Massive black hole spin evolution

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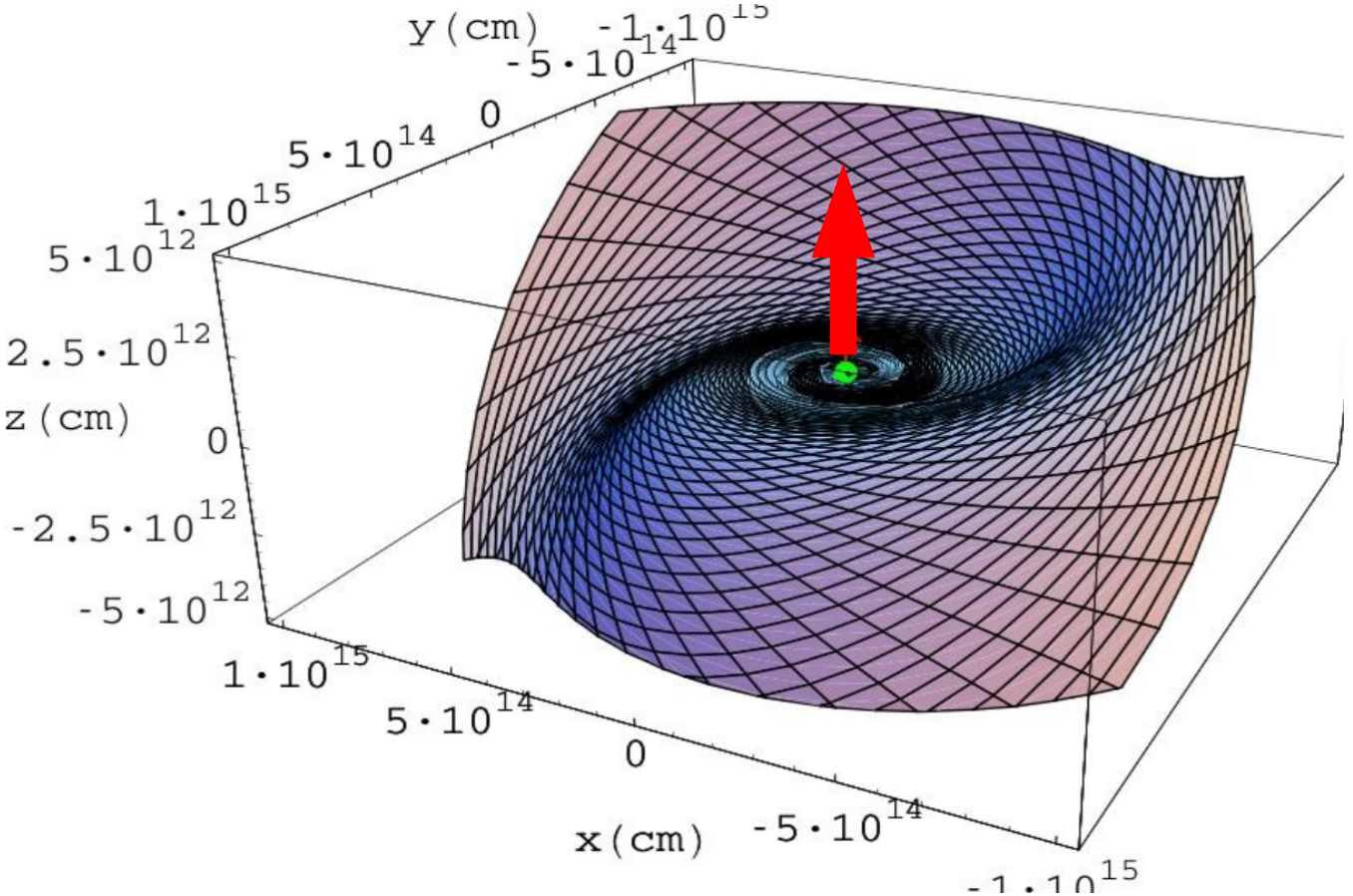


Collaborators
Simone Pallini
Albino Perego
Monica Colpi
Marta Volonteri (2013)
& many others...

Why spins?

The Answer

(for a relativist)

'cause (astrophysical) black holes are characterized **ONLY** by their masses and their spins

(“No-Hair” theorem)

Why spins?

...the other (astronomer's) answers:

'cause spins influence the growth of BHs over the cosmic history through the radiative efficiency (Monday's talks)

'cause spins may (or may not) be linked to the production of jets

'cause spins influence the occupation fraction of BHs in galaxies (Laura's talk)

'cause we start measuring them!

How do spins evolve?

(gas) accretion

MBH mergers
(as a consequence of galaxy mergers)

From the so called **"Soltan argument"** we know this is a (the?) relevant channel for mass and spin evolution

Relevant if the MBHs do not accrete since the last coalescence (in particular, right after a coalescence)

How do spins evolve? (gas)

coherent accretion

chaotic accretion

“large” amounts of gas accrete onto the MBHs with a constant angular momentum direction, i.e. through a single long-lived massive accretion disc

“small” gas clouds accrete onto the MBHs, from random directions, forming accretion discs lying in random, uncorrelated planes

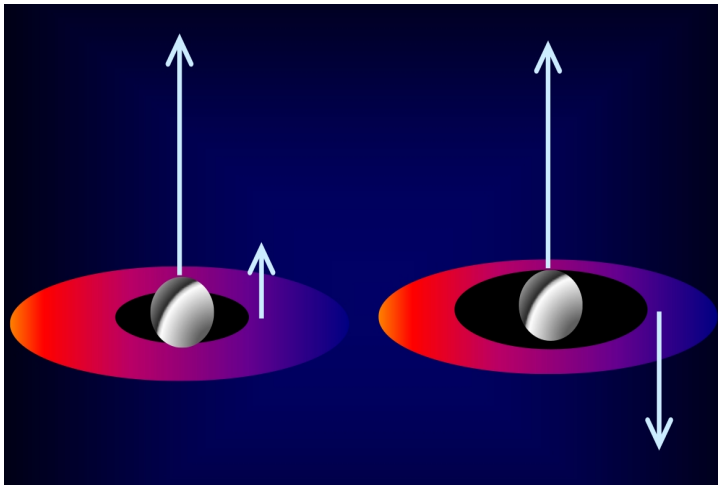
How do spins evolve?
(naive expectations)

coherent accretion

Adding coherently angular momentum to the MBHs results in a~1

note: accreting $6^{1/2}$ times the initial MBH mass is sufficient to transform a Schwarzschild MBH into a maximally rotating one

chaotic accretion



Since retrograde accretion has more angular momentum (per unit of mass), we expect a~0

The missing ingredients
(to a slightly less naive picture)

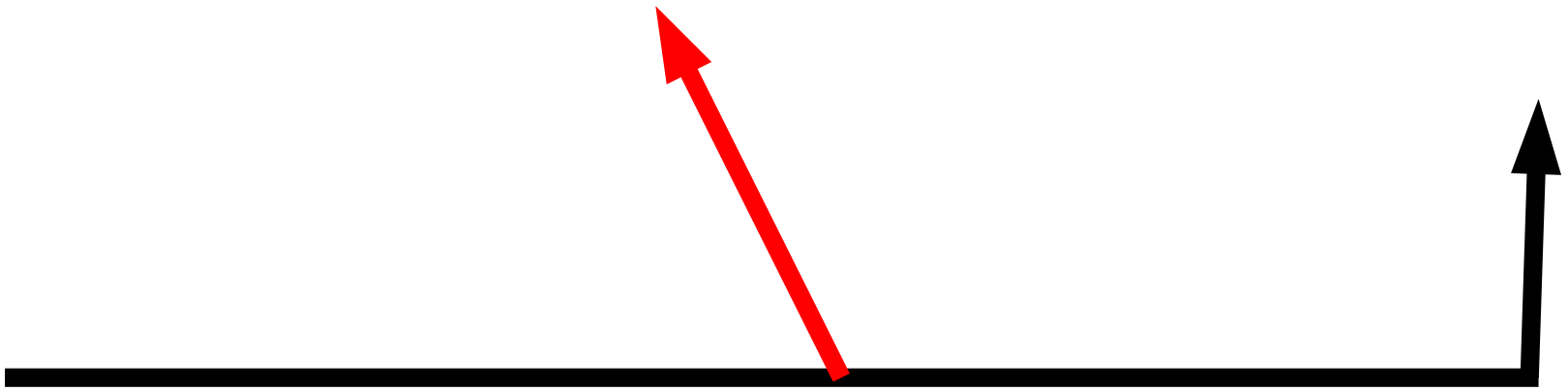
Differently from mass, spin is a vector

Accretion changes the spin orientation, and changes in the orientation affect the spin magnitude evolution

No reason to assume perfectly coherent accretion nor exact isotropy.

How does the orientation evolve?

(i.e. the Bardeen-Petterson effect)



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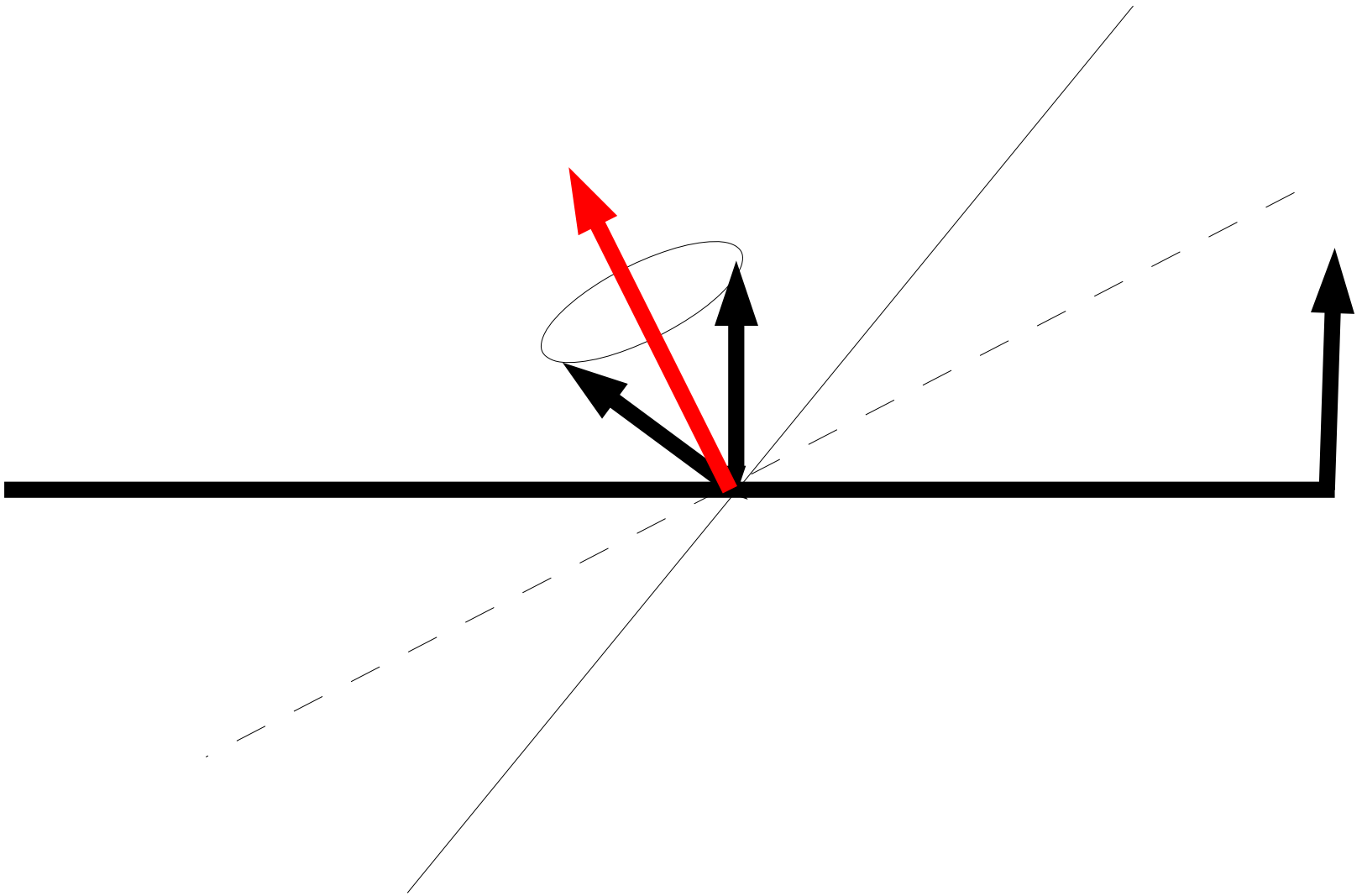

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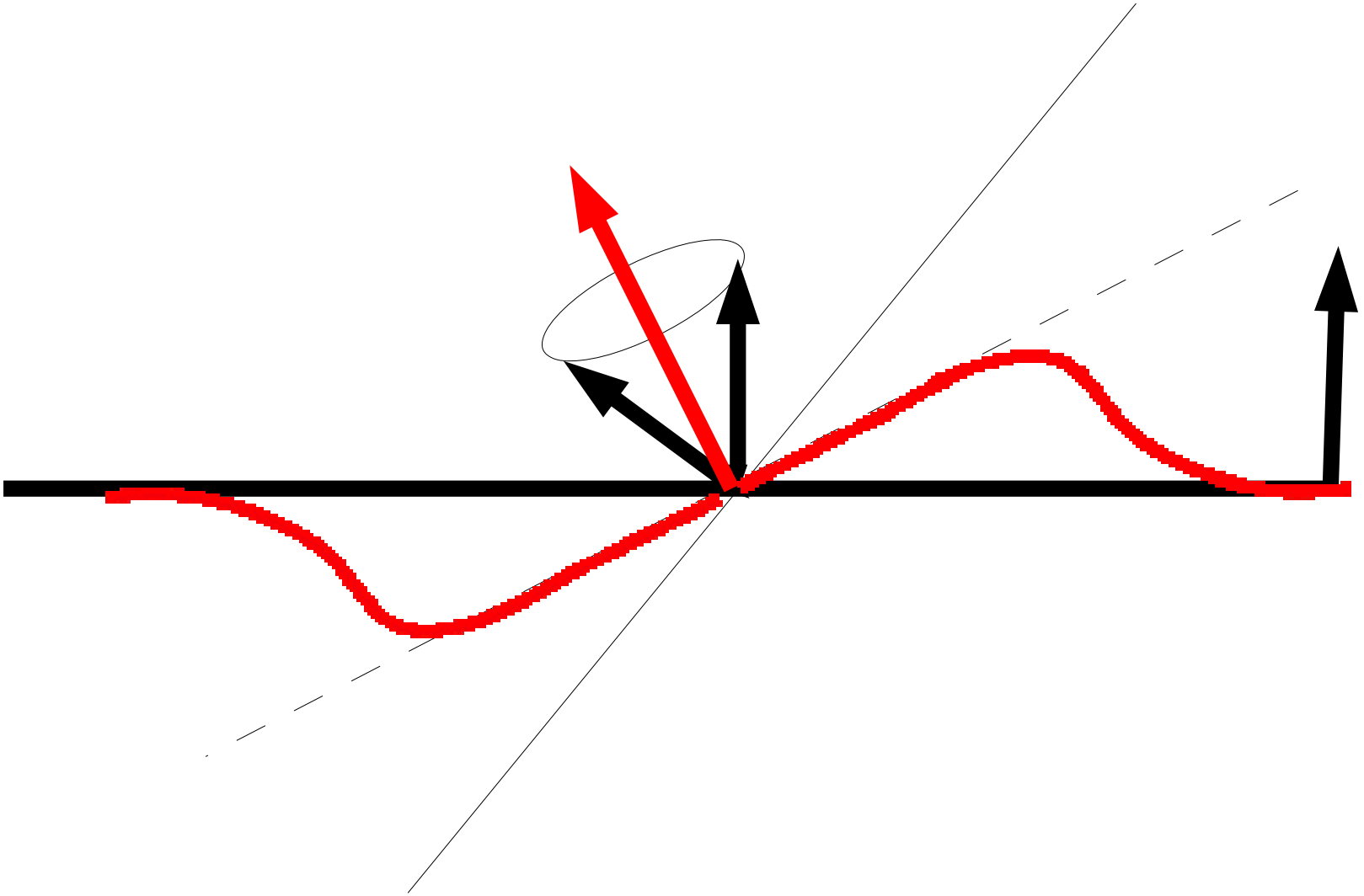

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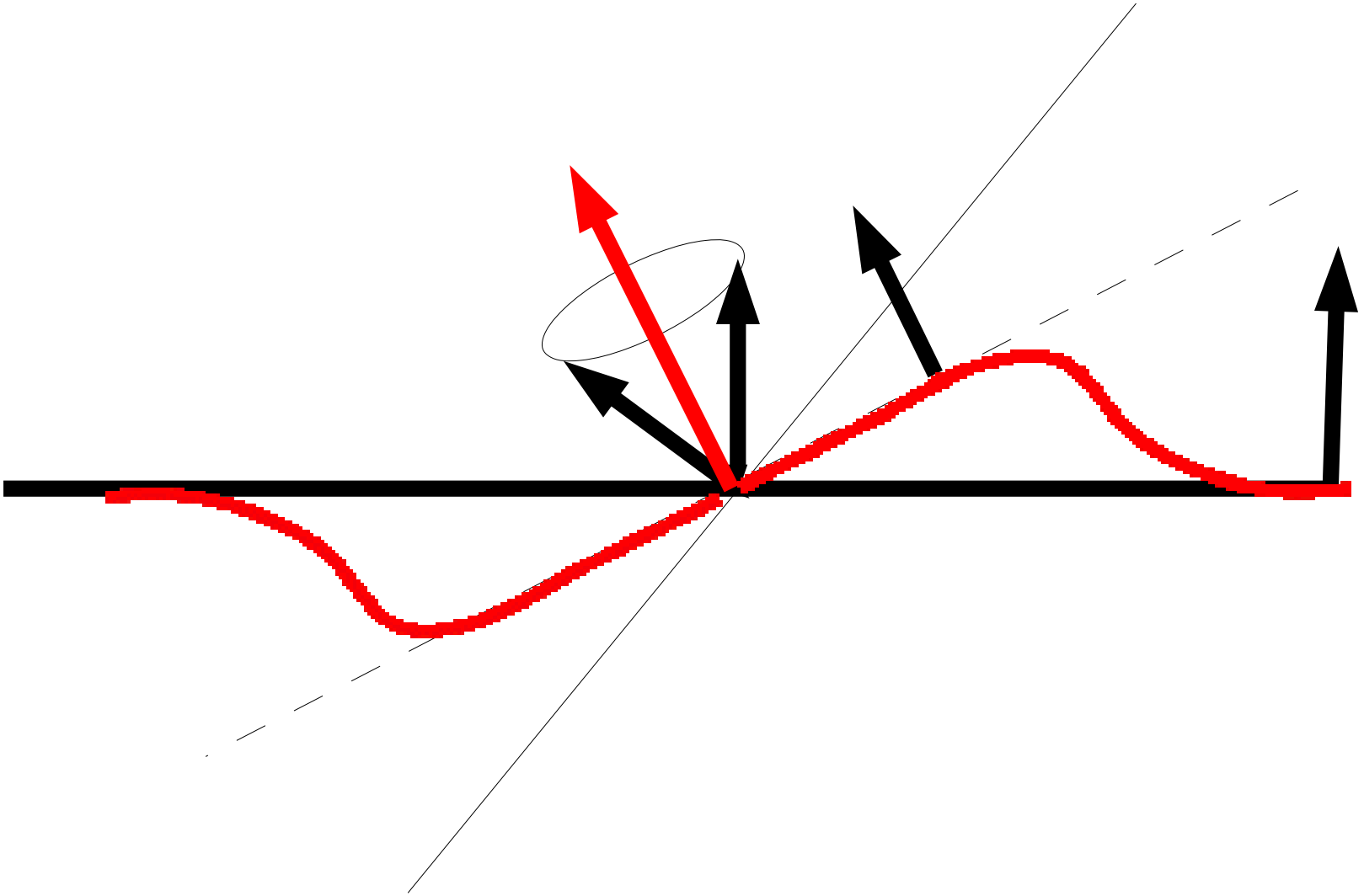

What if accretion isn't coherent?

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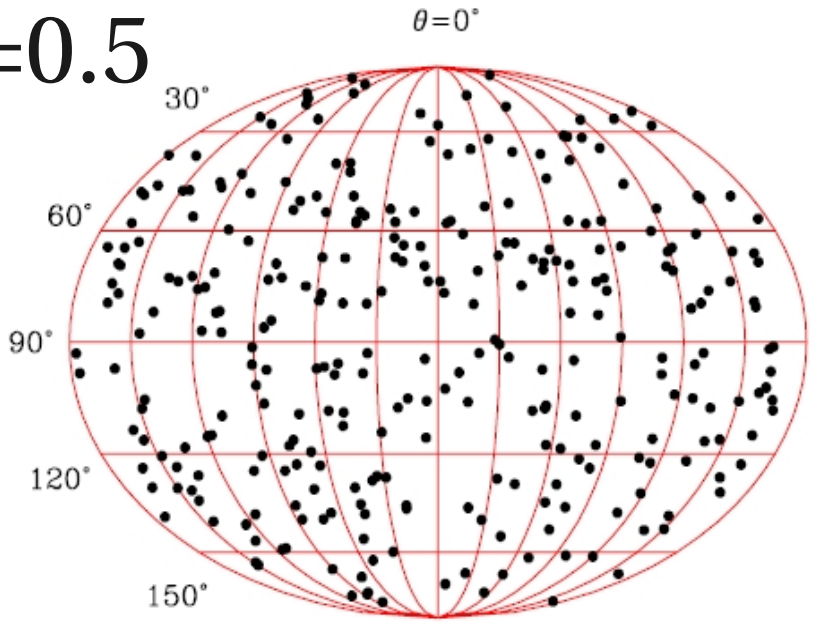

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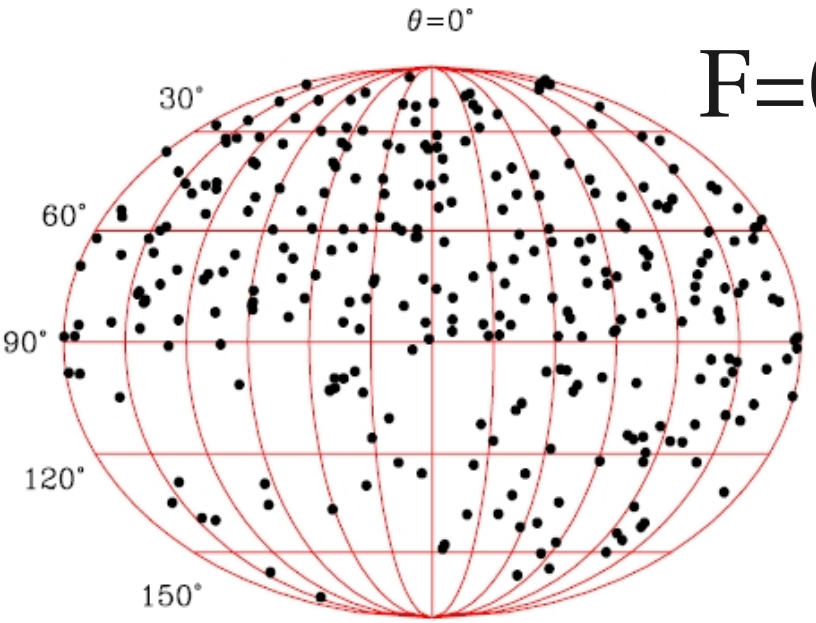

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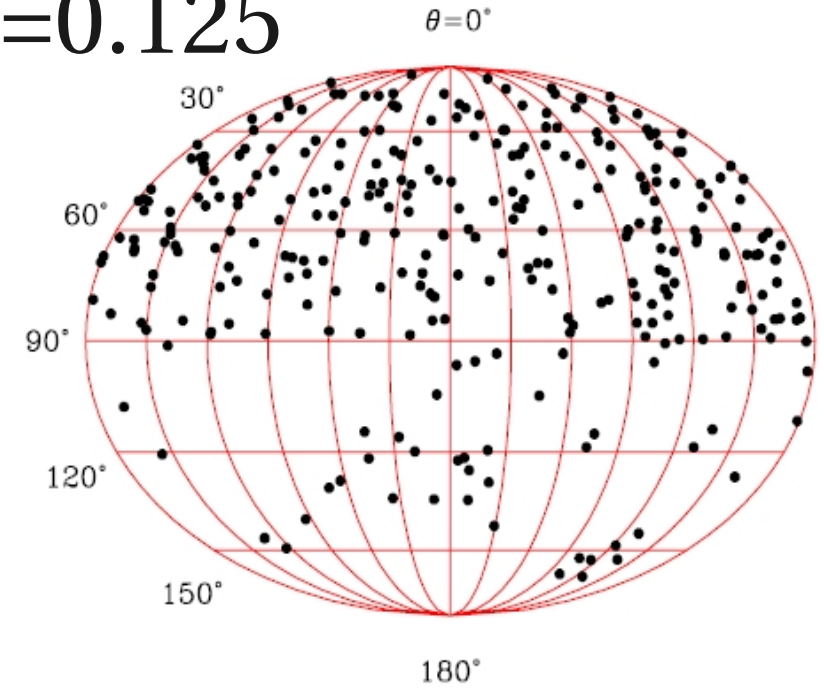

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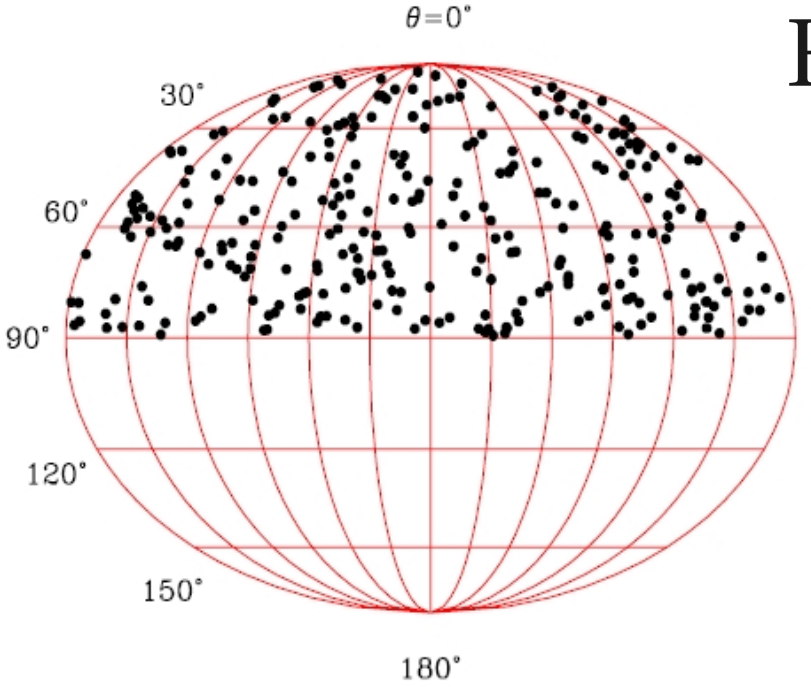

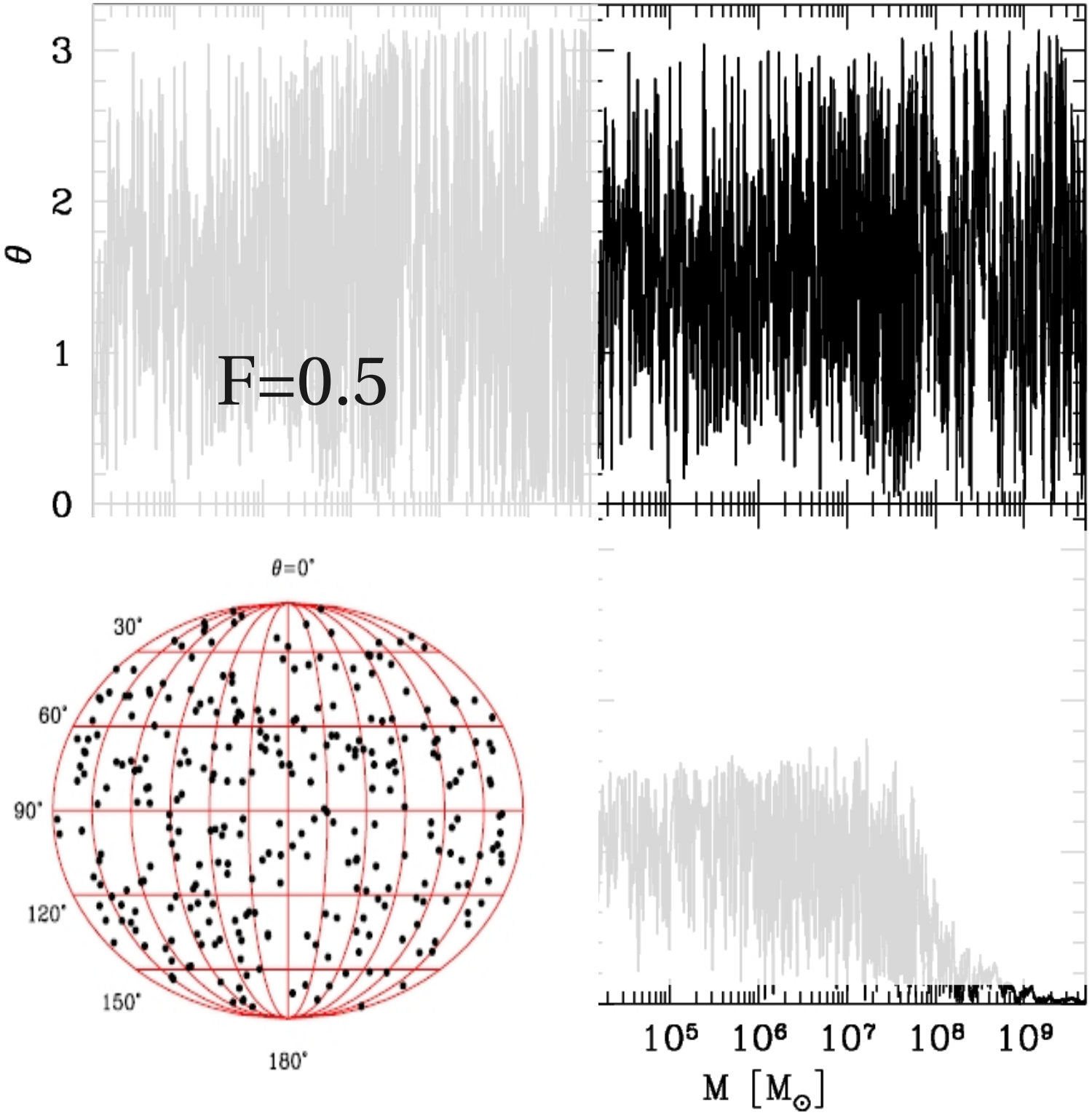
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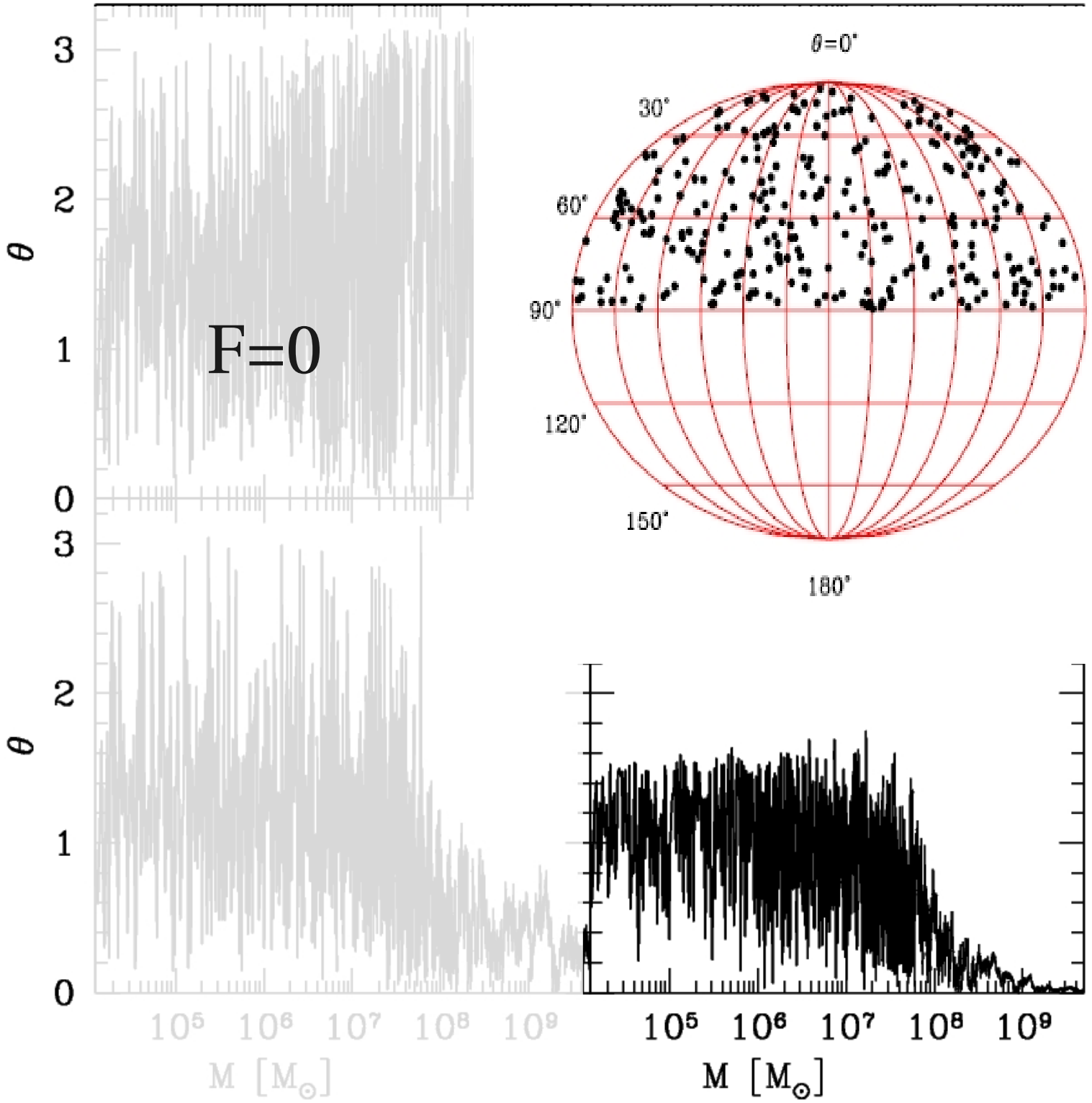
M [M⊙]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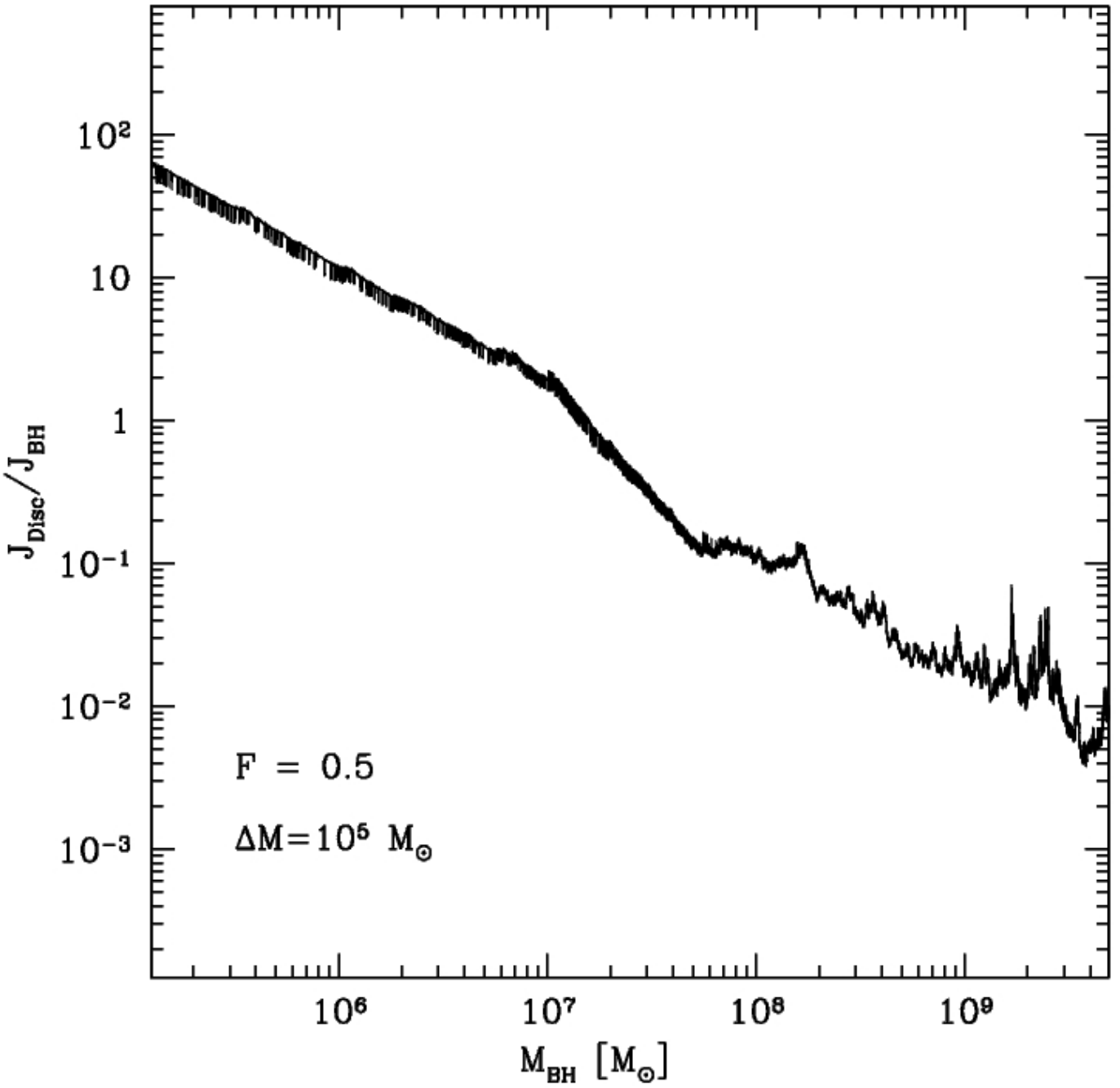
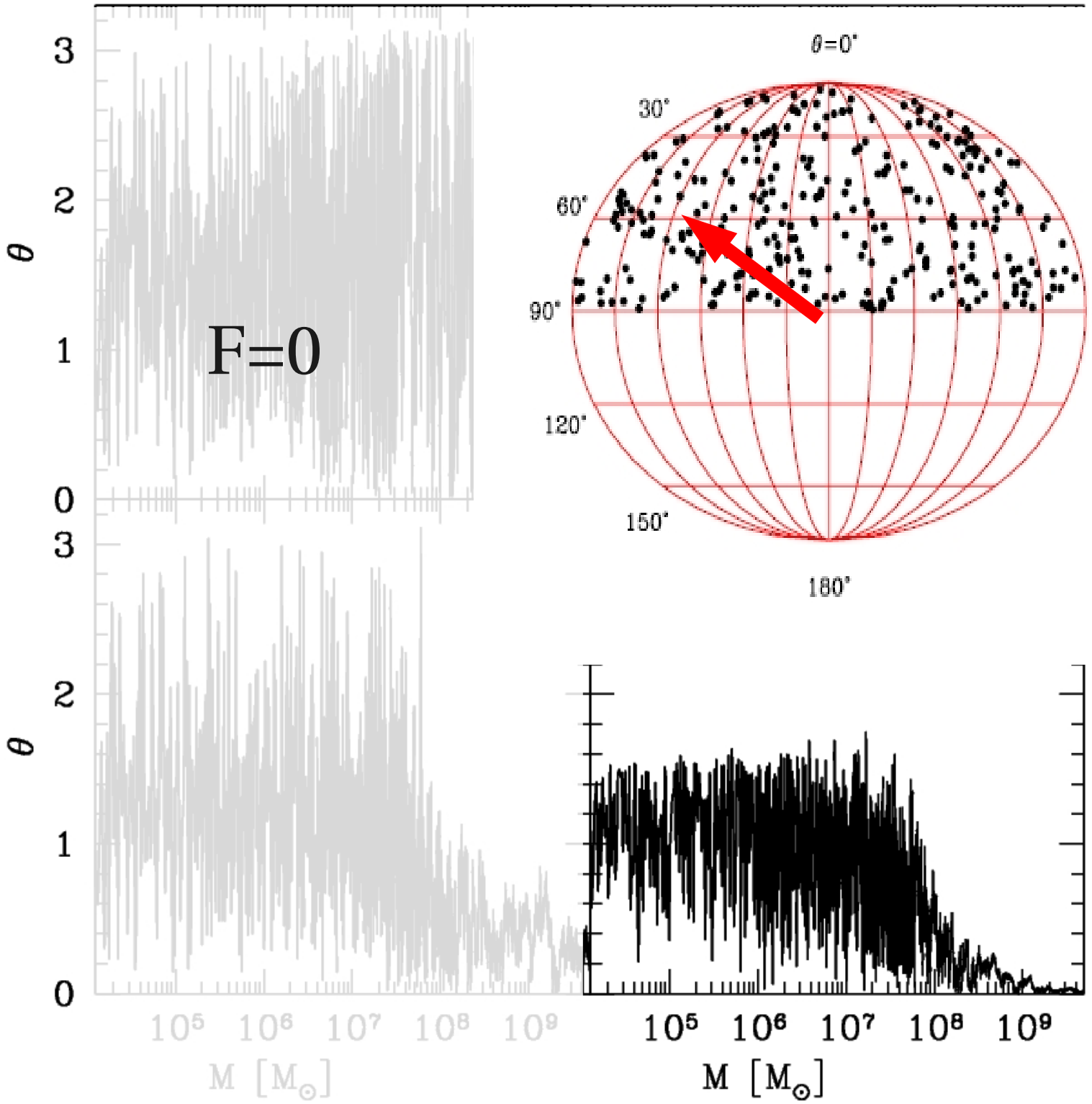
THE parameter: J_{Disc}/J_{BH}

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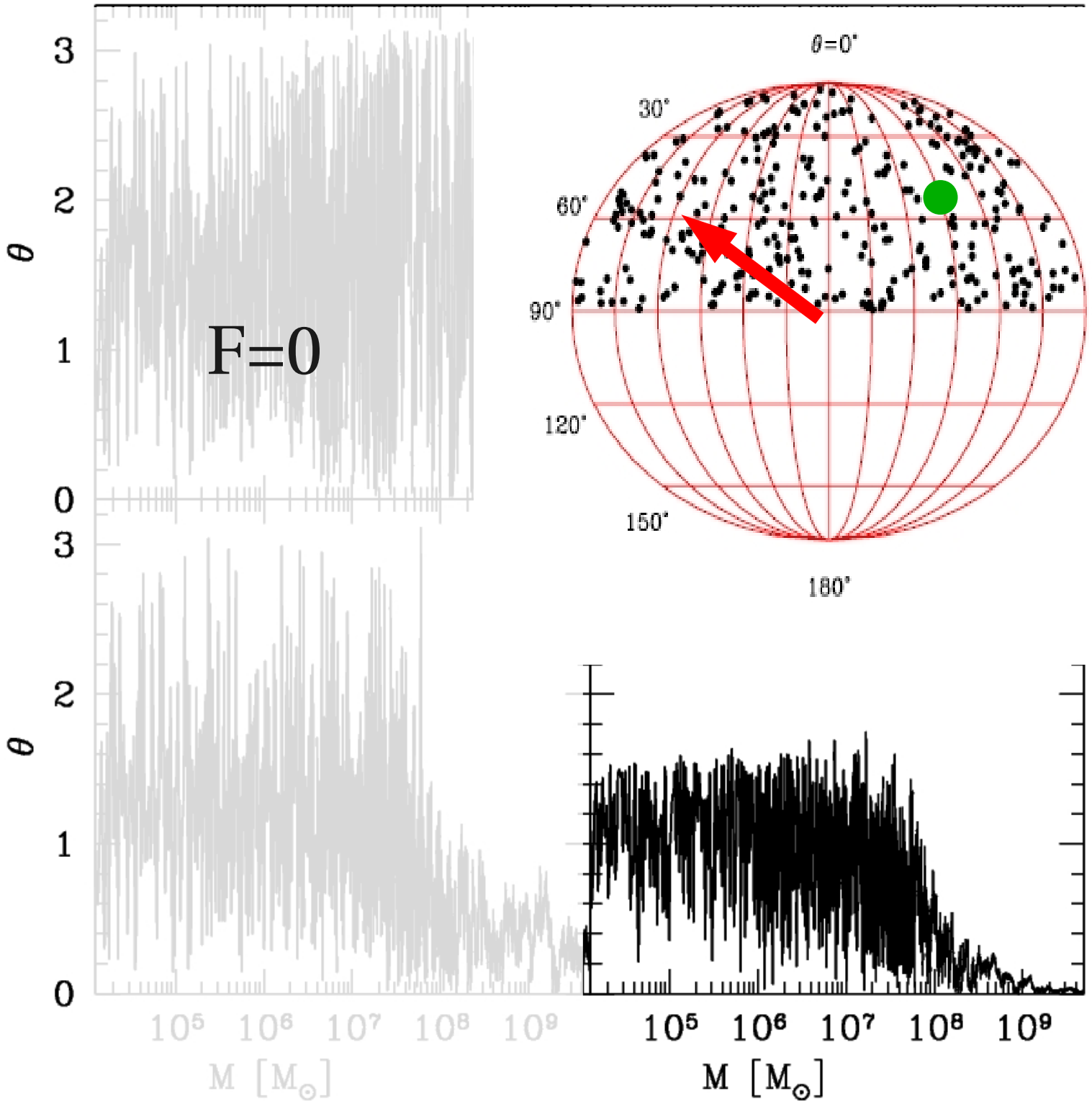
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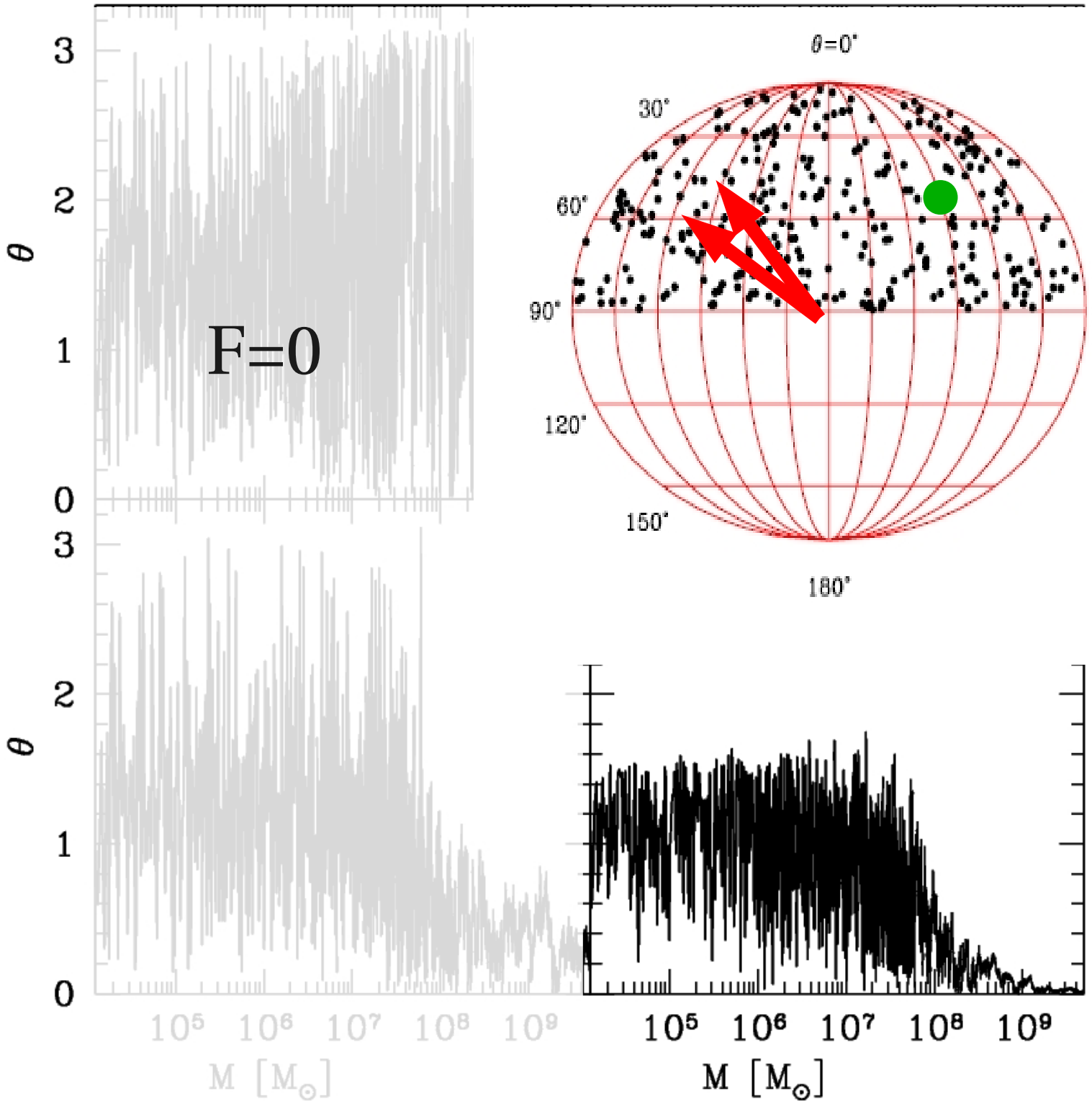
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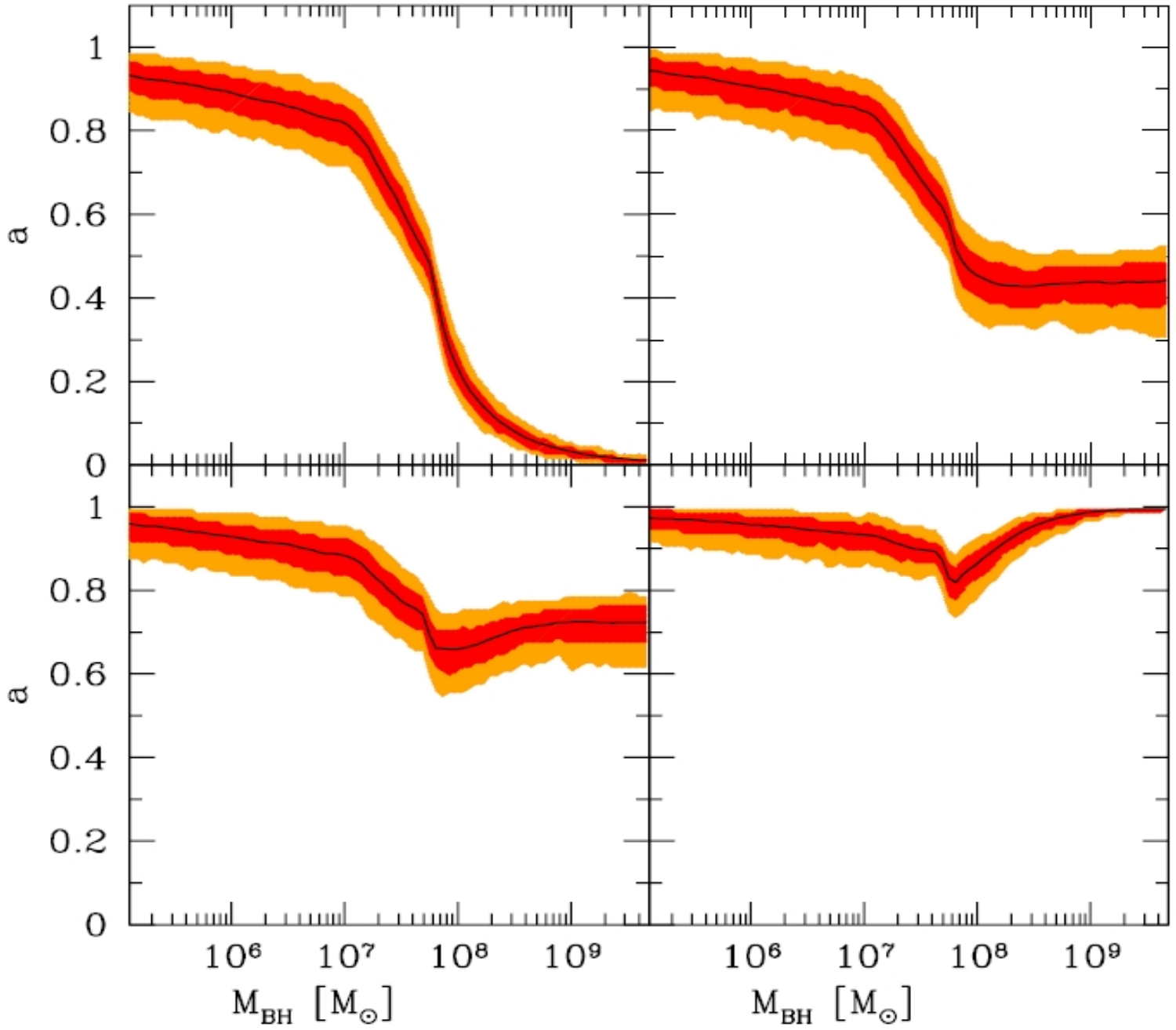

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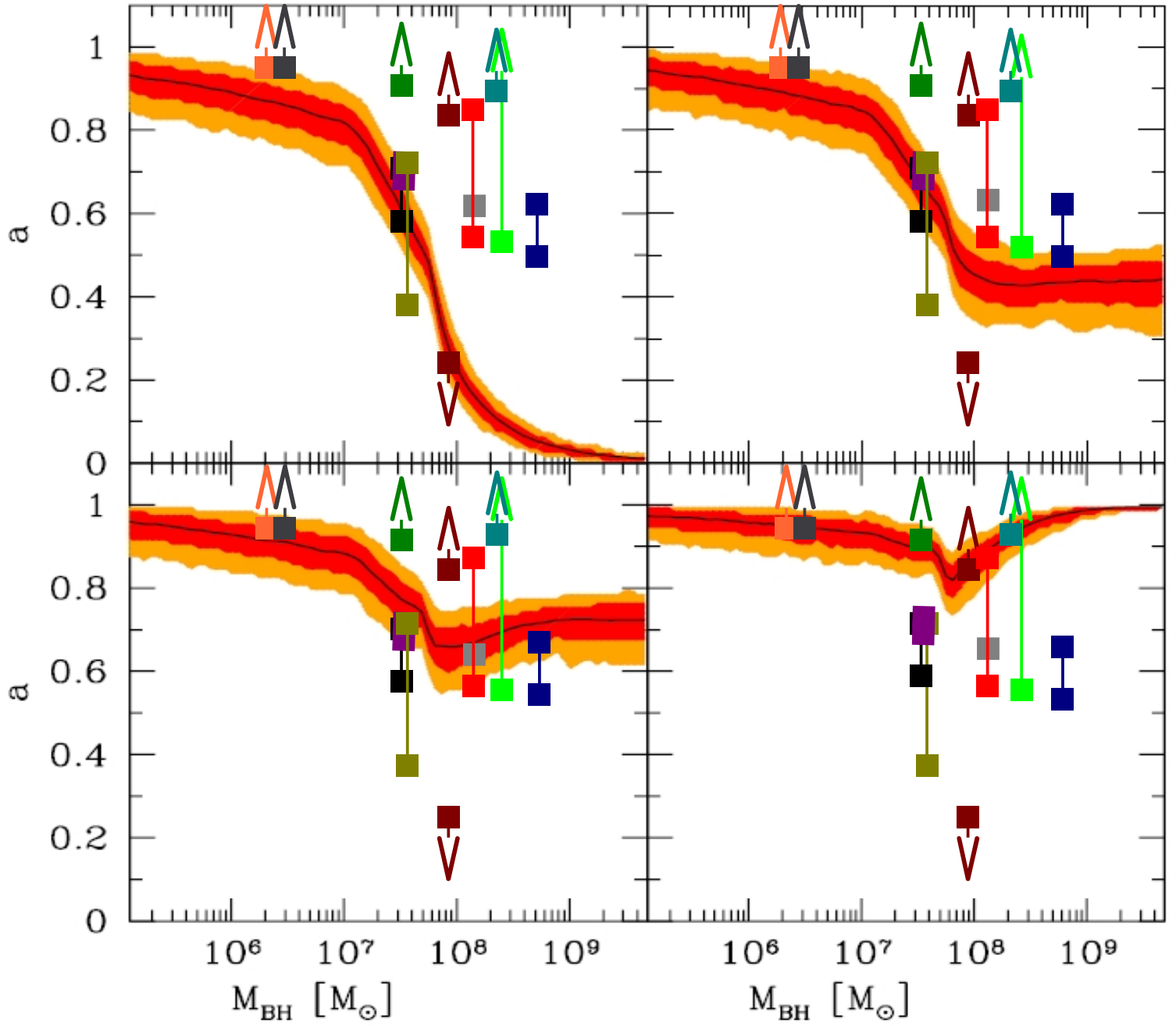

NGC 7469
Fairall 9
1H0707...
NGC 3783
Mrk 335
Mrk 79
Swift j2127
RBS 1124
Ark 120
Mrk 110
NGC 4051
MCG-6-30-15

+11 high spin objects (a>0.5) with poor mass estimates

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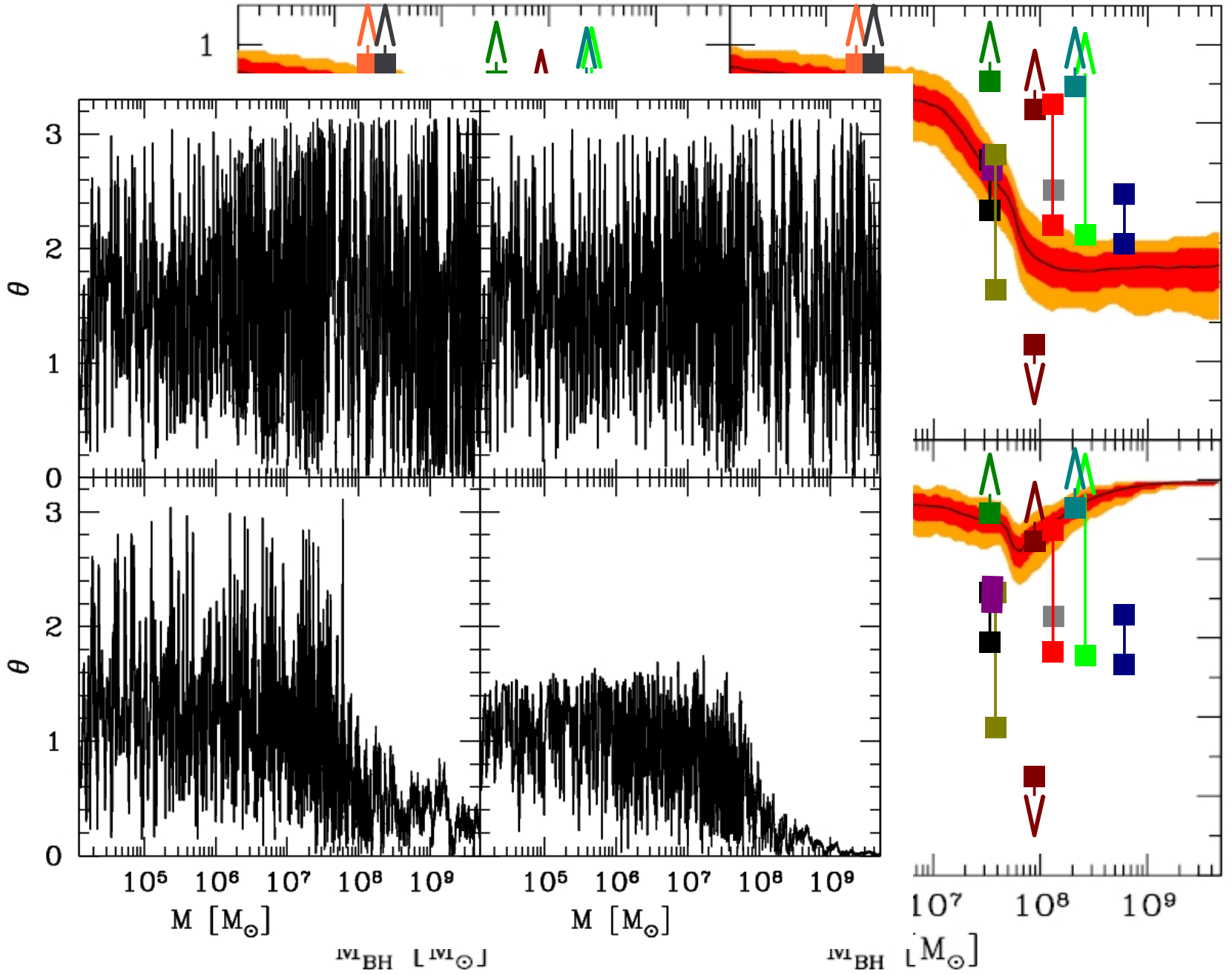

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CONCLUSIONS

spin is a vector, the evolution of its direction cannot be neglected

ONLY huge BHs keep a constant spin direction for long

small BHs are highly spinning (regardless gas dynamics)...

... but the most massive BHs have the highest spins
(if the accretion is not too chaotic)

gas dynamics matters, link to galaxy morphology?