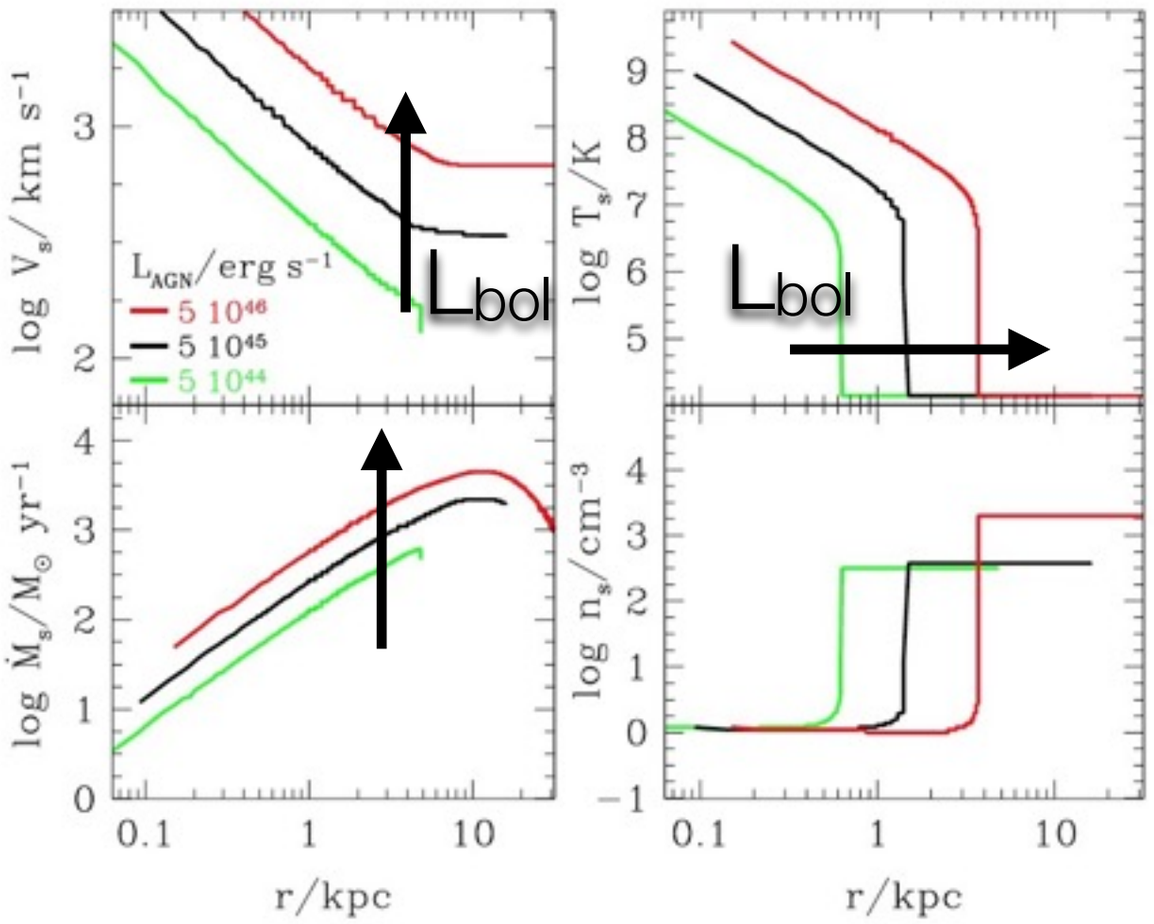
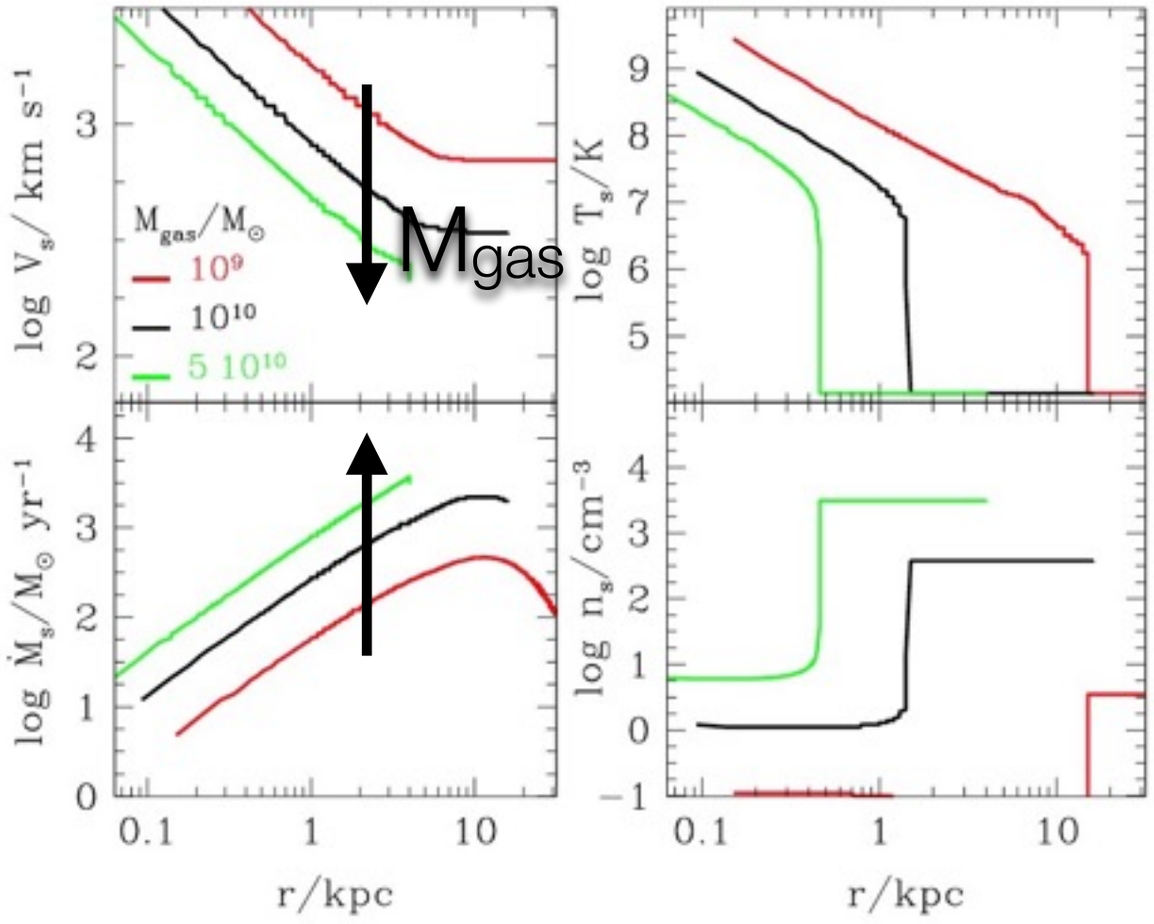
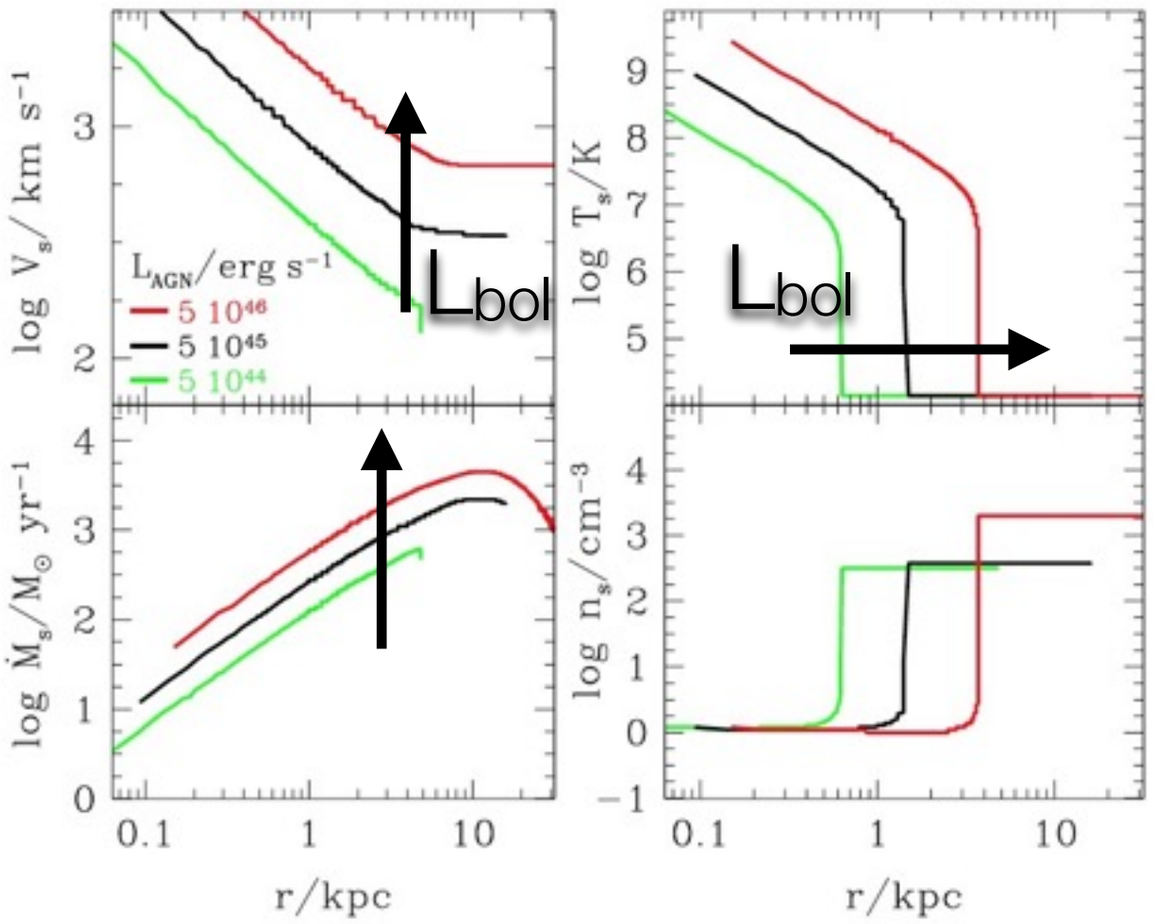


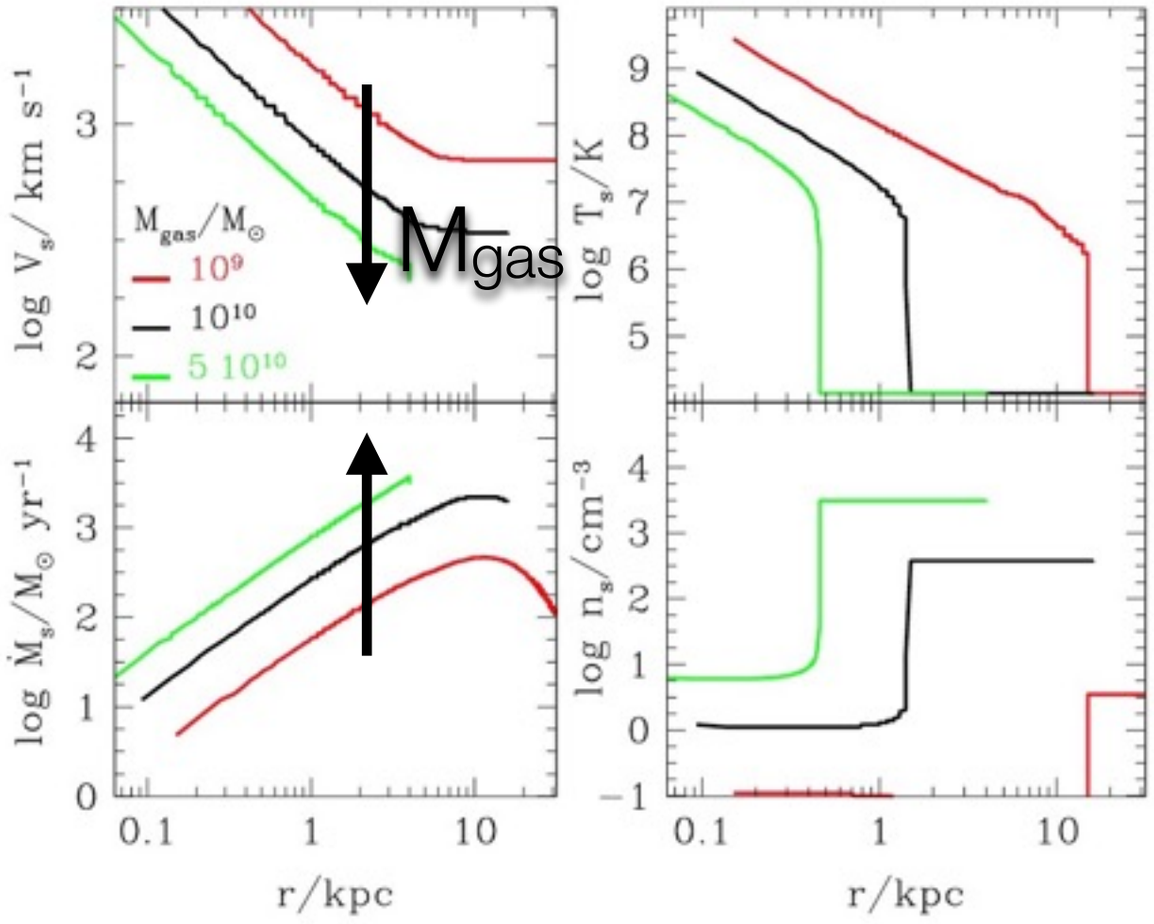


Menci, FF, CF+ 2018

AGN wind models

Follow the approach of Richings & F-G 2017
Adopt an exponential density profile





$v_{OF} \sim L_{bol}^{0.55} \times M_{gas}^{-0.33}$ $dM_{OF}/dt \sim L_{bol}^{0.33} \times M_{gas}$

Menci, FF, CF+ 2018

Y/kpc

20
10
0
−10
−20

−20 −10 0 10 20

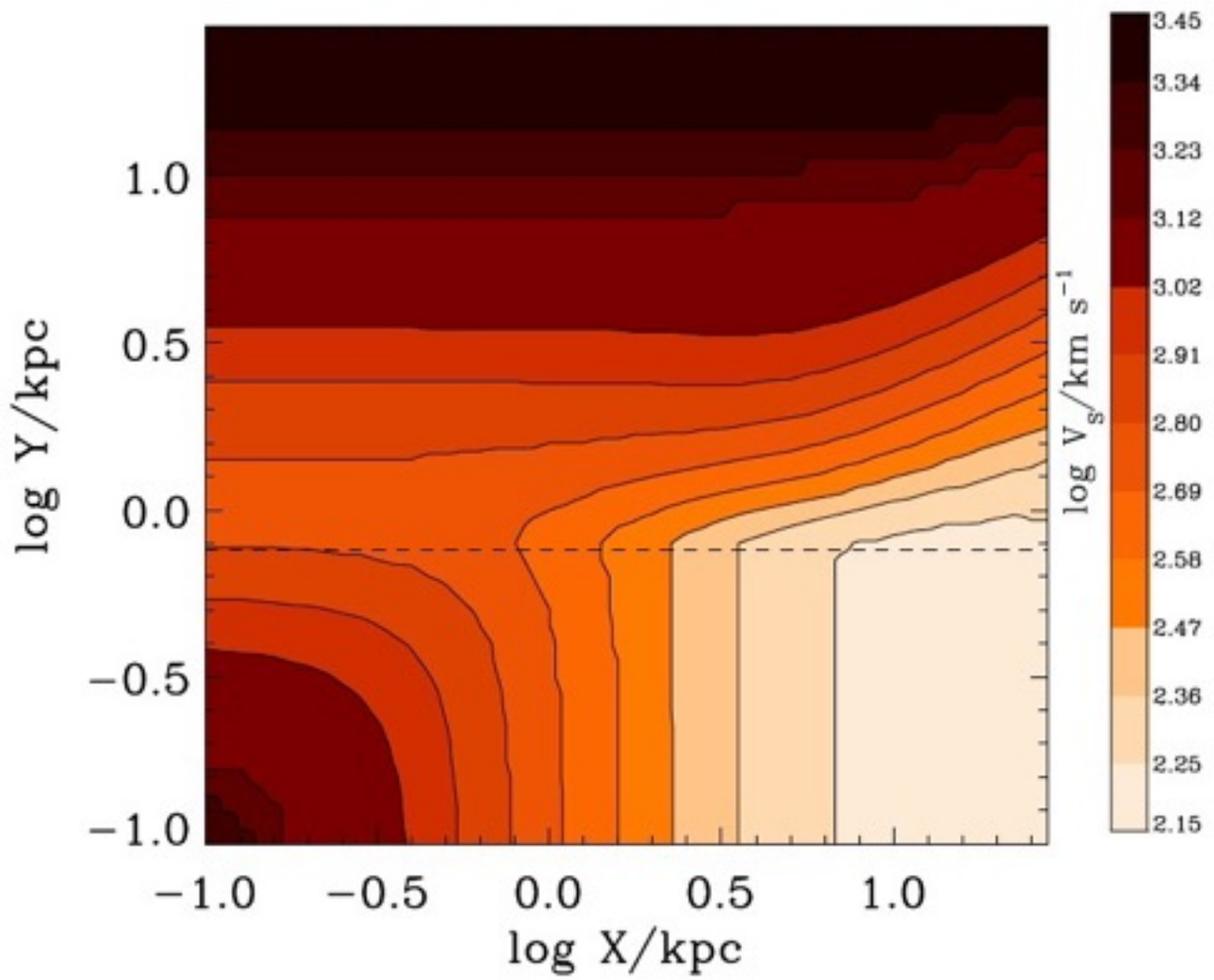
X/kpc

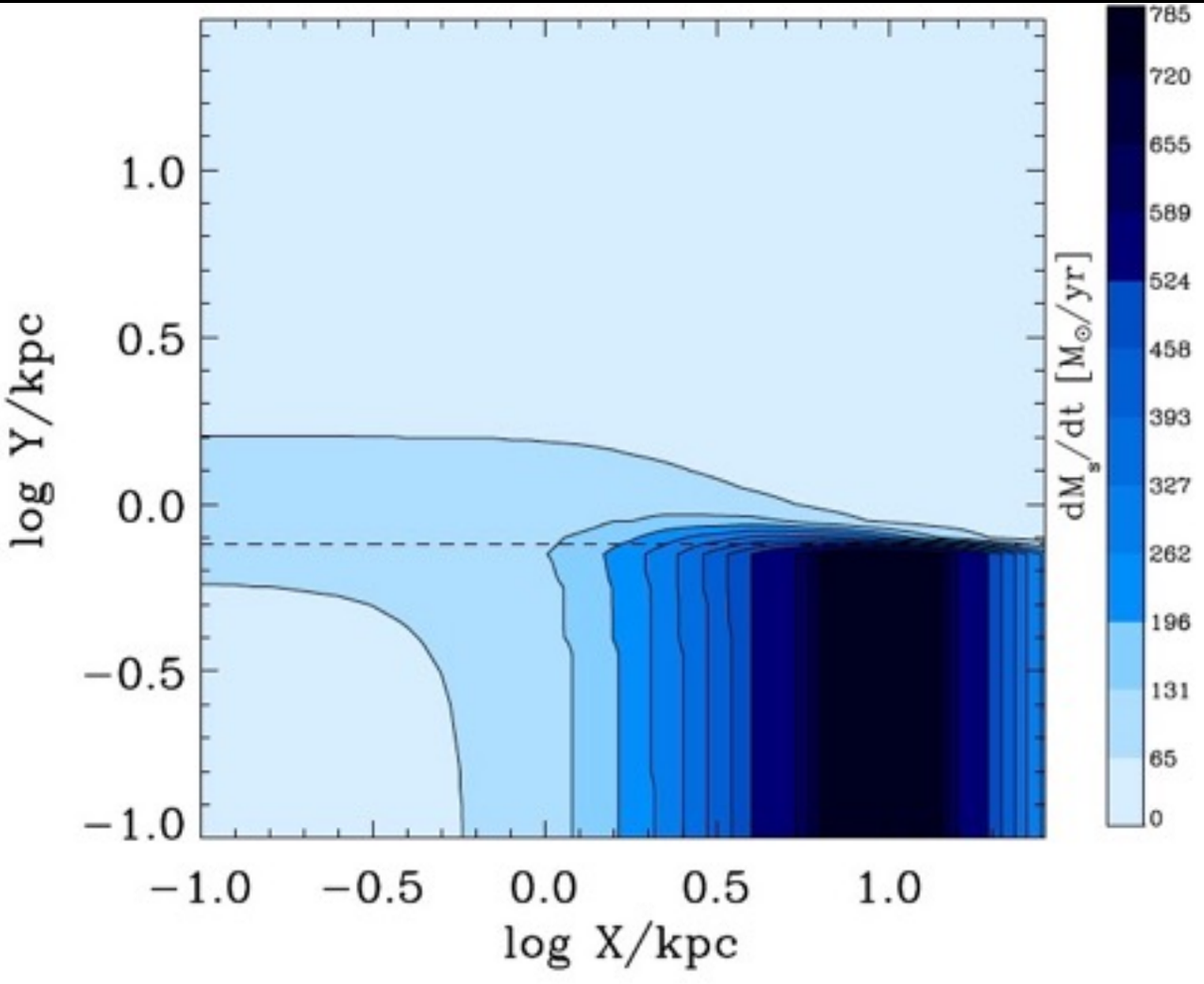
Time [10^6 yr]

123.920
112.670
101.419
90.169
78.919
67.669
56.418
45.168
33.918
22.668
11.417
0.167

Velocity

Mass outflow rate





Recap

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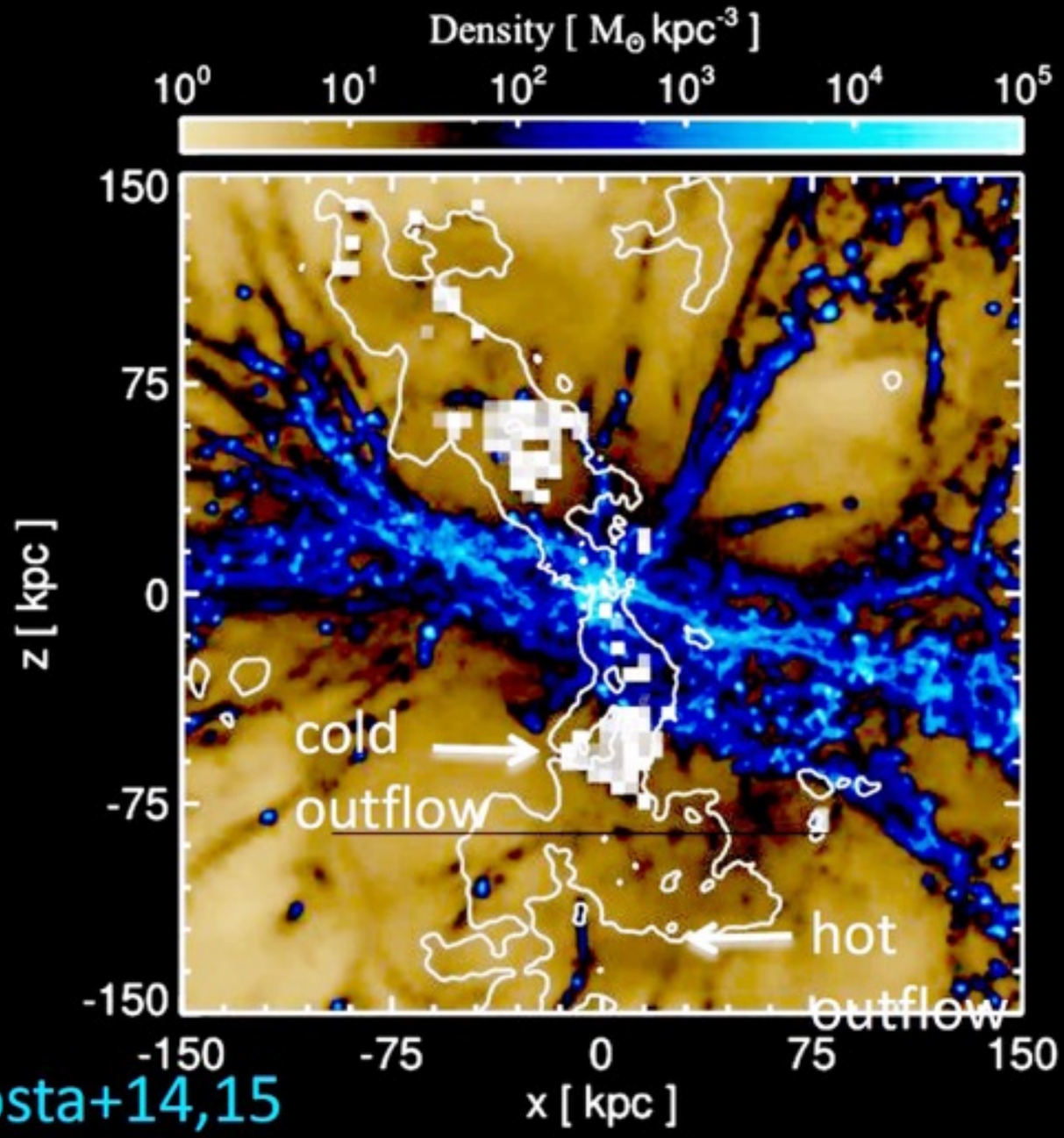
For these AGN Molecular gas fraction smaller than that of MS galaxies

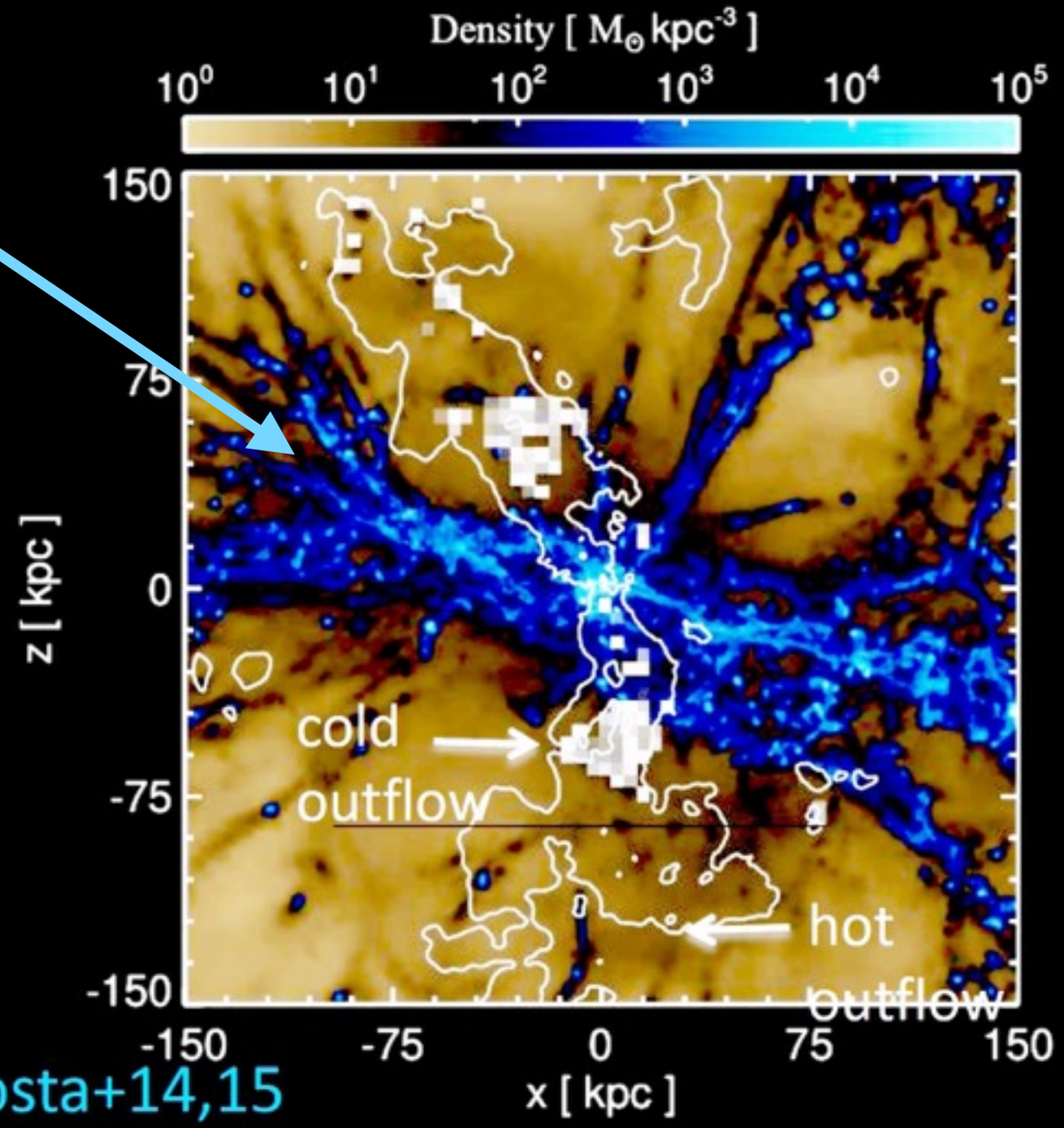
In & out (from a galaxy): the CGM



Costa+14,15

In & out (from a galaxy): the CGM

Pristine gas accretes on galaxies, cold and hot flows



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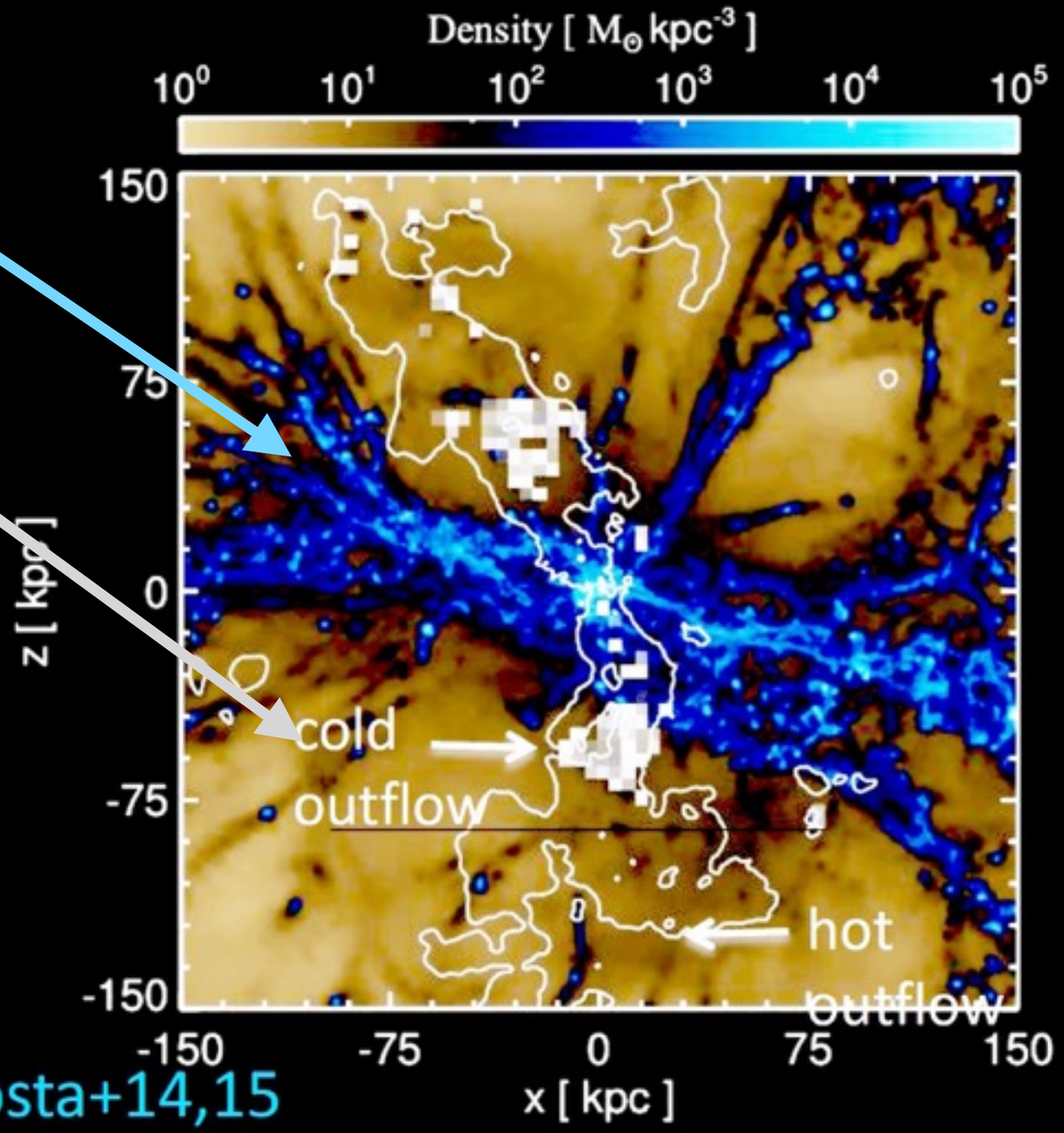
Enriched gas flows out from galaxies, cold and hot winds



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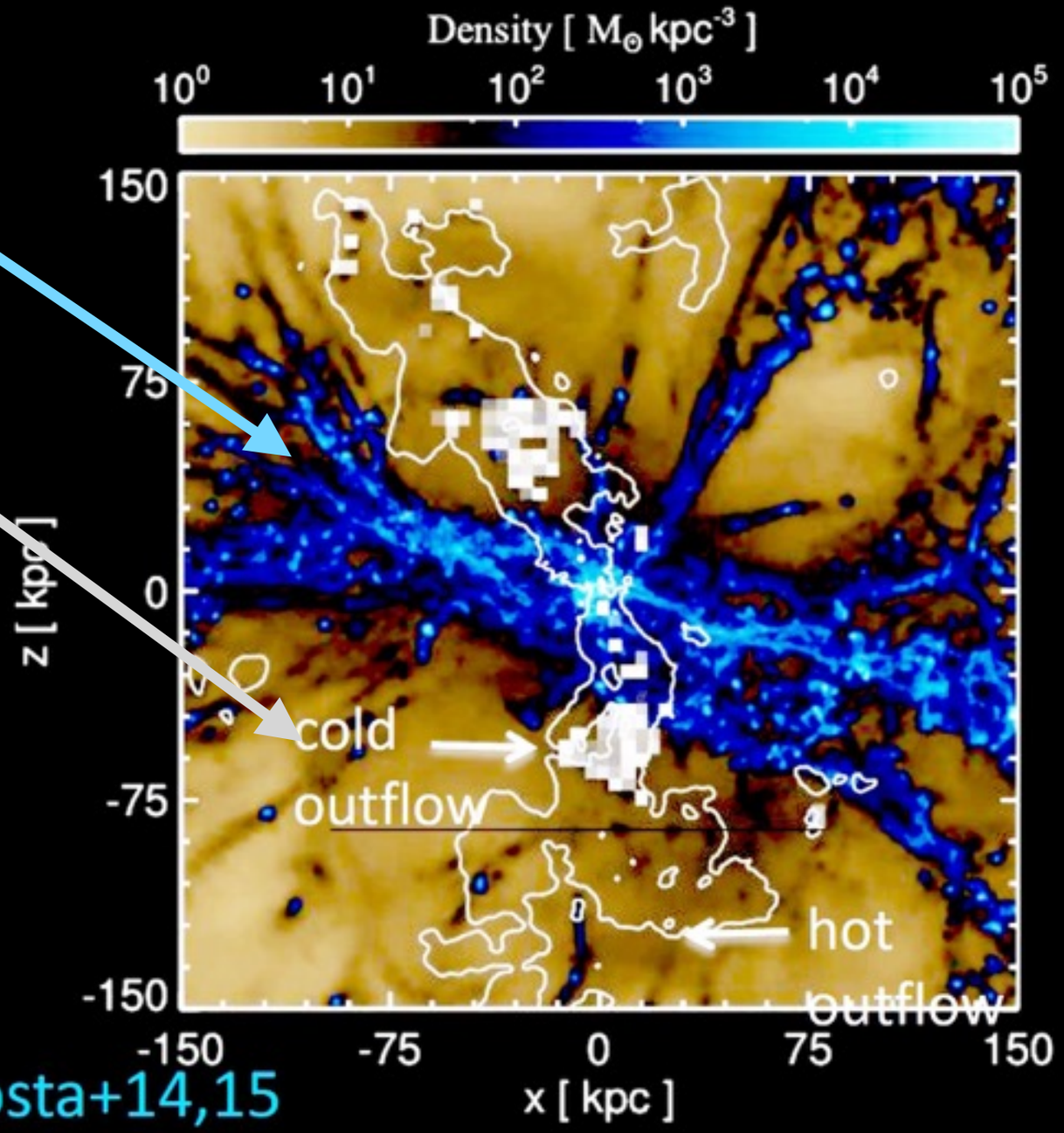

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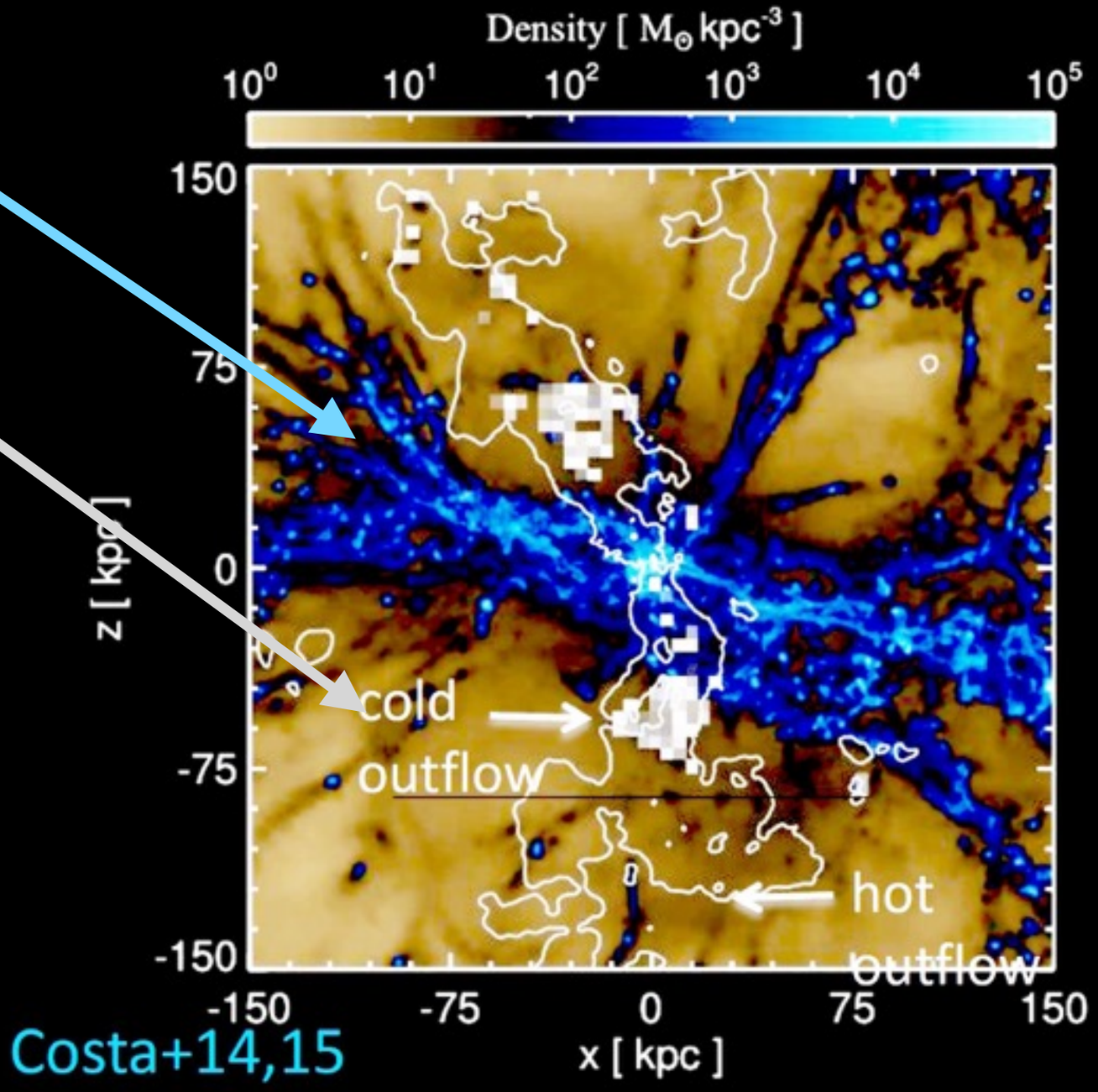

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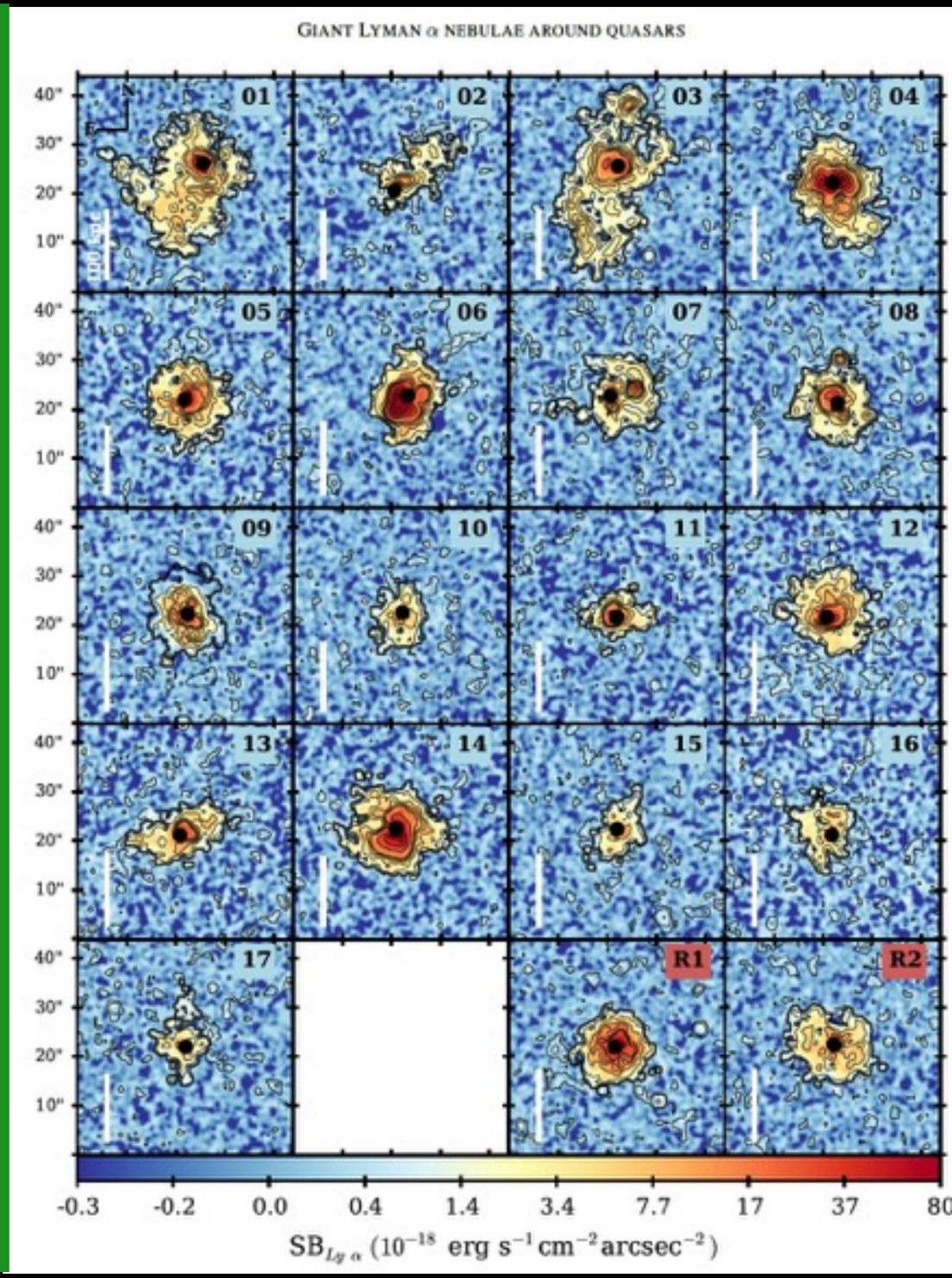

Borisova+2016

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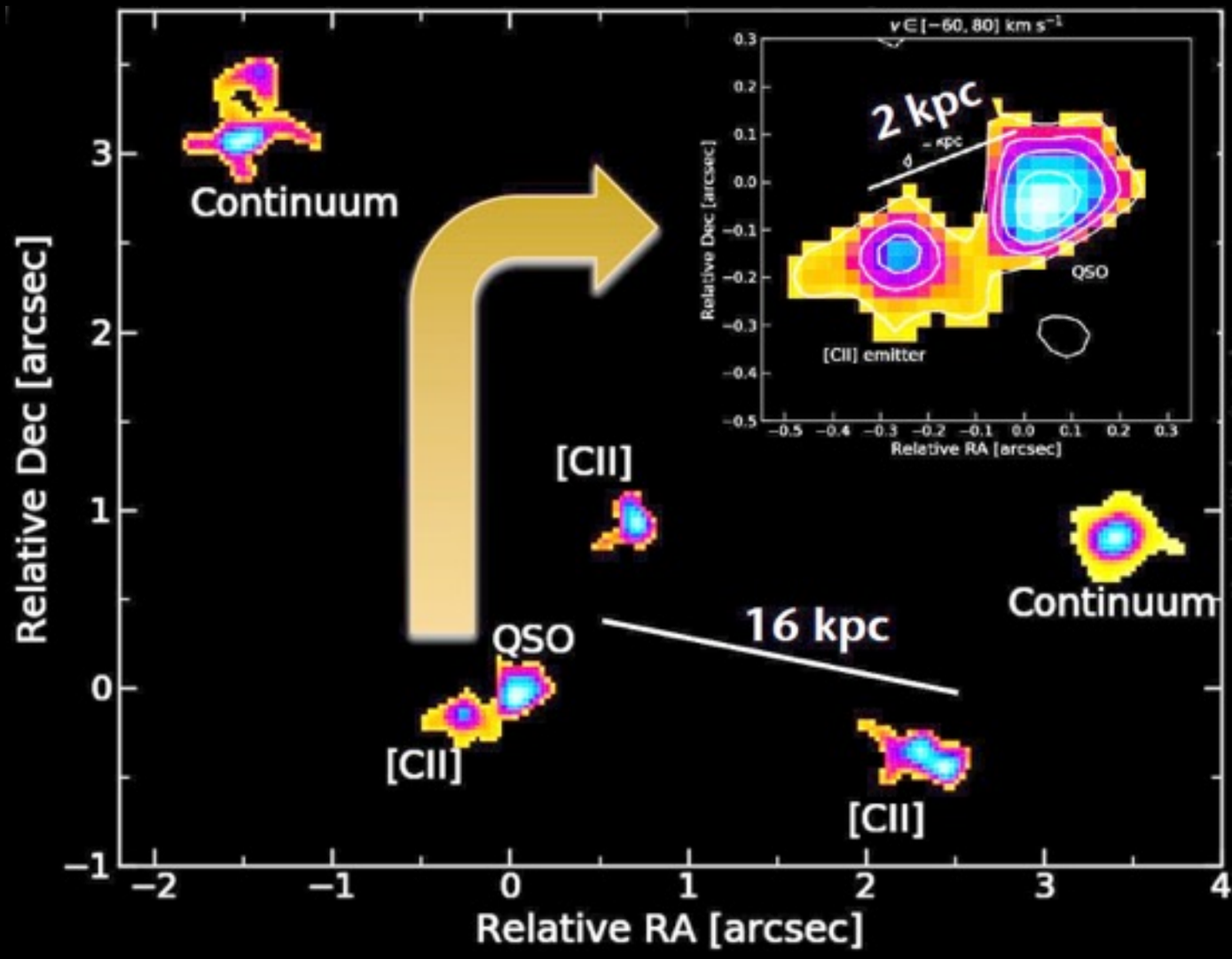
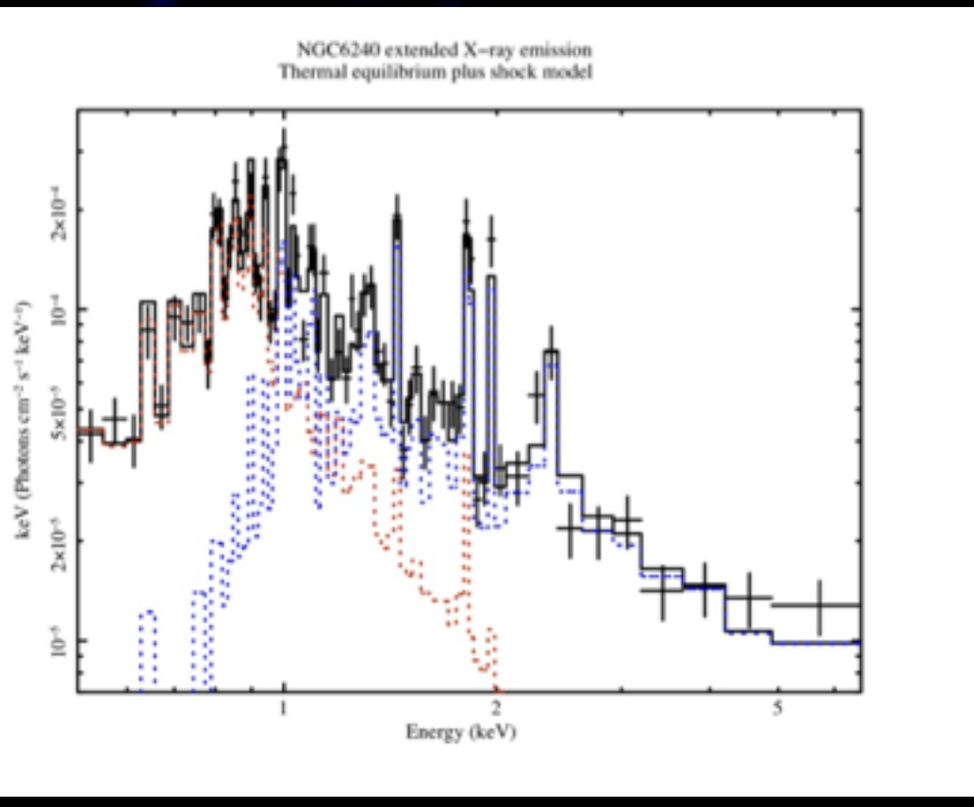


color = Hα
white = X-rays
green = fast CO-> outflow

NGC 6240: shock cooling?



Chandra spectra: shocked gas at the position of the Hα emission,

color = Hα
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NGC 6240: shock cooling?

The Beast: a weirdo

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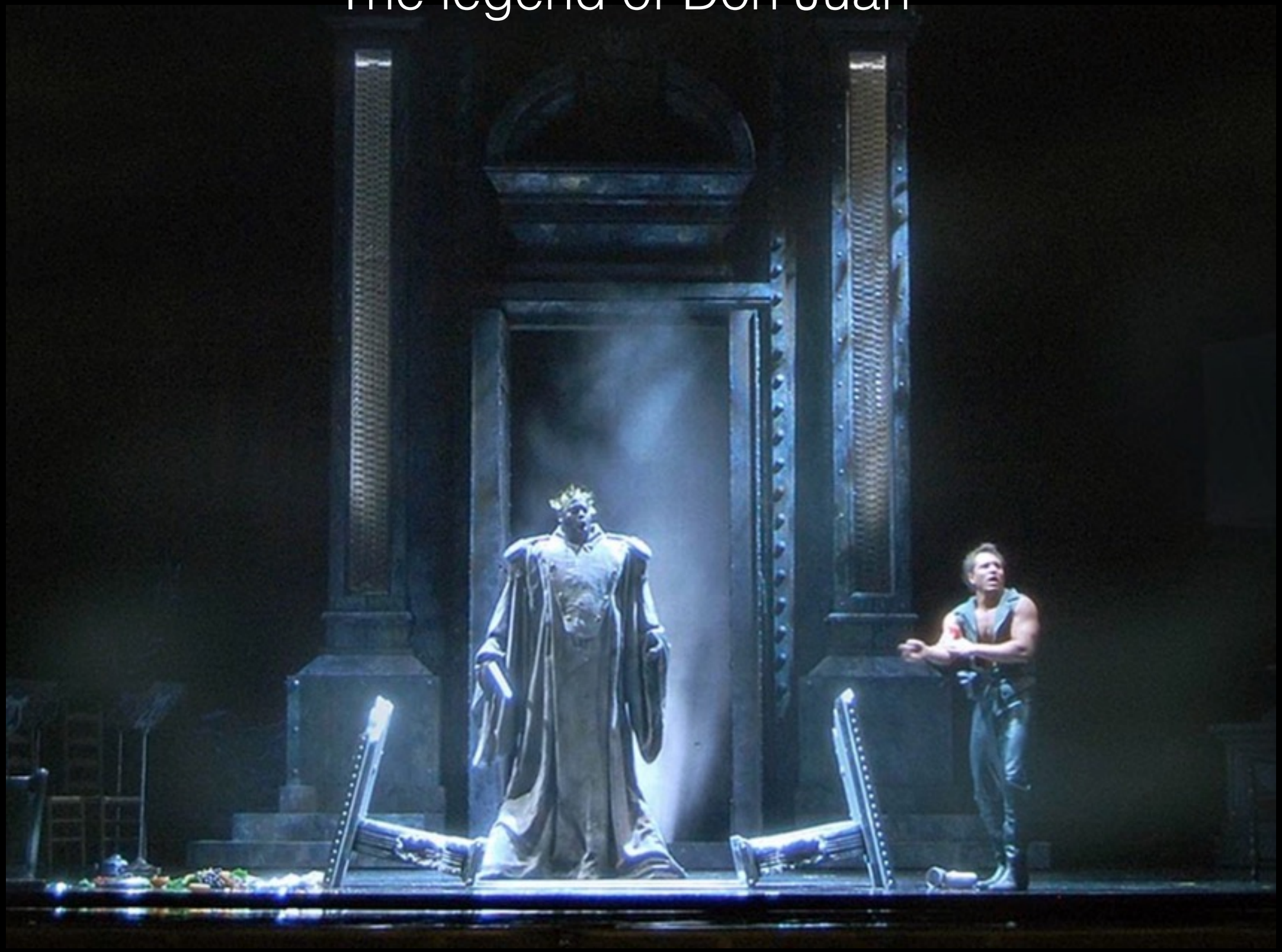
The Stone Guest

The legend of Don Juan



The legend of Don Juan

Principal scene:

On the evening of the supper, the talking statue of the father of Donna Anna, killed by Don Juan, in greeting him, holds out his hand, “dragging it with him to hell”

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