

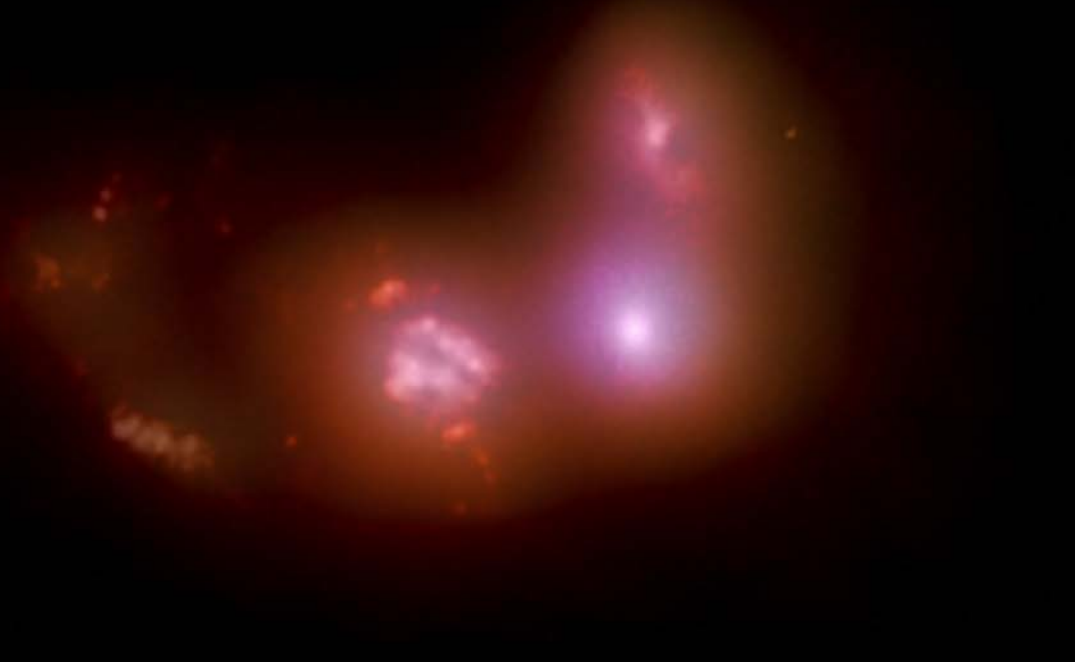
Three's a crowd: Triple Galaxy Collisions and Their Impact on Black Hole Accretion

Dr. Adi Foord

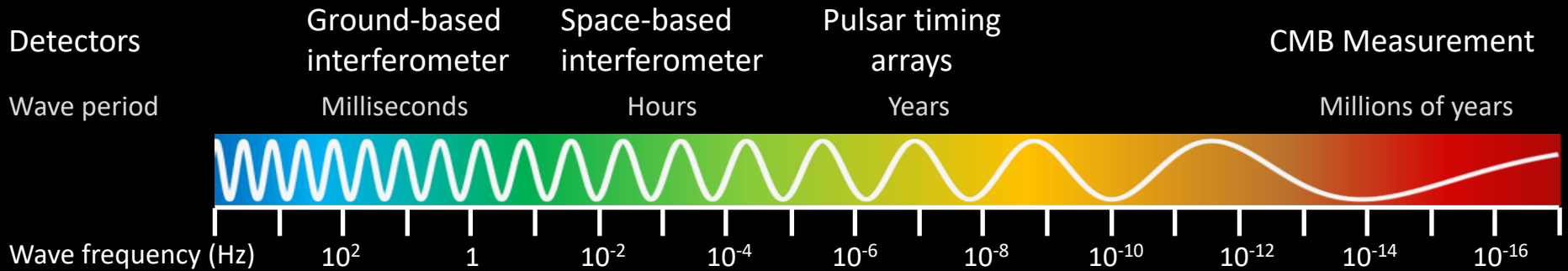
Porat Postdoctoral Fellow
Stanford University

✉ foord@stanford.edu

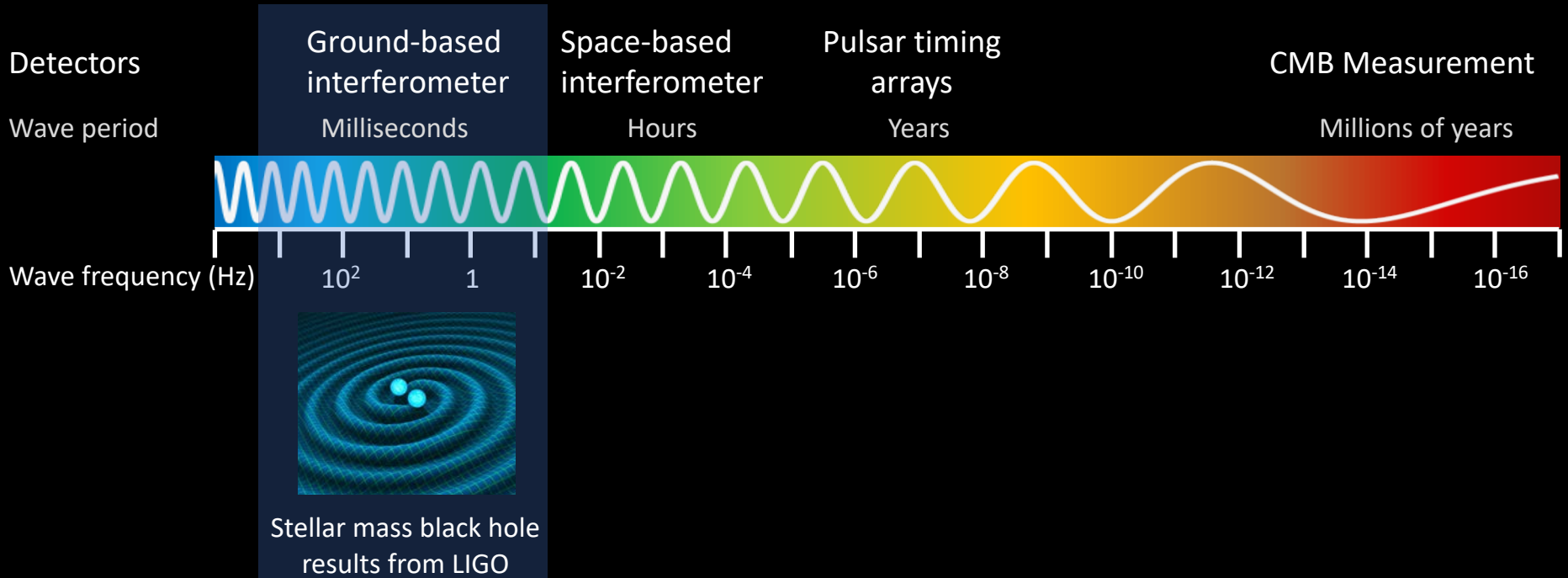
🐦 @AdiFoord



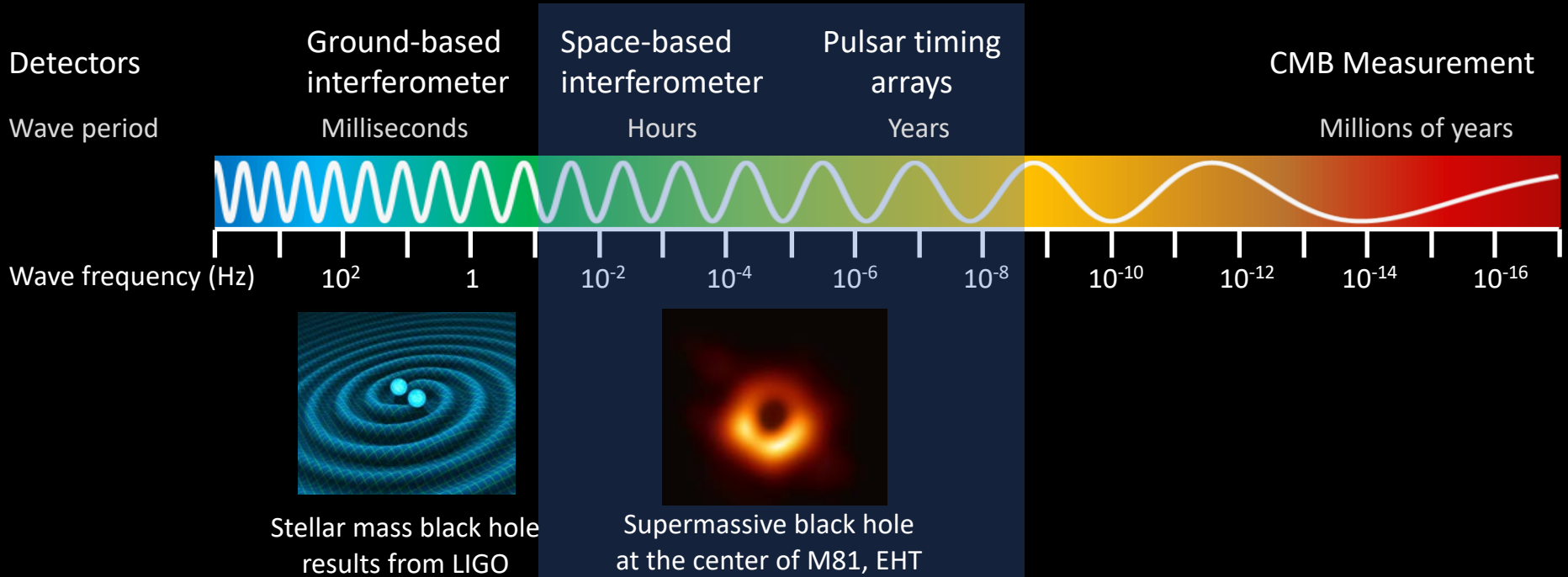
We now have proof that black holes exist and merge



We now have proof that black holes exist and merge



We now have proof that black holes exist and merge



Galaxy mergers are the best observational evidence for supermassive black hole collisions



NGC 2207

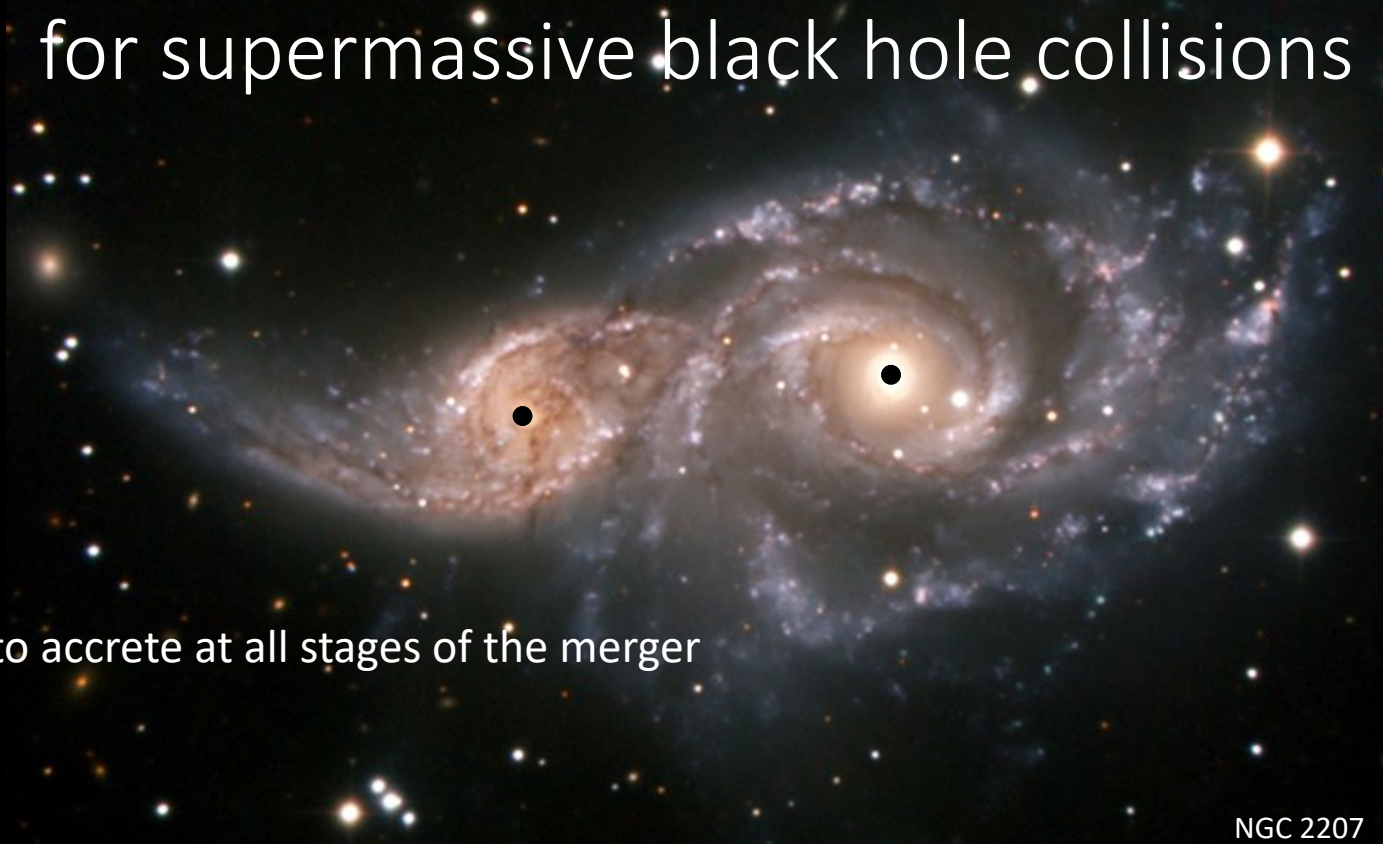


Galaxy mergers are the best observational evidence for supermassive black hole collisions



NGC 2207

Galaxy mergers are the best observational evidence for supermassive black hole collisions



Needs gas to accrete at all stages of the merger

NGC 2207

Galaxy mergers are the best observational evidence for supermassive black hole collisions

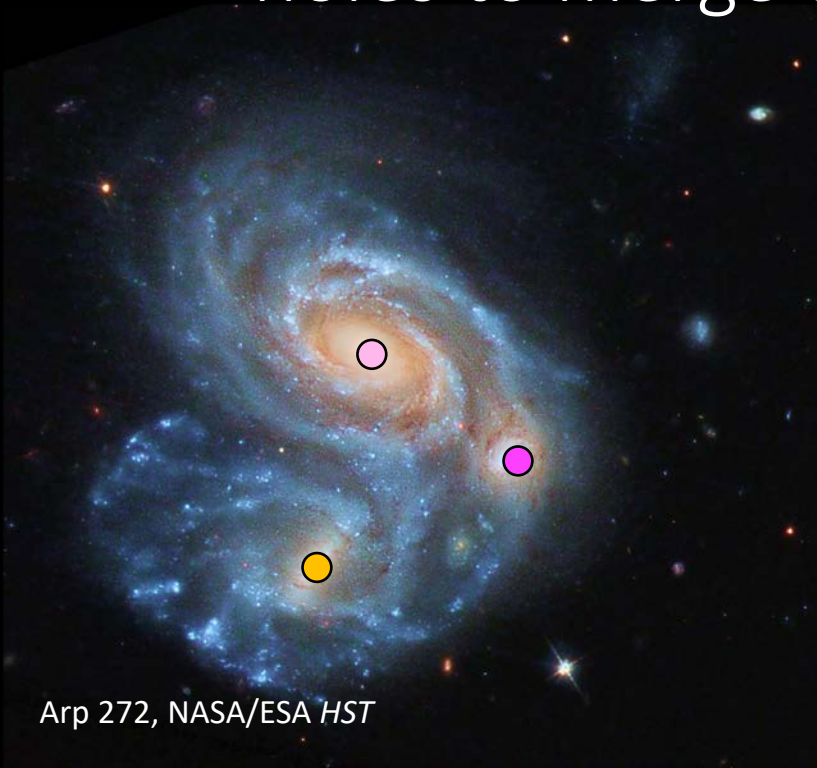


Needs gas to accrete at all stages of the merger

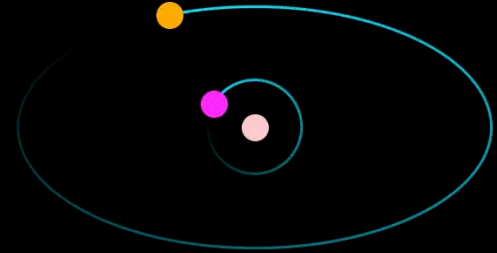
Merger timescale can still be greater than the age of the Universe (13.8 billion years)!

NGC 2207

Triple galaxy mergers allow supermassive black holes to merge on realistic timescales



Arp 272, NASA/ESA HST



A systematic search for nearby triple supermassive black holes



“AGN Triality of Triple Mergers: Detection of Faint X-ray Point Sources”

Foord, Gültekin, Runnoe, & Koss 2021a, *The Astrophysical Journal* (arXiv:2012.00761)

“AGN Triality of Triple Mergers: Multi-wavelength Classifications”

Foord, Gültekin, Runnoe, & Koss 2021b, *The Astrophysical Journal* (arXiv:2012.00769)



A systematic search for nearby triple supermassive black holes



Goals:

- (1) Find new triple growing SMBH systems
- (2) Analyze how many growing SMBHs (0, 1, 2, 3) are in each triple galaxy merger
- (3) Compare environmental properties of each merger

“AGN Triality of Triple Mergers: Detection of Faint X-ray Point Sources”

Foord, Gültekin, Runnoe, & Koss 2021a, *The Astrophysical Journal* (arXiv:2012.00761)

“AGN Triality of Triple Mergers: Multi-wavelength Classifications”

Foord, Gültekin, Runnoe, & Koss 2021b, *The Astrophysical Journal* (arXiv:2012.00769)



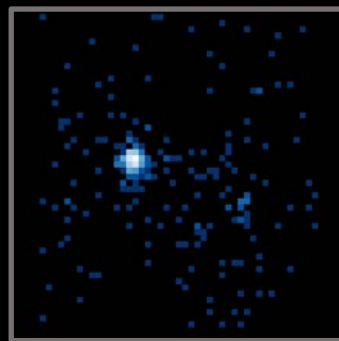
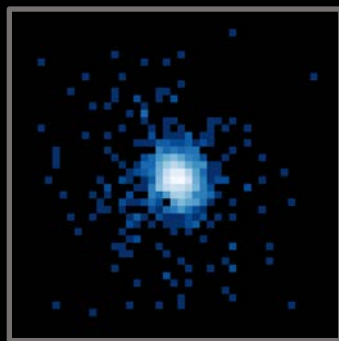
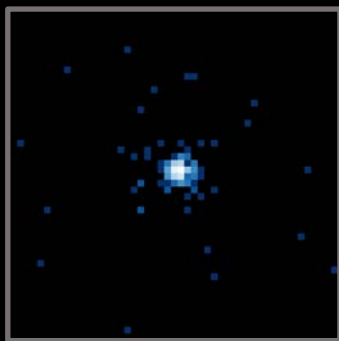
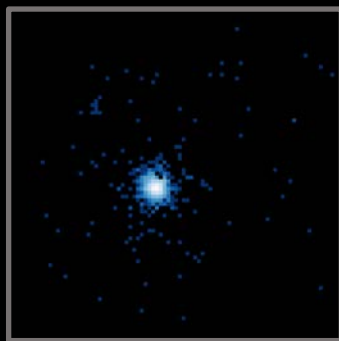
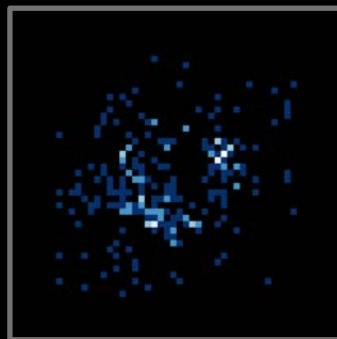
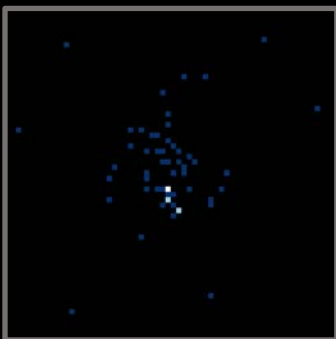
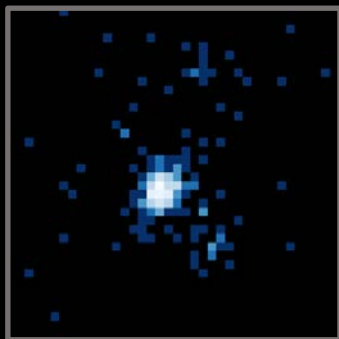
A systematic search for nearby triple supermassive black holes

Sloan Digital Sky Survey
(SDSS)



A systematic search for nearby triple supermassive black holes

Chandra X-ray
Observatory

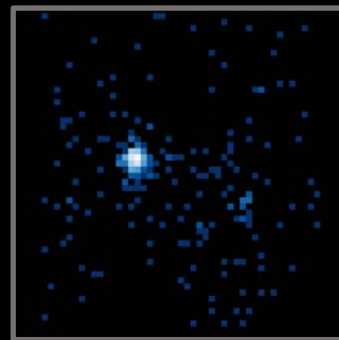
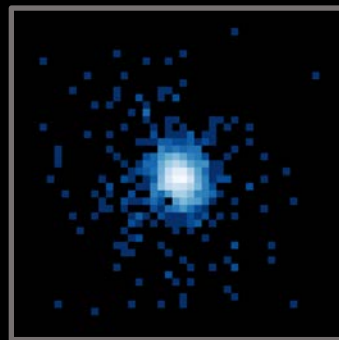
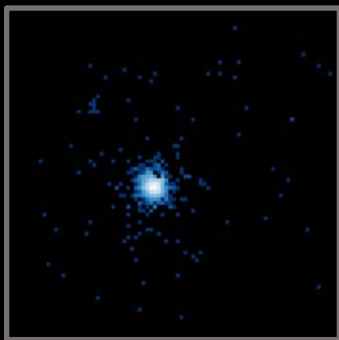
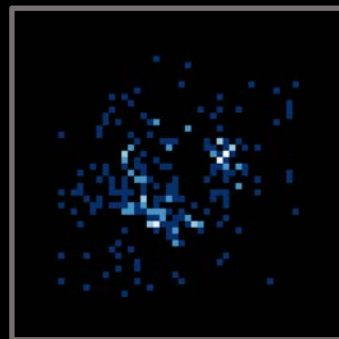
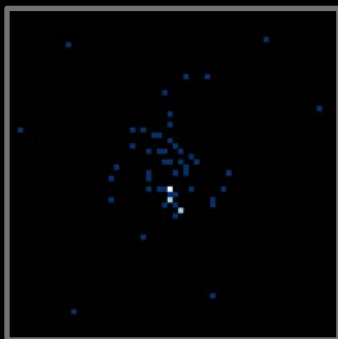
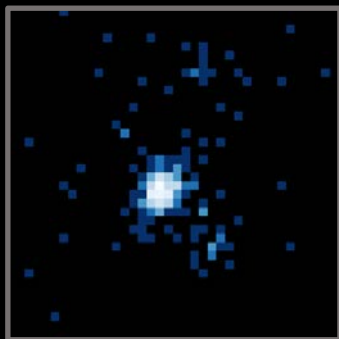


A systematic search for nearby triple supermassive black holes

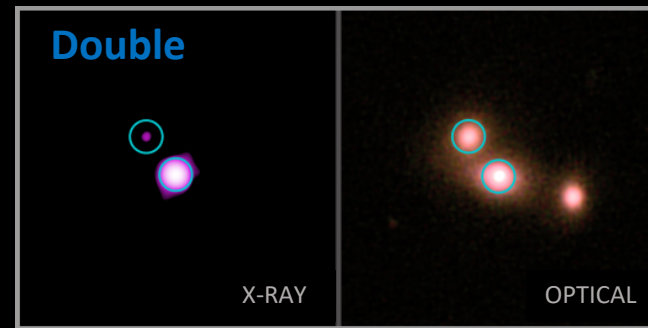
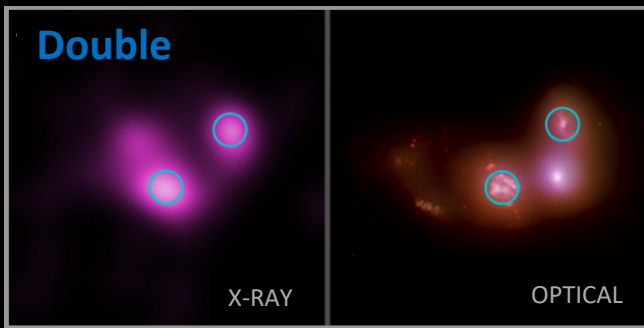
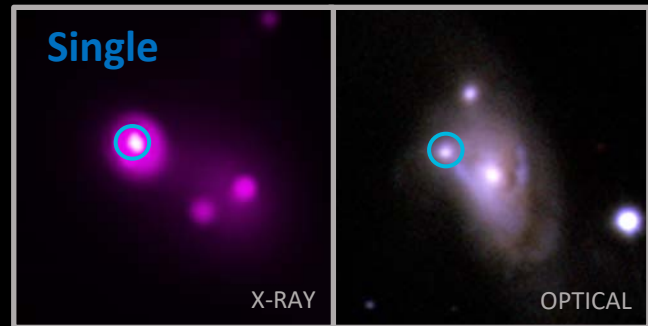
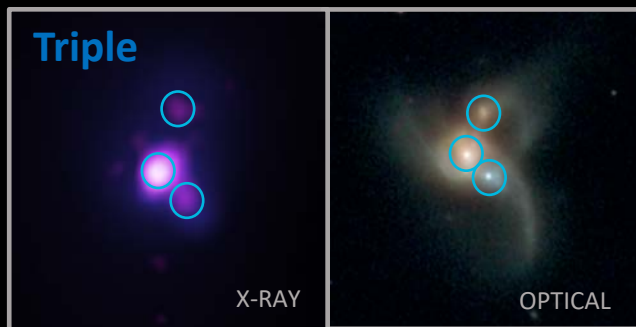
Chandra X-ray
Observatory



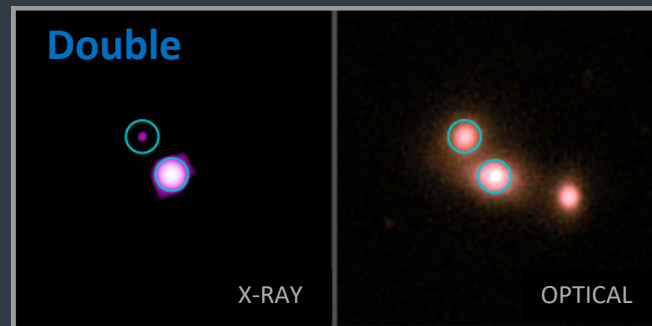
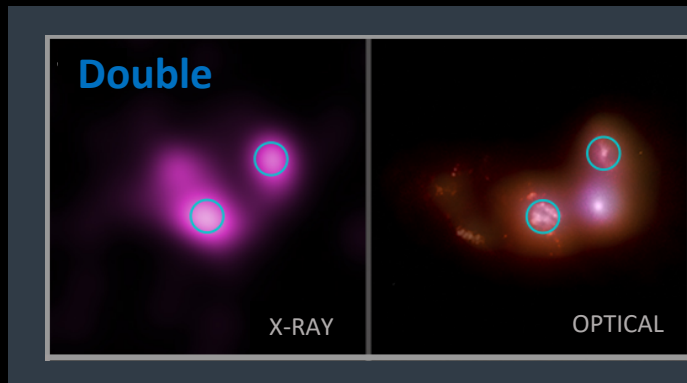
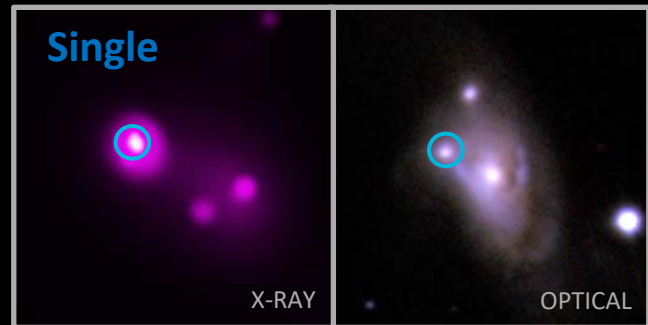
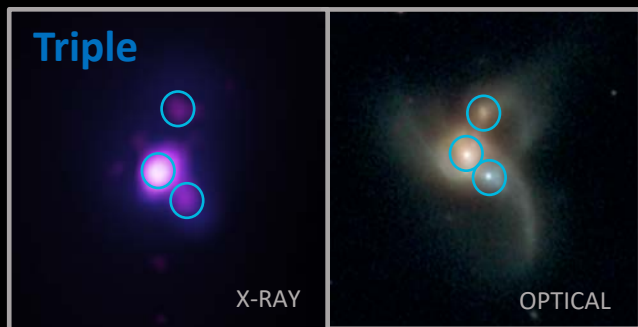
BAYMAX



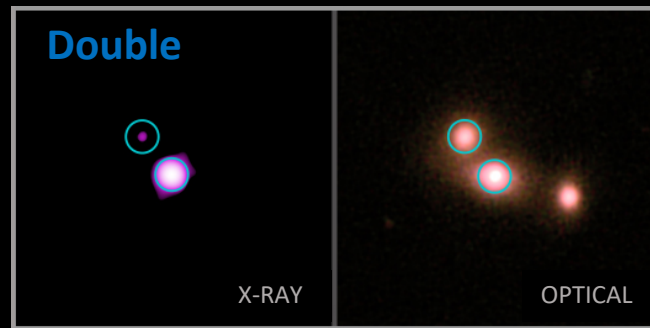
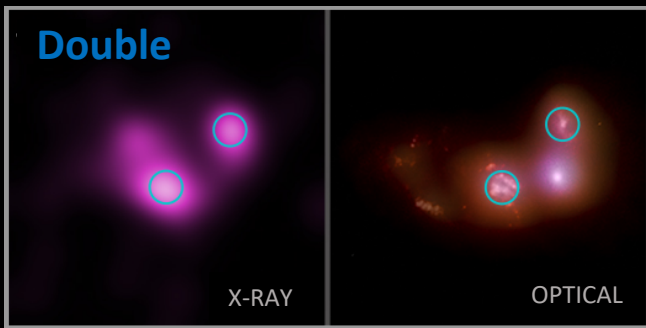
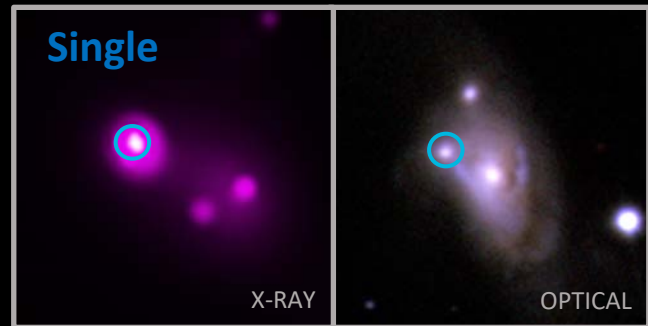
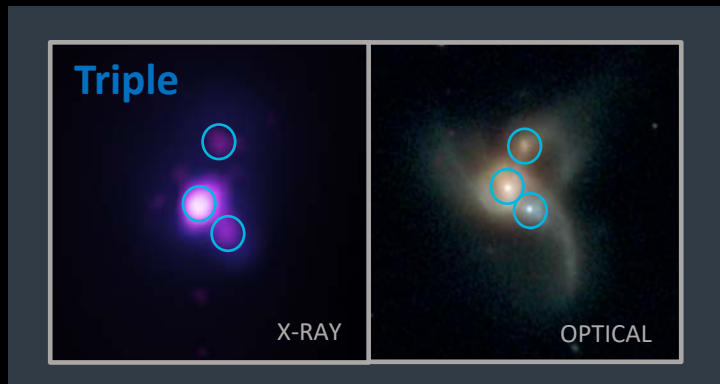
The triple mergers had a wide range of SMBH activity



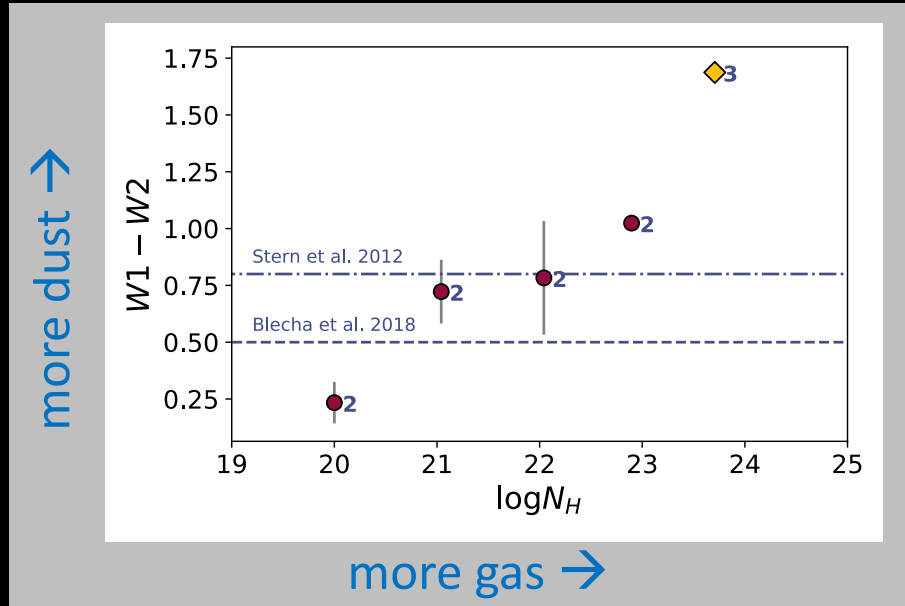
The triple mergers had a wide range of SMBH activity



The triple mergers had a wide range of SMBH activity



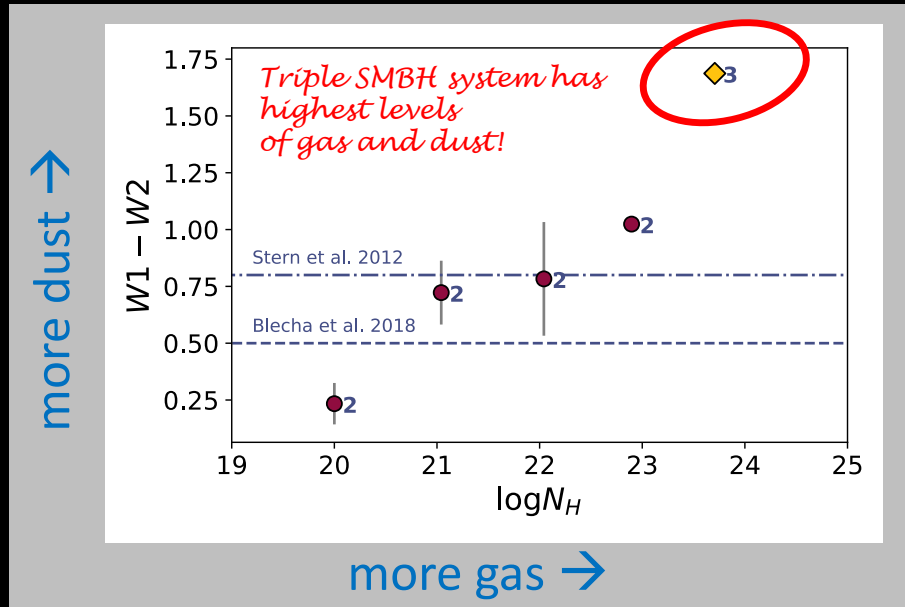
Increasing gas and dust levels may give rise to more growing SMBHs



We found a trend between the **levels of gas and dust** in the mergers.

This suggests that the **motions of gas and dust are coupled** in merging environments, & large amounts can be **efficiently funneled into the active central region.**

Increasing gas and dust levels may give rise to more growing SMBHs



We found a trend between the **levels of gas and dust** in the mergers.

This suggests that the **motions of gas and dust are coupled** in merging environments, & large amounts can be **efficiently funneled into the active central region.**

Triple Galaxy Collisions and Their Impact on Black Hole Accretion

Recap:

This study used X-ray, optical, and IR observations of supermassive black holes to study **how** supermassive black holes grow and **what** triggers this growth

We focused on a sample of triple galaxy systems, which are important for supermassive black hole growth and evolution via mergers



Triple Galaxy Collisions and Their Impact on Black Hole Accretion

Recap:

Analyzed sample of 7 triple galaxy mergers to search for triple supermassive black hole systems

Discovered 4 likely double supermassive black hole systems and confirmed one triple supermassive black hole system

Gas and dust levels are linked, and the triple supermassive black hole system has the highest levels of both

