Uncovering a Hidden Mini-Monster: A Heavily Obscured Active Galactic Nucleus in a Dwarf Star-Forming Galaxy

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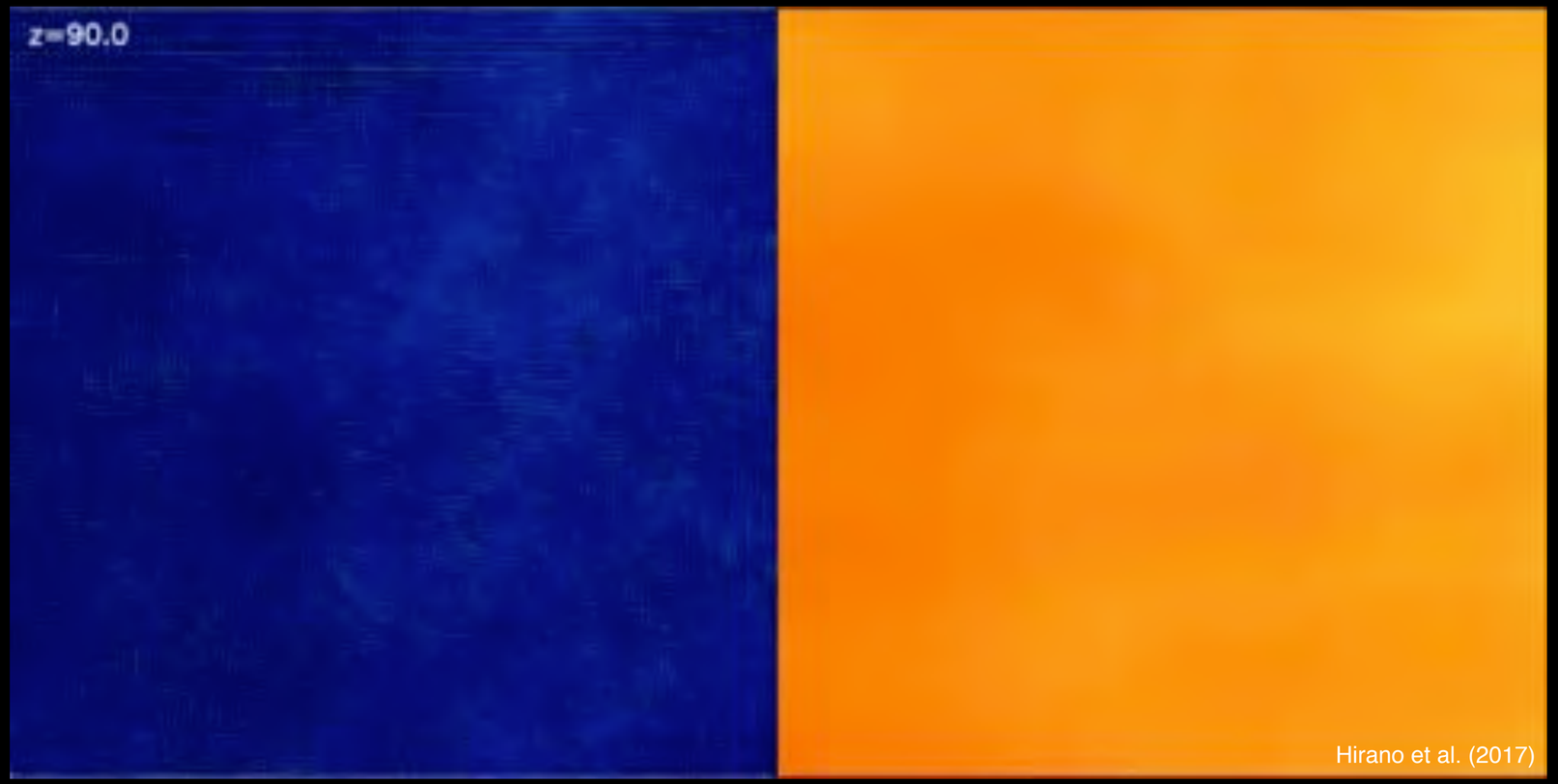
Image Credit: Credit: X-ray: NASA/CXC/Dartmouth Coll./J. Parker & R. Hickox; Optical/IR: Pan-STARRS

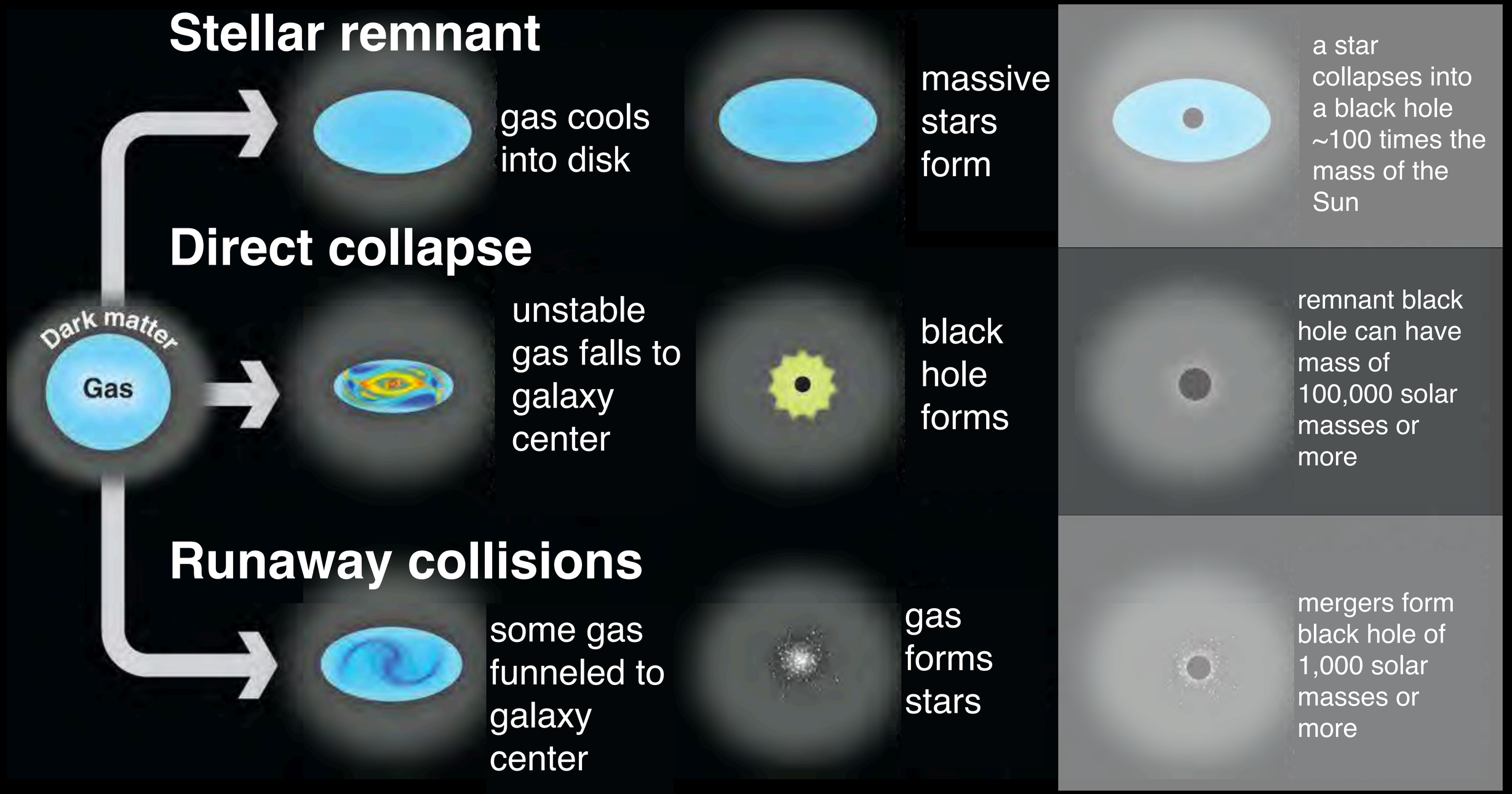
What is the origin of **supermassive black holes**?

Image Credit: NASA



Hirano et al. (2017)

The earliest supermassive black holes, more than 1 billion times more massive than the Sun, are observed when the Universe is less than a billion years old. **How did these black holes form?** There are multiple potential pathways.



Adapted from Volonteri (2012)

Simulated image by Snyder et al. (2017)

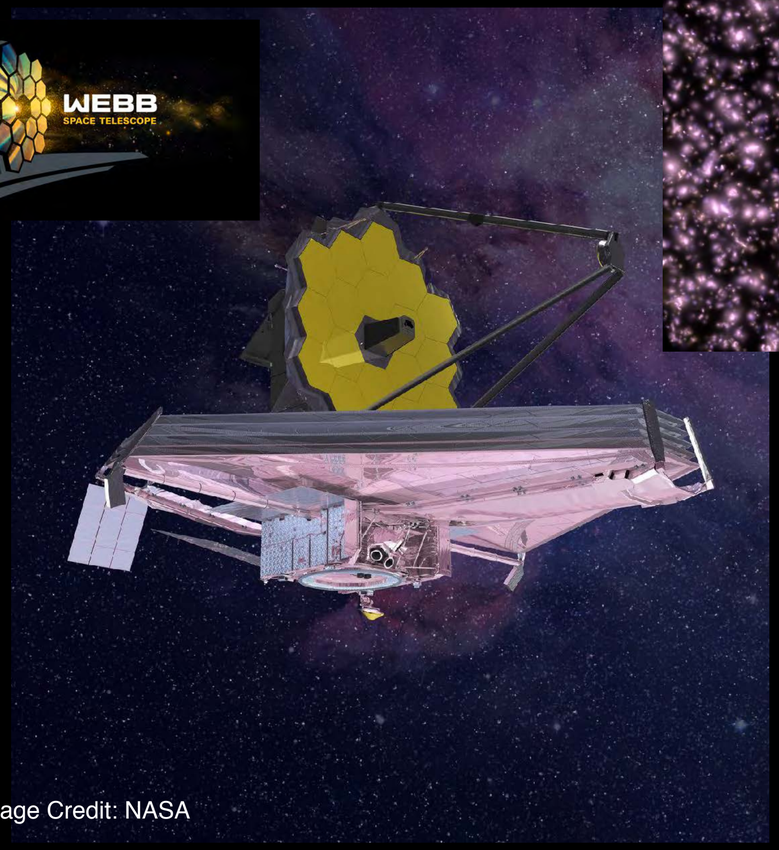


Image Credit: NASA

We are on the verge of detecting the galaxies that host these early black holes with *Webb.* But still, they are **distant**, **faint and very hard to study**!

So let's look nearby:

Dwarf galaxies are useful for studying early black holes, because they have grown relatively little over the history of the Universe

The Large Magellanic Cloud (credit: Eckhard Slawick)

Direct collapse → massive “seed black holes”

RARE process, so we would expect **relatively few** dwarf galaxies to contain massive black holes (> one hundred thousand solar masses)

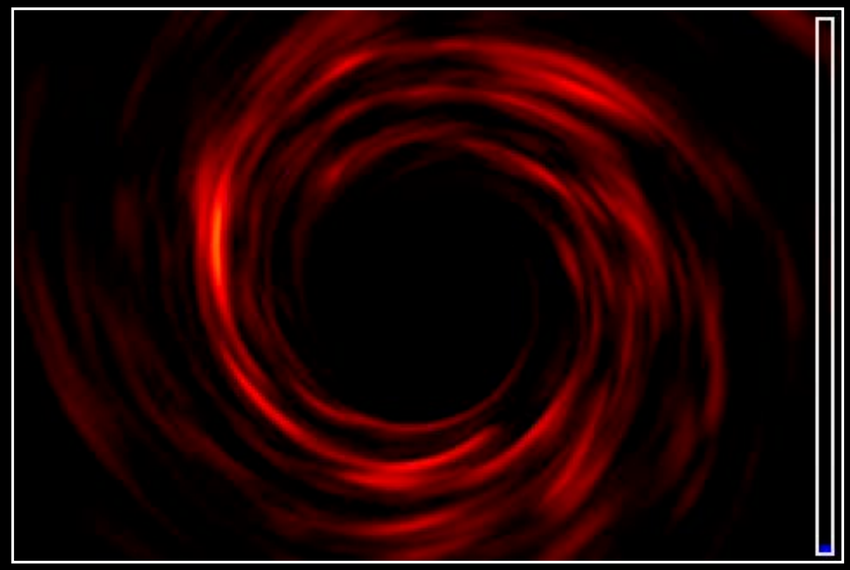
Stellar processes → light “seeds”

These are COMMON, so if we would expect **most** dwarf galaxies to contain massive black holes

BUT black holes in dwarf galaxies are **hard to find**, largely because the the light from black holes can be swamped by that from the galaxy.

We can find them by looking for light produced by **black holes accreting surrounding material** (“active galactic nuclei”; See also next presentation by Mallory Molina!)

This process is especially good at producing **X-rays**.



Armitage & Reynolds (2003)

Targeted with the **Chandra X-ray Observatory**:
Eight nearby dwarf galaxies that have some evidence for growing black holes from visible light observations

Mrk 1488

UGC 6192

NGC 5112

Mrk 462

CGCG 032-017

MCG +08-22-083

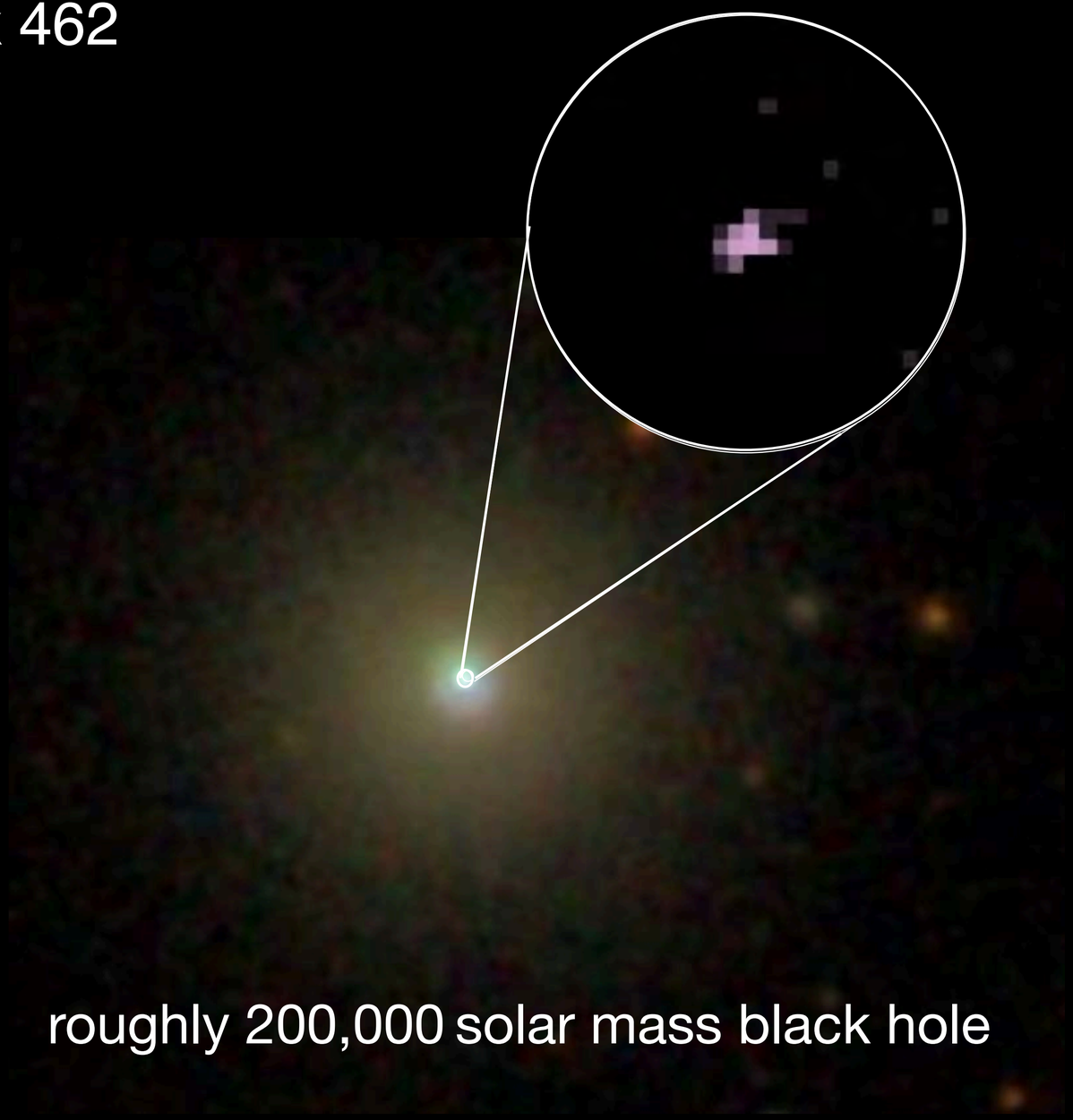
VCC 0764

UGC 0944

Image Credits: SDSS, sample taken from Reines et al. (2013)


MRK 462

Growing black hole in Mrk 462



Two things surprising about this black hole:

1. More *high-energy* than low-energy X-rays
2. X-ray brightness is fainter than you'd expect from visible and infrared emission

This black hole is **heavily obscured** by intervening material! One of the first such heavily obscured black holes in dwarf galaxies.

Growing black hole in Mrk 462

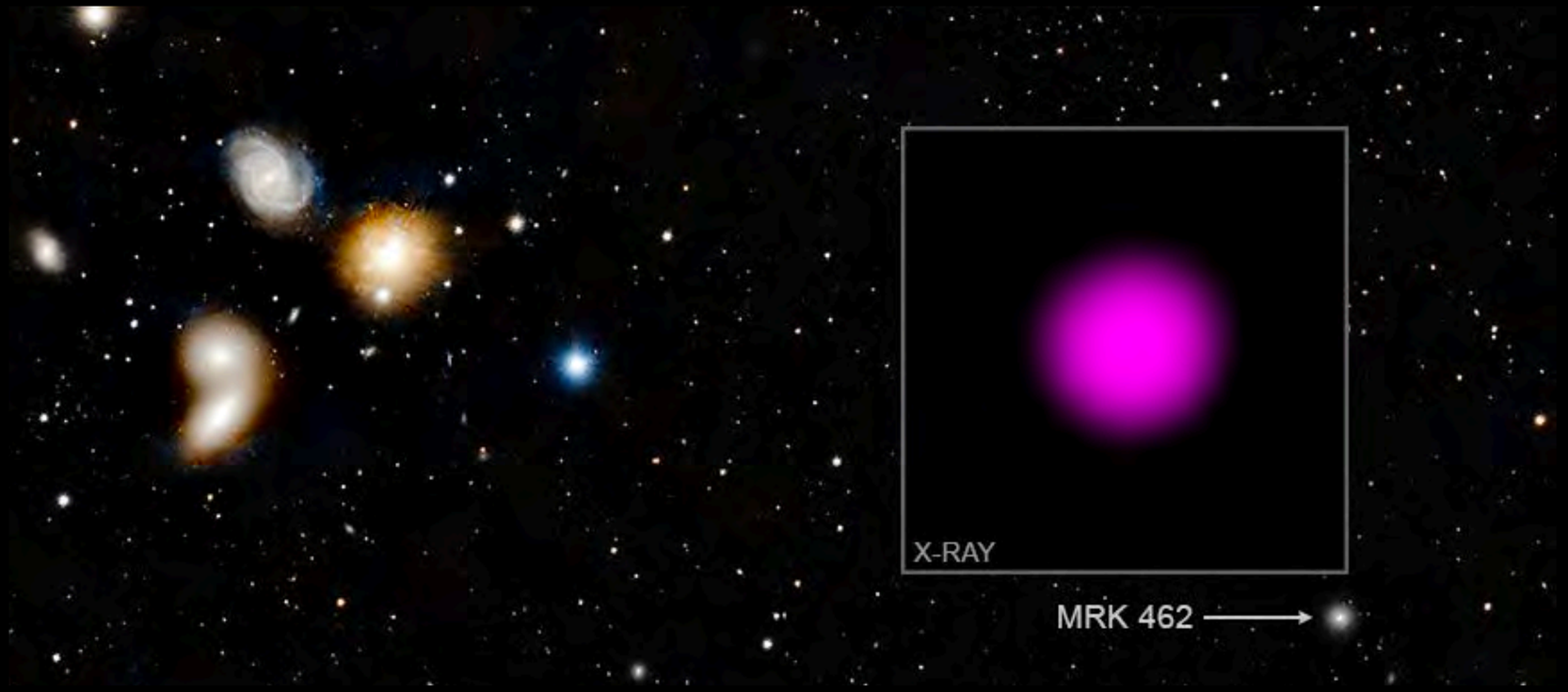
Two things surprising about this black hole:

1. More *high-energy* than low-energy X-rays
2. X-ray brightness is fainter than you'd expect from visible and infrared emission

This black hole is **heavily obscured** by intervening material! One of the first such heavily obscured black holes in dwarf galaxies.

Conclusions

Chandra observations show the dwarf galaxy Mrk 462 contains a **heavily obscured, growing, massive black hole**. Other such obscured black holes may be “missing” from previous surveys, and could indicate a much larger population of massive black holes in dwarf galaxies.



This could have important implications for **how the first black holes formed** in the early Universe, and whether **black holes have an important role to play in the lives of dwarf galaxies**.

Thanks to the Chandra Press Office:
https://chandra.si.edu/press/_releases/press_0110.html
https://chandra.si.edu/photo/2022/mrk462/

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