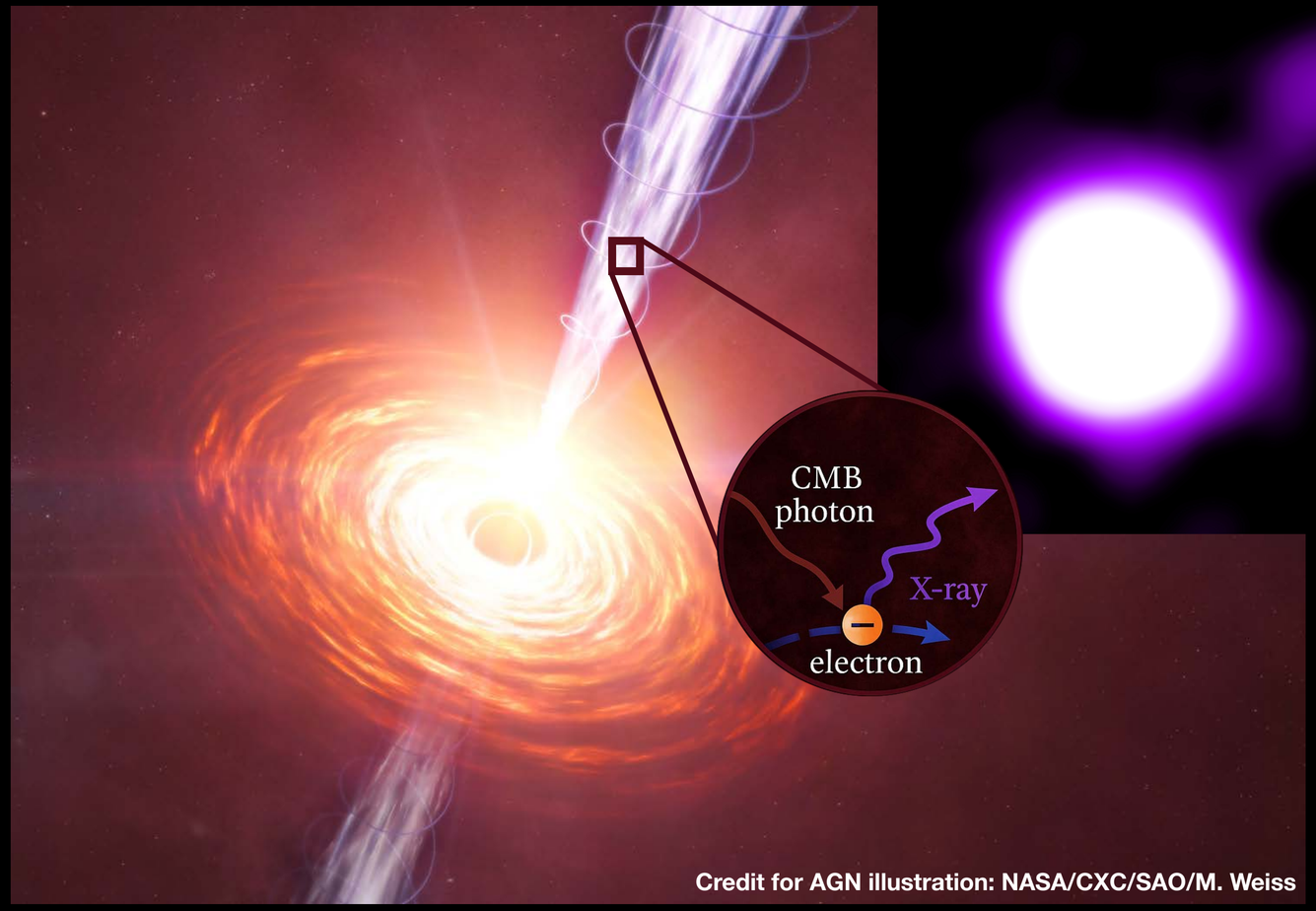
Chandra Reveals Two Distant Quasars Transforming Universe's First Light into High-Energy X-Ray Jets



Jaya Maithil

SAO Postdoctoral Research Fellow

with

Dan Schwartz, Aneta Siemiginowska

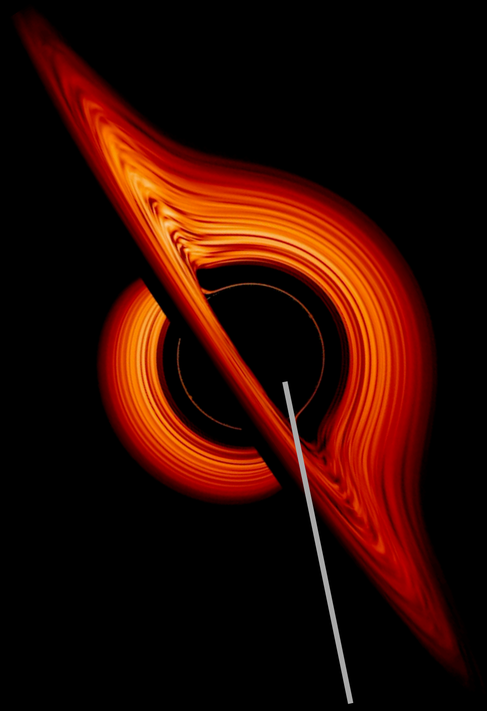
and the team

CENTER FOR ASTROPHYSICS
HARVARD & SMITHSONIAN

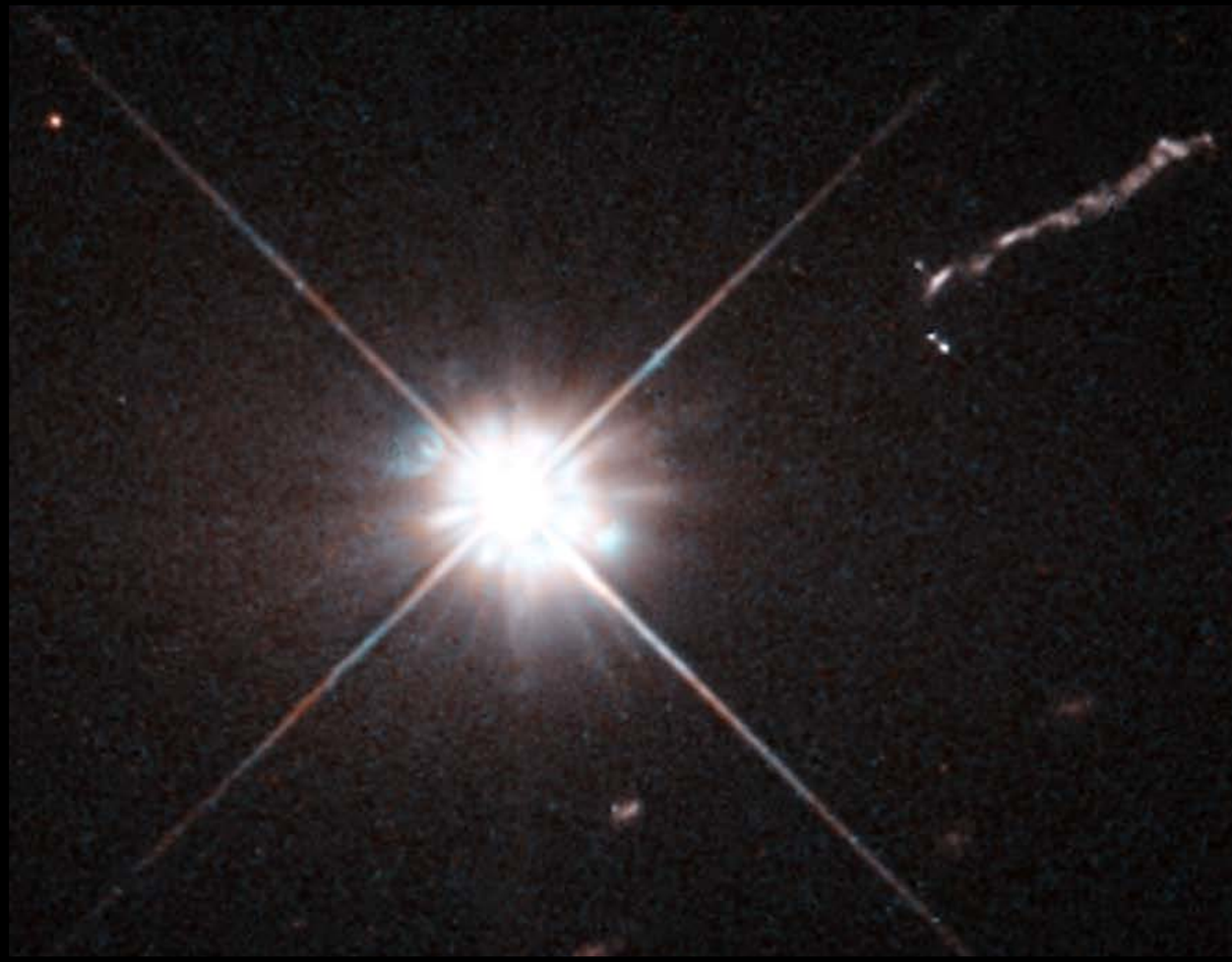
jaya.maithil@cfa.harvard.edu

Quasars: The Universe's Brightest Lighthouses

Mass ~ Million to Billion x Sun, Brightness ~ 1000 x Milky Way, Size ~ Solar System



Supermassive
Black Hole
$\approx 10^{36} - 10^{39}$ kg

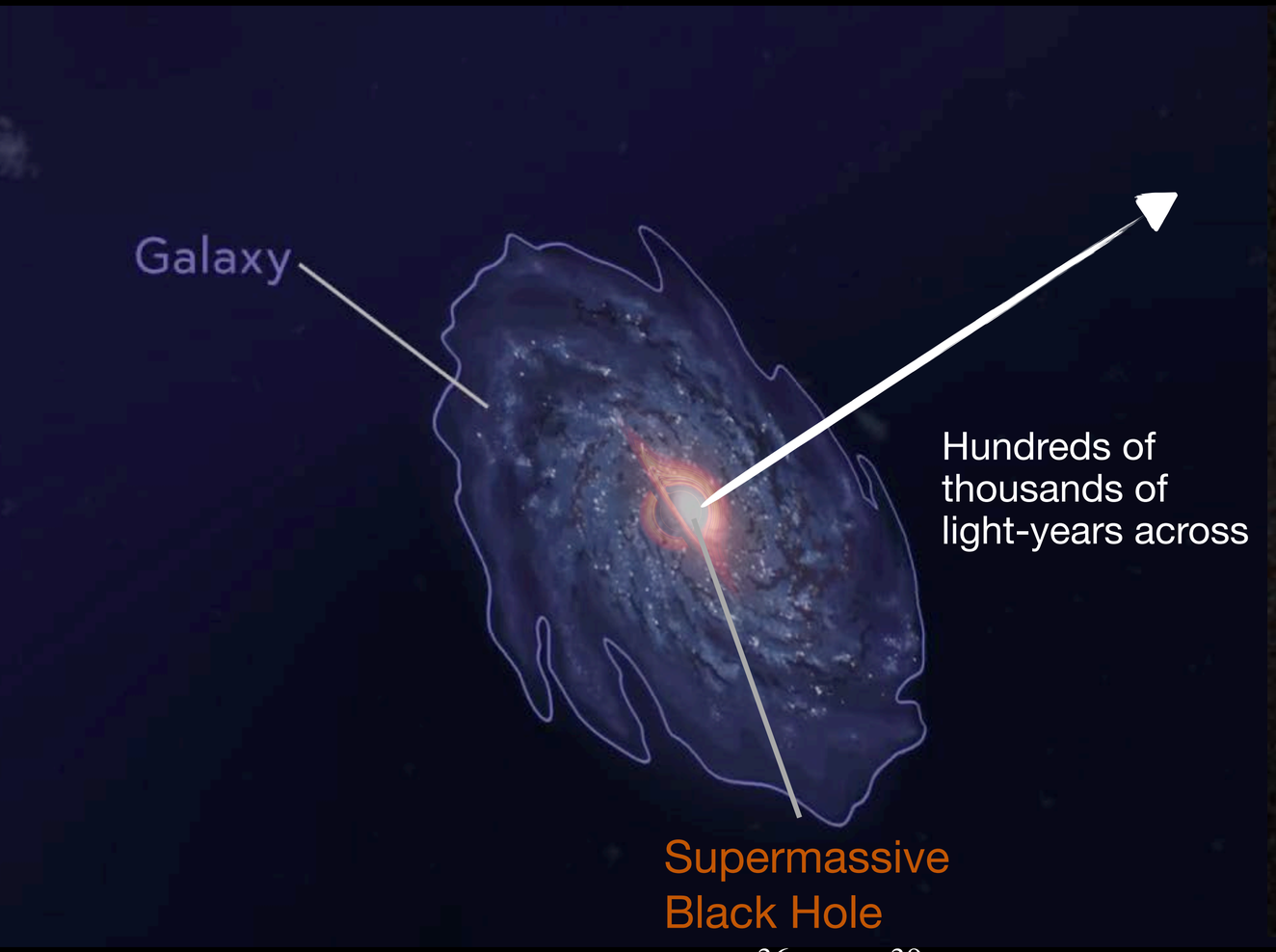


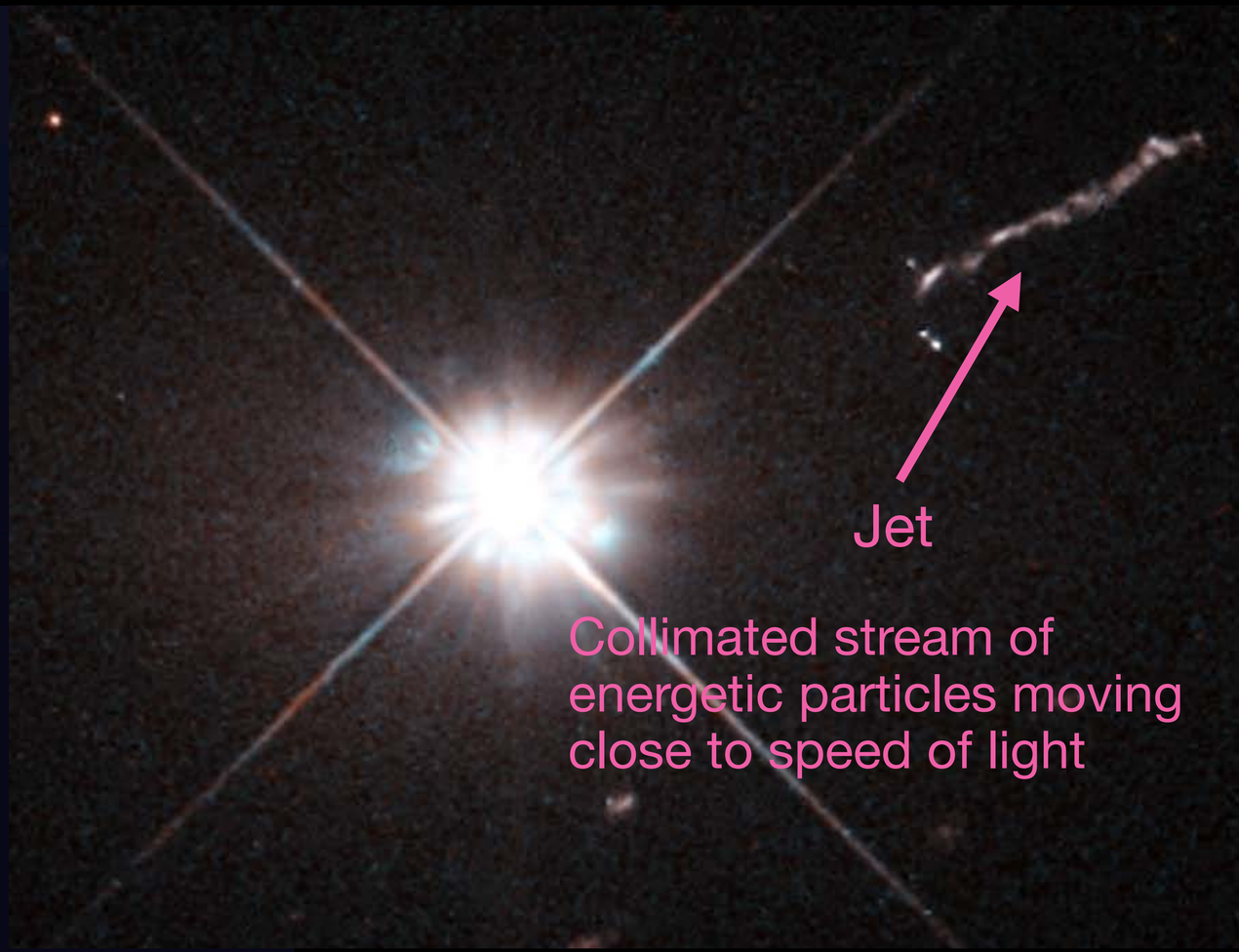
3C 273: First quasar ever identified in 1963

Credit for accretion disk animation: NASA's Goddard Space Flight Center/Jeremy Schnittman Credit for 3C273 image (rotated): NASA and J. Bahcall (IAS)

Quasars: The Universe's Brightest Lighthouses

Mass ~ Million to Billion x Sun, Brightness ~ 1000 x Milky Way, Size ~ Solar System

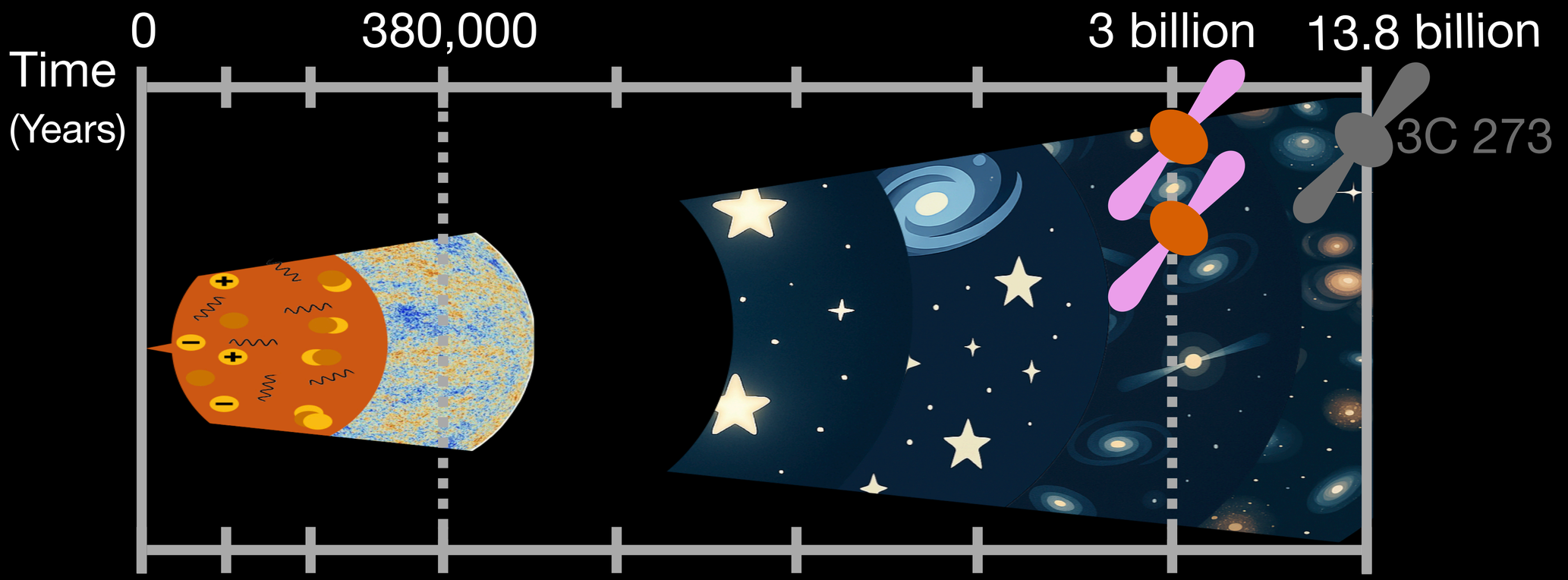




3C 273: First quasar ever identified in 1963

Credit for accretion disk animation: NASA's Goddard Space Flight Center/Jeremy Schnittman Credit for 3C273 image (rotated): NASA and J. Bahcall (IAS) Credit for galaxy animation: NASA, ESA, Leah Hustak (STScI)

Cosmic Context: Why This Matters



Big Bang
Birth of space and time

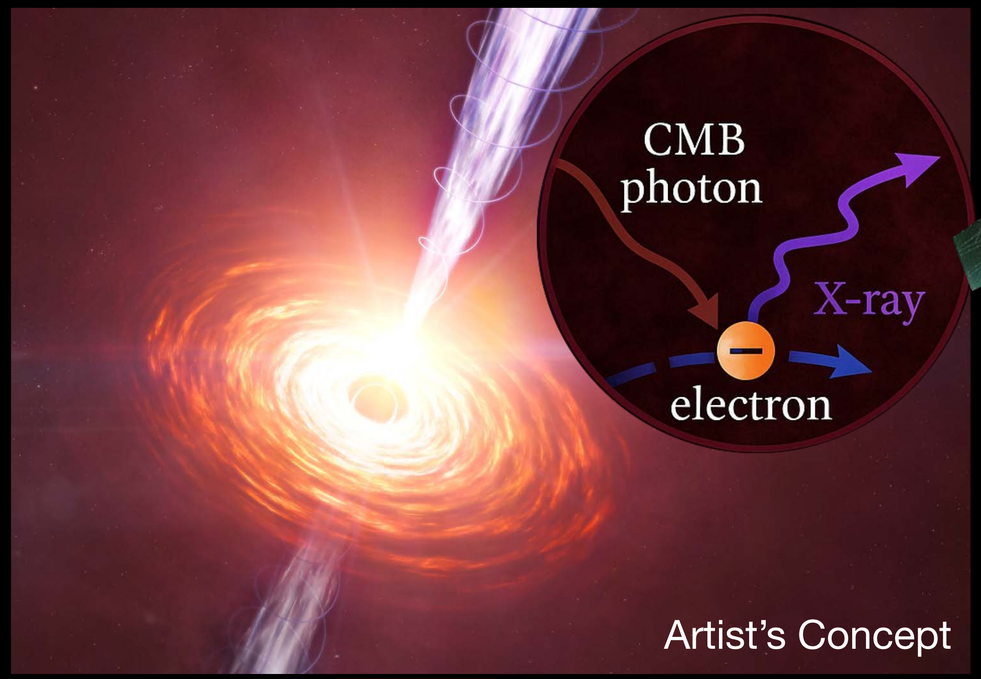
Cosmic Microwave Background (CMB)
Universe cools enough for photons to decouples and travels freely

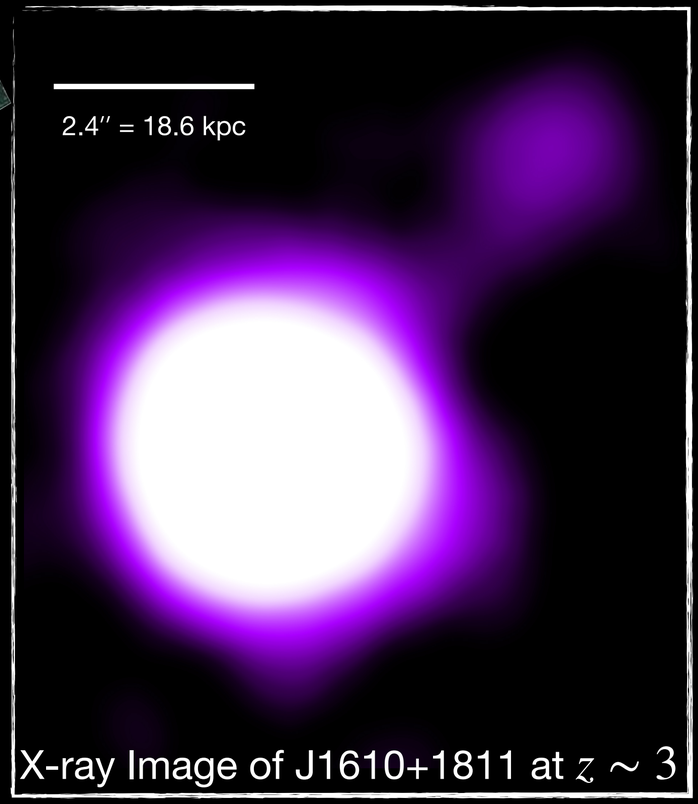
Cosmic “Noon”
Peak of star formation and quasar activity

J1405+0415 & J1610+1811

You Are Here

NASA's Chandra Reveals Surprisingly Strong Black Hole Jet at Cosmic "Noon"



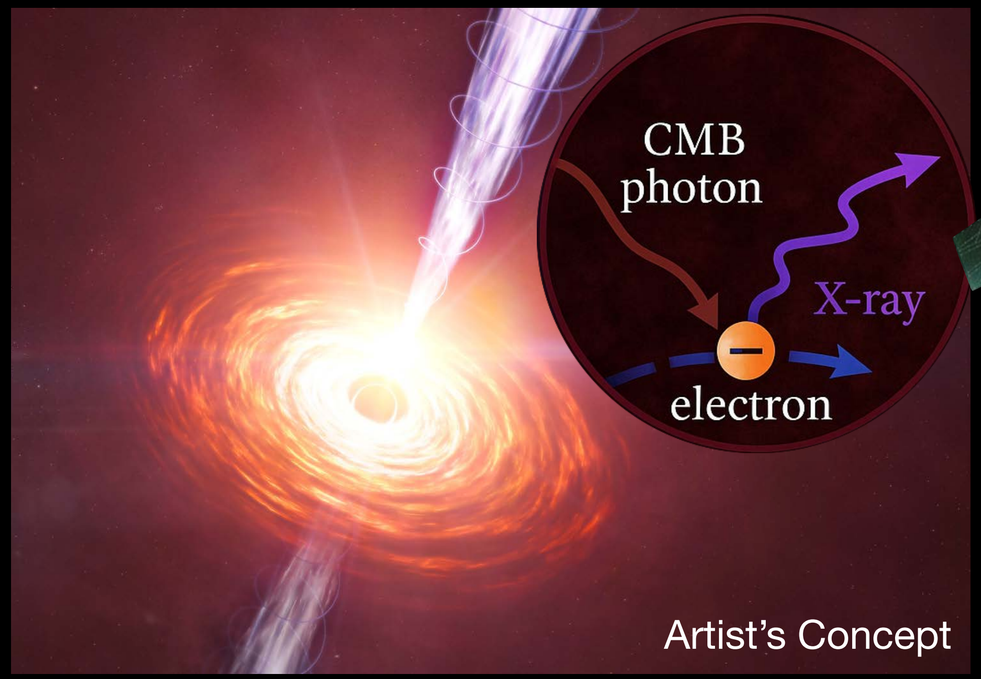


Chandra's superior X-ray resolution enabled detection of these jets despite their extreme distance and proximity to bright quasar cores

Credit for AGN illustration: NASA/CXC/SAO/M. Weiss

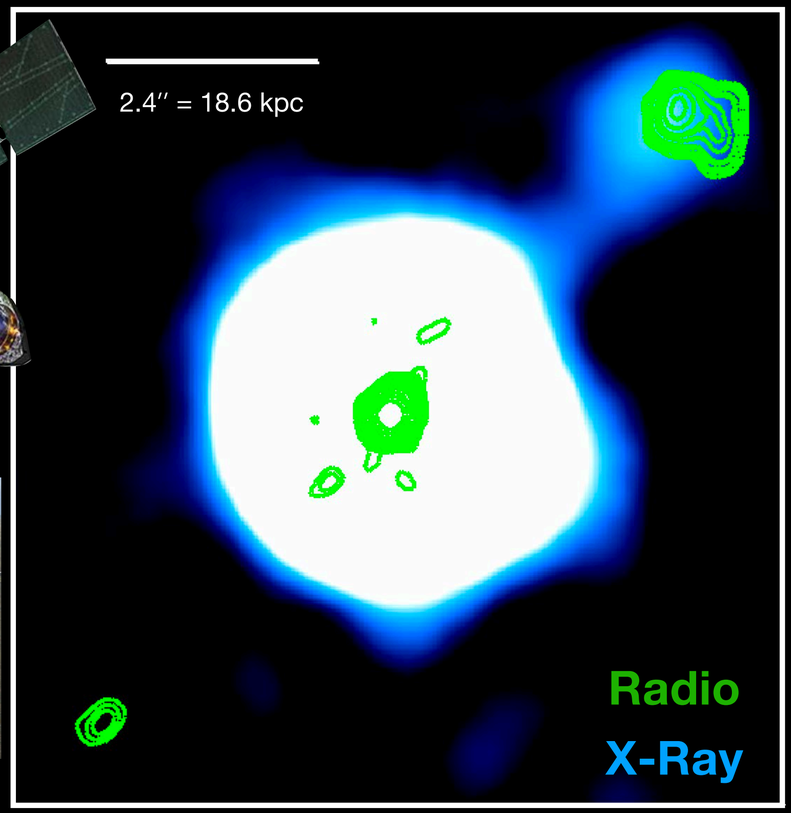
A Multi-wavelength View

Continuous X-ray Jets Without Radio Counterparts



Chandra

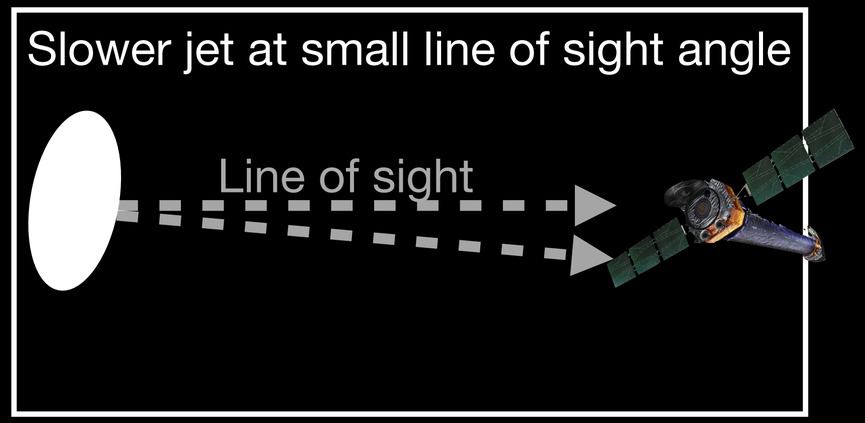
Very Large Array

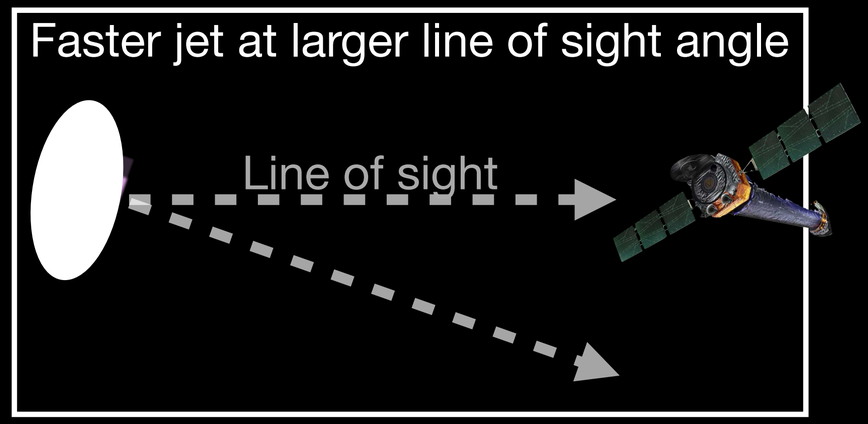


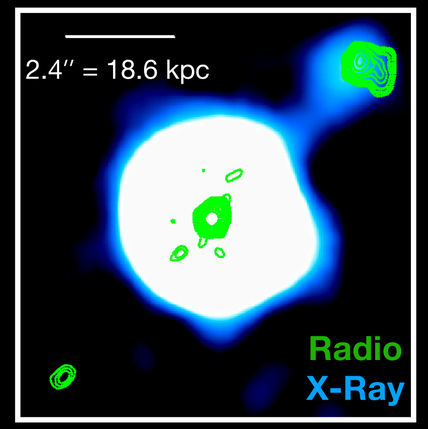
Radio-emitting electrons fade faster than X-ray-emitting ones that boost CMB

Credit for AGN illustration: NASA/CXC/SAO/M. Weiss

Revealing How Fast & How Direct Quasar Jets Really Are



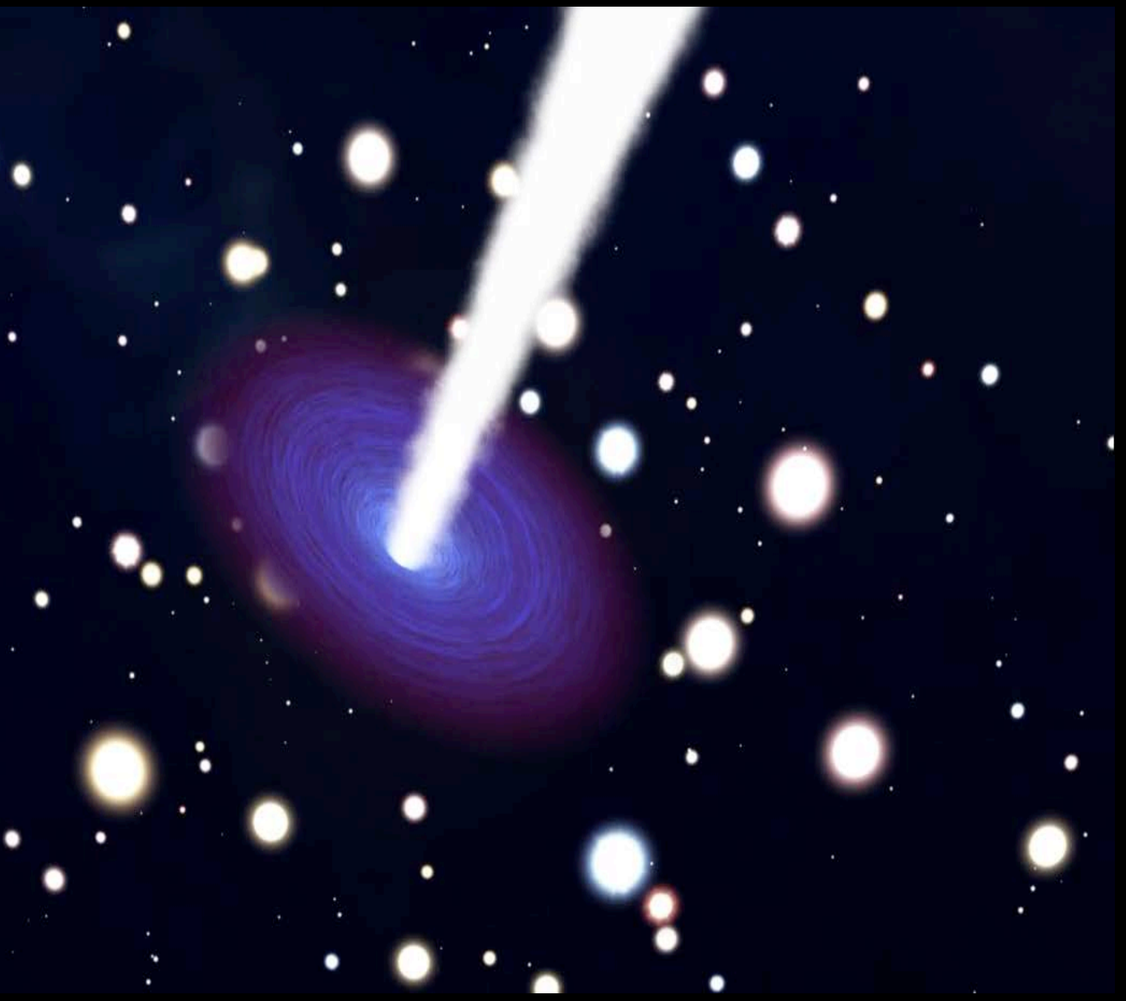




Our novel approach untangles jet speed ↔ angle

	Speed (% of light-speed)	**Angle**
J1405+0415	97%	9°
J1610+1811	95%	11°

Surprisingly Powerful Jet in J1405+0415



Power: 5×10^{46} erg $s^{-1} \approx 10$ trillion Suns

Jet carries half of quasar's total power output

Enormous energy funneled into a narrow beam

Over 10 million years ⇒ $\sim 10^{54}$ Joules

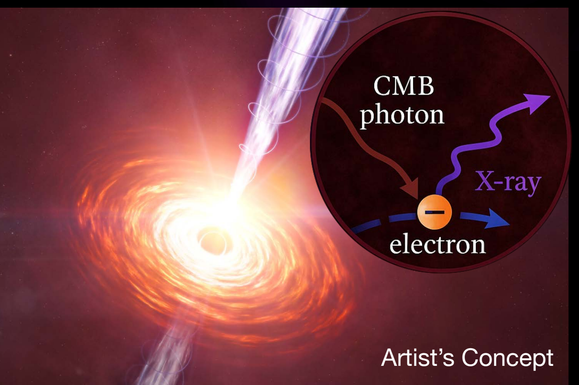
Dominates energy of cluster they reside in

Reshapes host galaxy and its cosmic neighborhood

Credit for Animation : NASA, ESA, and the Hubble SM4 ERO Team

Discovery Highlights

- Chandra finds 300,000 ly long X-ray jets in J1405+0415 & J1610+1811 at cosmic noon
- CMB recycling explains X-ray but no radio
- Our novel approach untangles jet speed ↔ angle
  - Jets travel at 97% & 95% of light speed
  - Point only ~10° from us (9°, 11°)
- J1405+0415 jet carries ≈ 1/2 of quasar's total power



Press Release

Published in ApJ, DOI:10.3847/1538-4357/adccc1

Science Talk in Session #410 on June 12 at 11:00 AM

Contact: jaya.maithil@cfa.harvard.edu