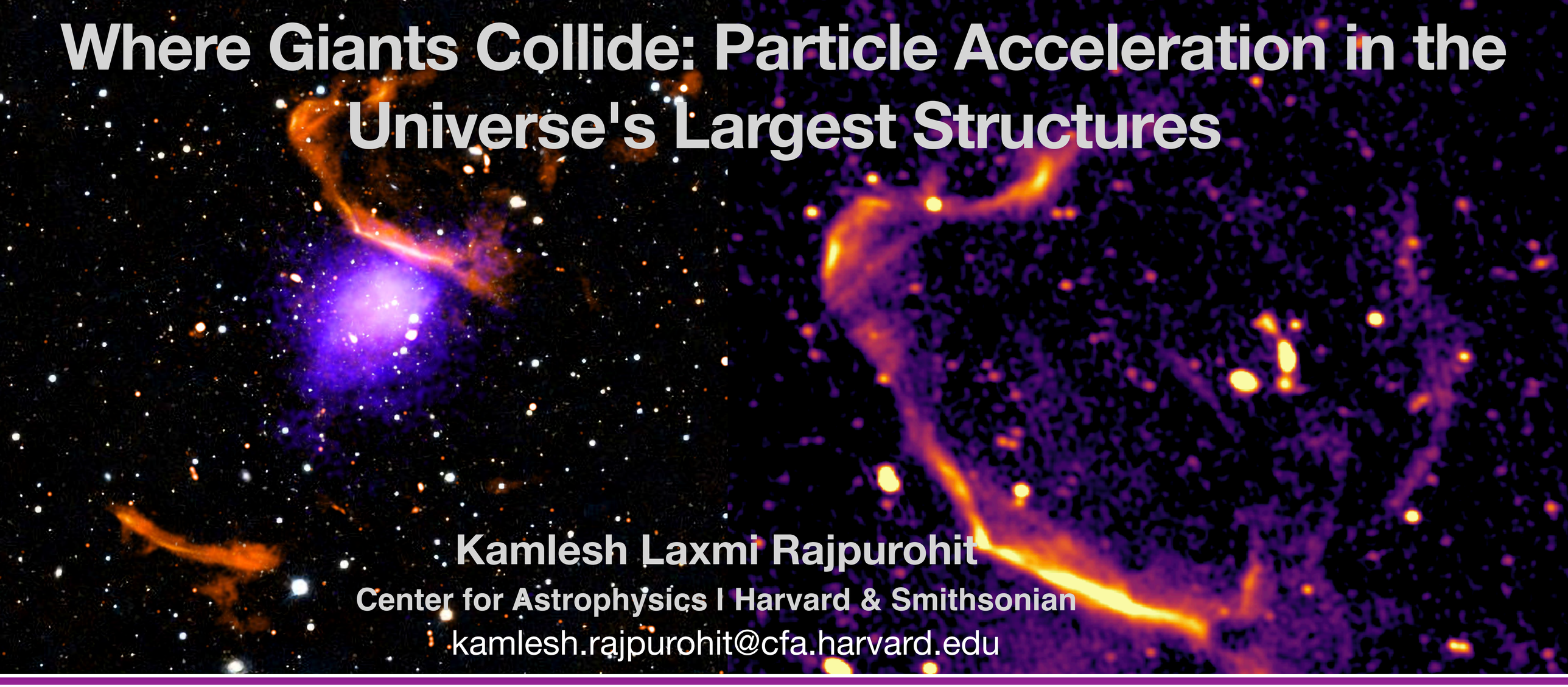
Where Giants Collide: Particle Acceleration in the Universe's Largest Structures



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Smithsonian Astrophysical Observatory

CENTER FOR ASTROPHYSICS HARVARD & SMITHSONIAN

Why we care about the large-scale structures?

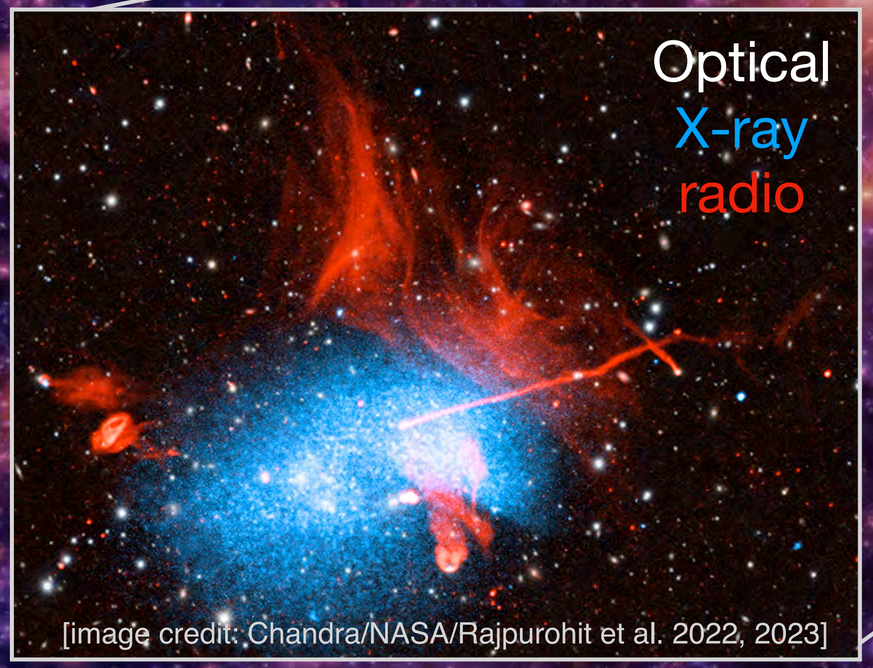
They carries memories of the early Universe, offering a window into its origins and evolution

Millennium Simulation

Why we care about the large-scale structures?

Clusters mergers are the most energetic events since the Big Bang

Galaxy Cluster

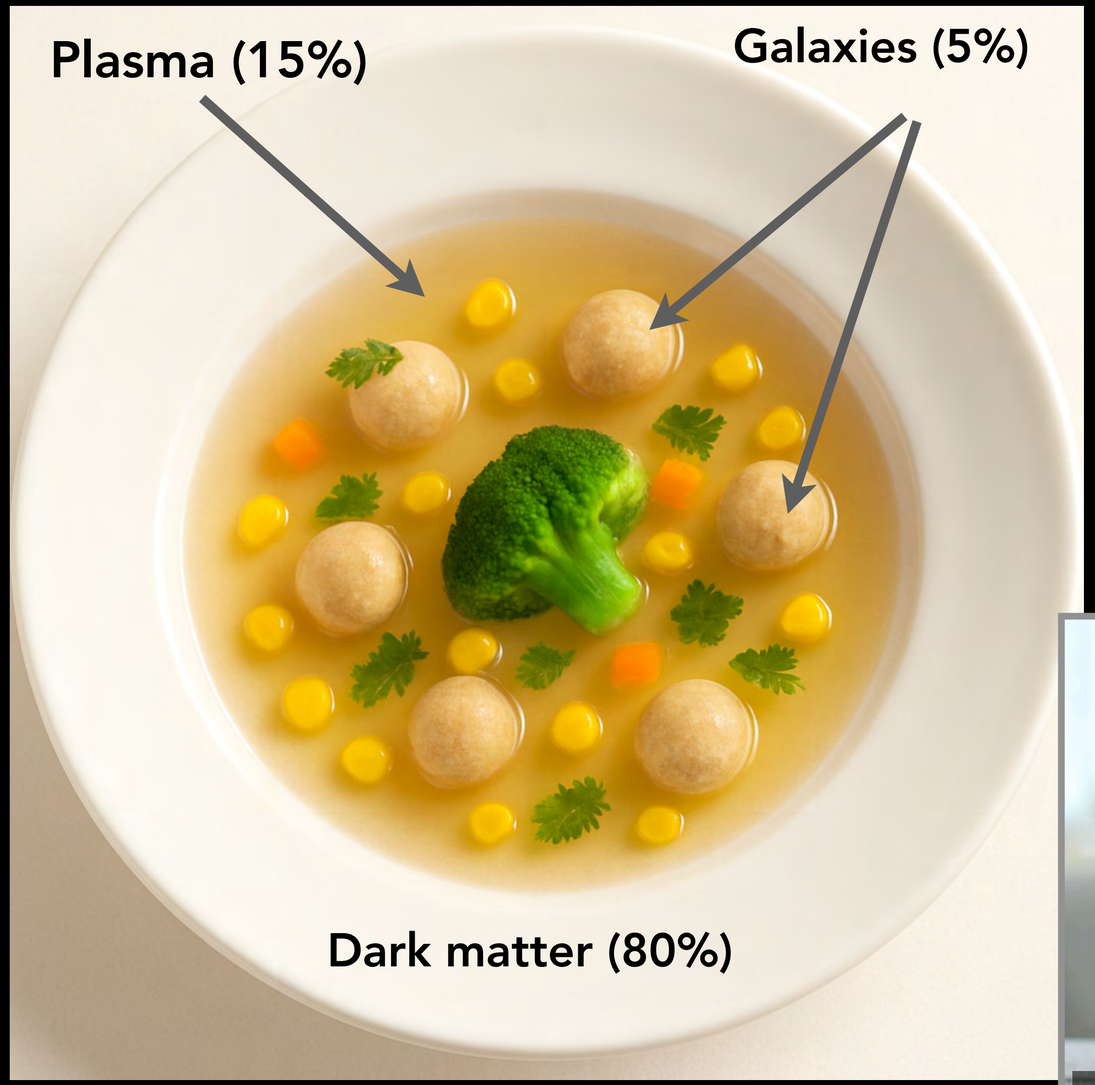


[image credit: Chandra/NASA/Rajpurohit et al. 2022, 2023]

They contains hot plasma (gas) that glows in X-rays and lights up in radio

Millennium Simulation

Galaxy Clusters: Hot, Massive, and Full of Secrets



- Mass: 100 to 1000 trillion Suns!
- Three mass components (like a soup):
  - galaxies containing stars, gas and dust
  - plasma (hot gas, emit in X-rays)
  - dark matter (invisible)

Cosmic Rays + Magnetic Fields

radio light

PLCKG287.0+32.9: One of the most massive clusters

located at 5 billions of light years from earth

[image credit: DESI]

Optical

visible light (galaxies)

DESI telescope

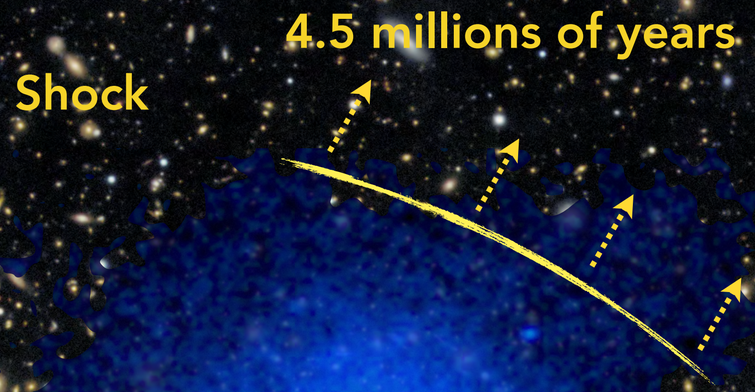
Through Chandra's Eyes: X-ray View

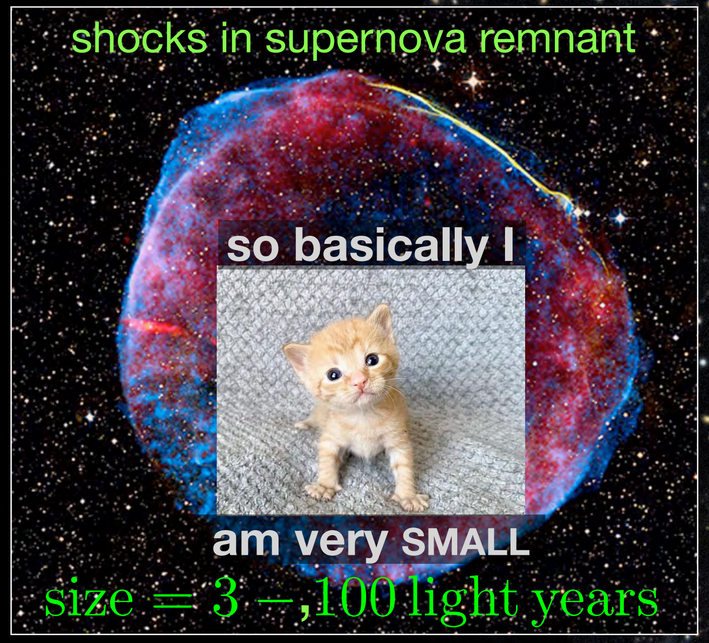
X-rays: extremely hot gas
(heated to millions of degrees)

Chandra telescope

Shocks can be detected in X-rays

X-rays: extremely hot gas
(heated to millions of degrees)



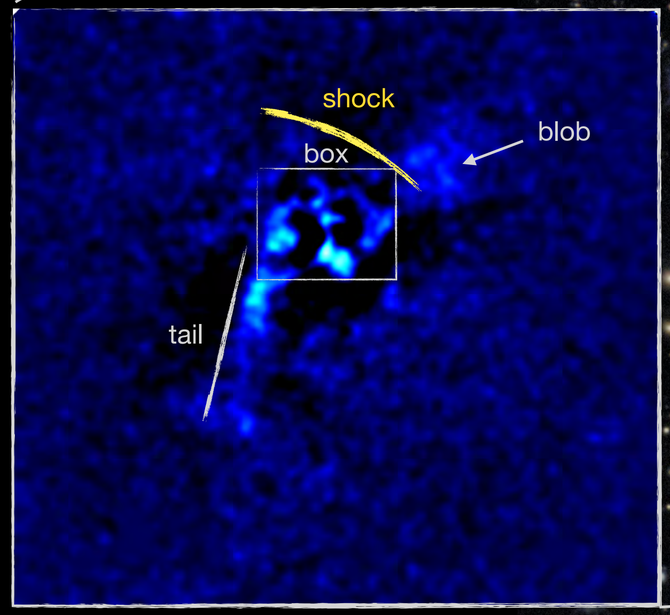


[image credit: NASA]

Cluster Shocks are weak but very large!
(~ millions of light years)

Chandra revealed several structures

X-rays: extremely hot gas
(heated to millions of degrees)



Chandra telescope

When viewed at radio light: a beautiful mess

Cosmic rays + magnetic fields

5 millions light years

Our own galaxy Milky Way
(0.1 millions light years)

MeerKAT Telescope

Multi-wavelength view of the cluster

radio features trace shocks
(powerful sites of acceleration)

X-ray shock

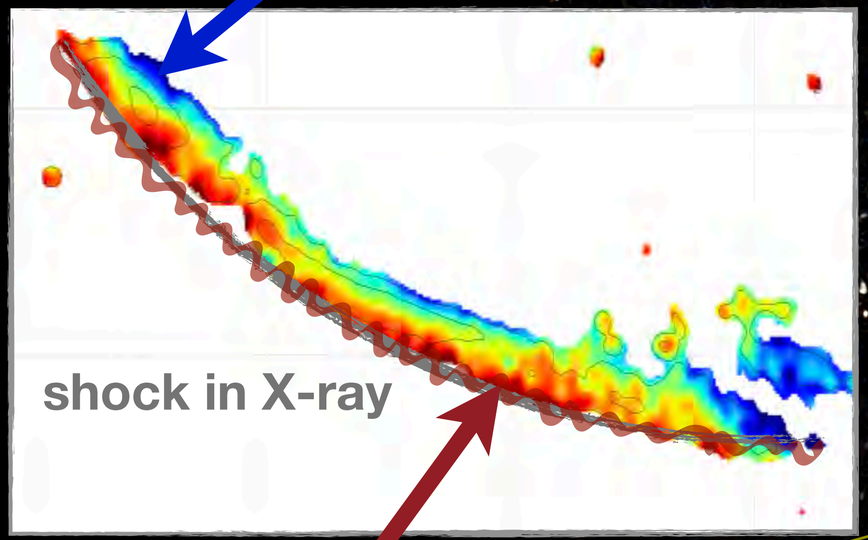
separated by
12 millions light years

X-ray shock

X-ray: extremely hot plasma
Radio: Cosmic rays + magnetic fields

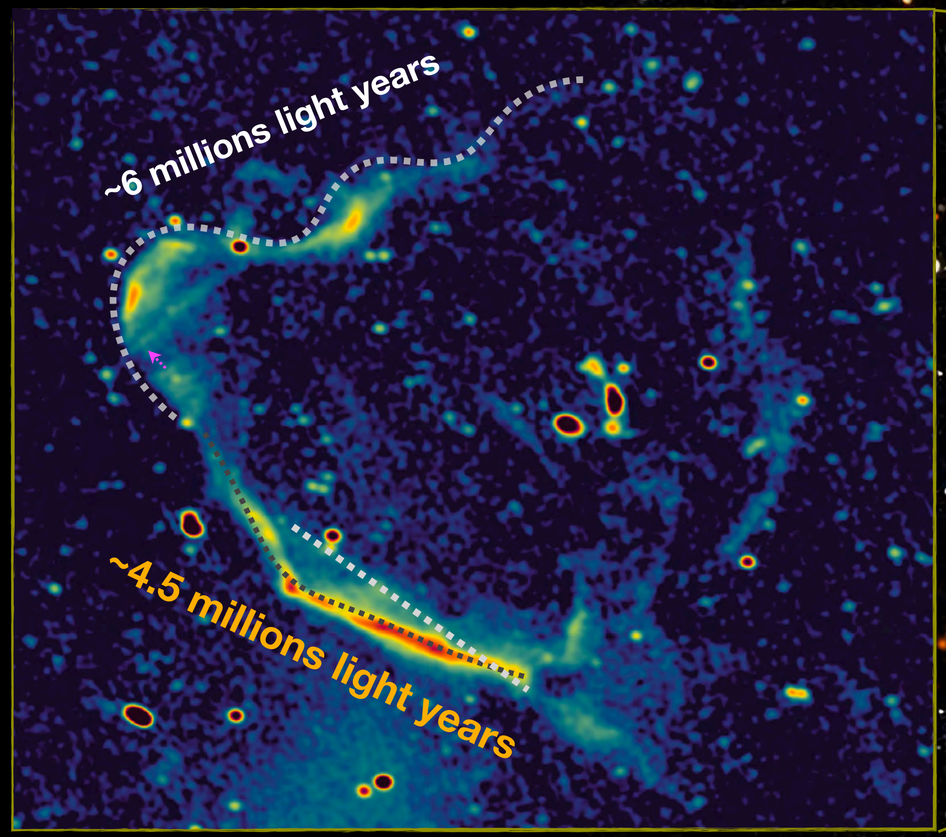
Zoom-in to the shocks: multitude of substructures

I'm old
(lost energy)



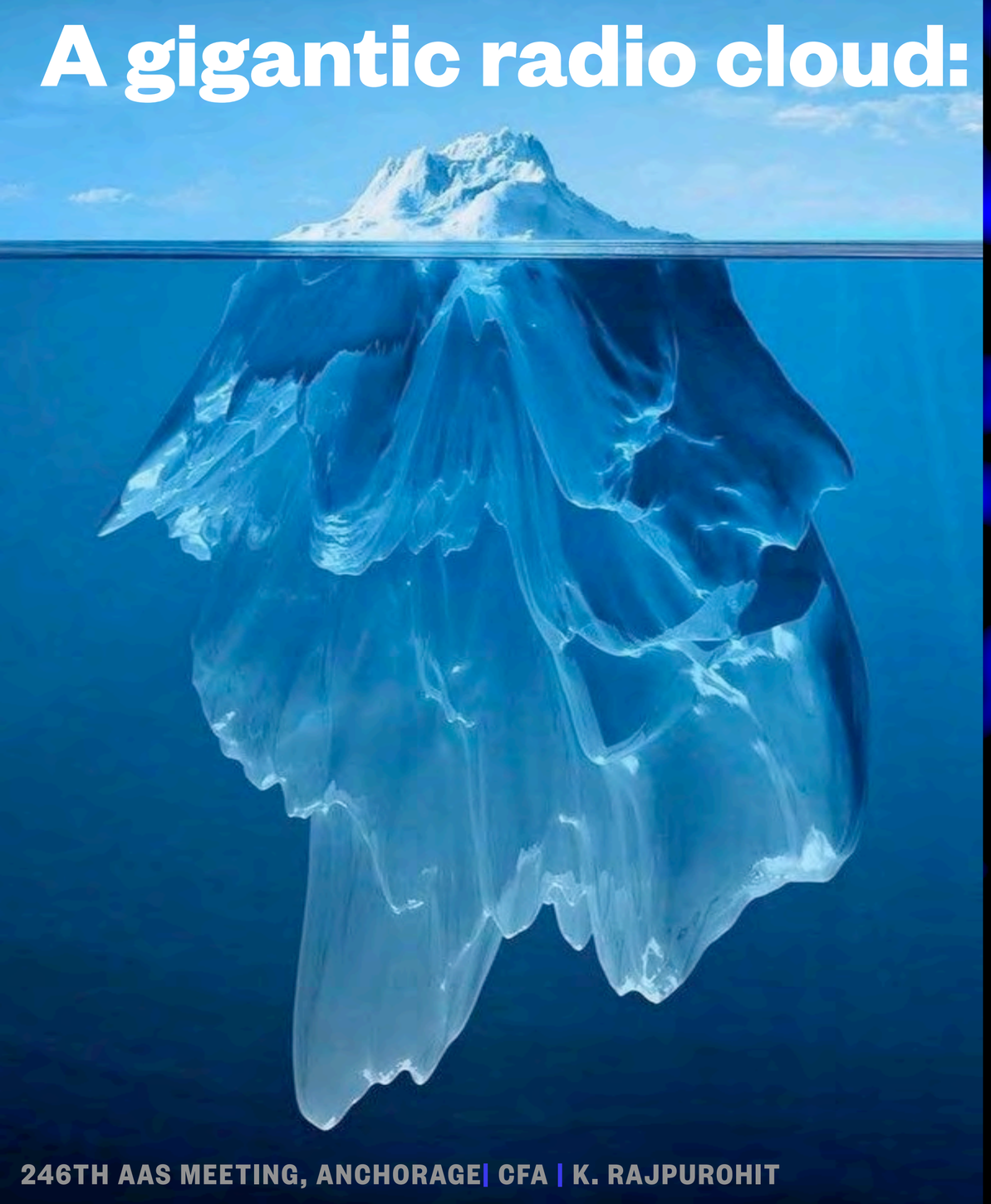
(acceleration site)
I'm young

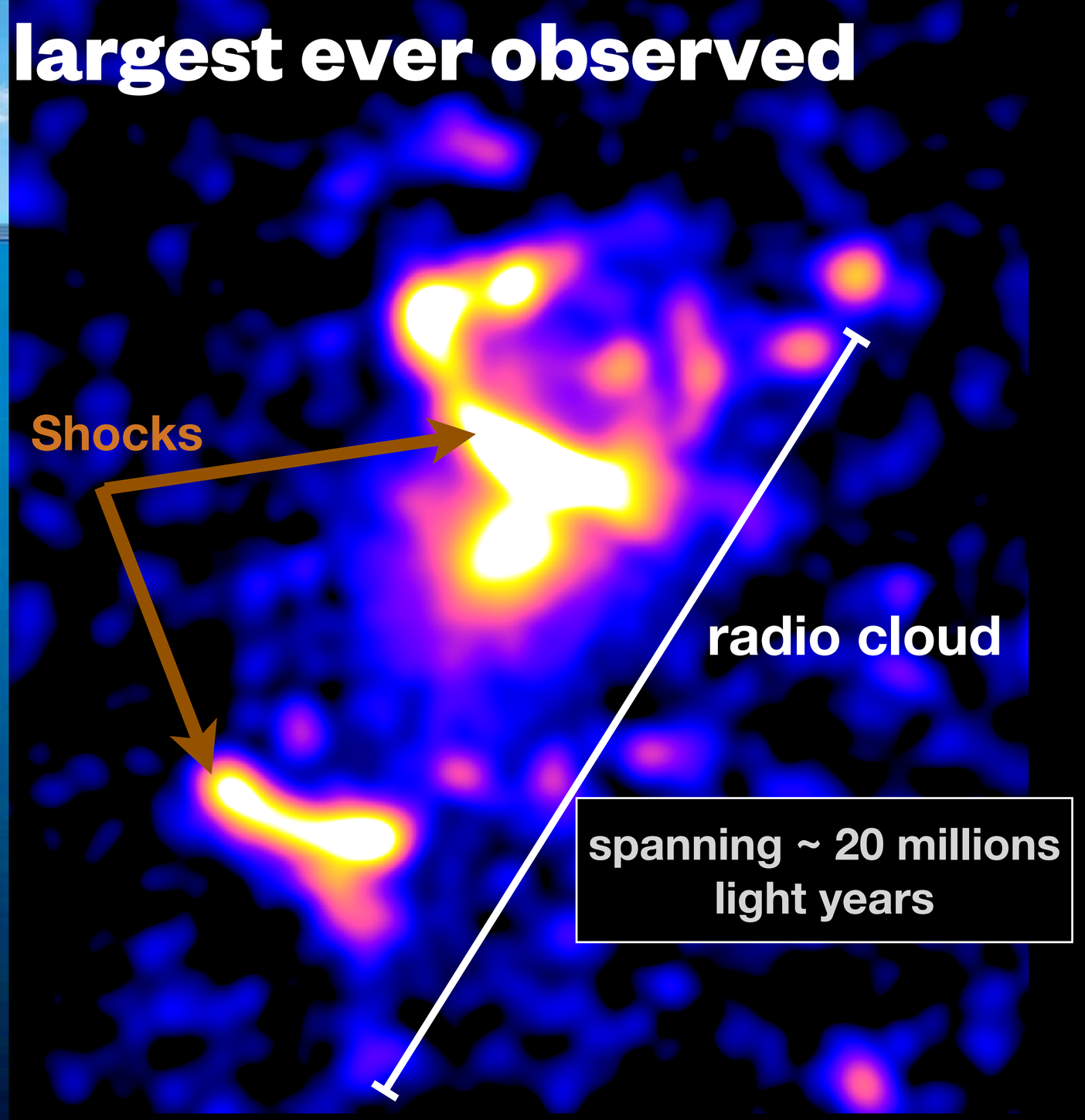
Zoom-in to the shocks: multitude of substructures



Chandra shows a hint of two shocks

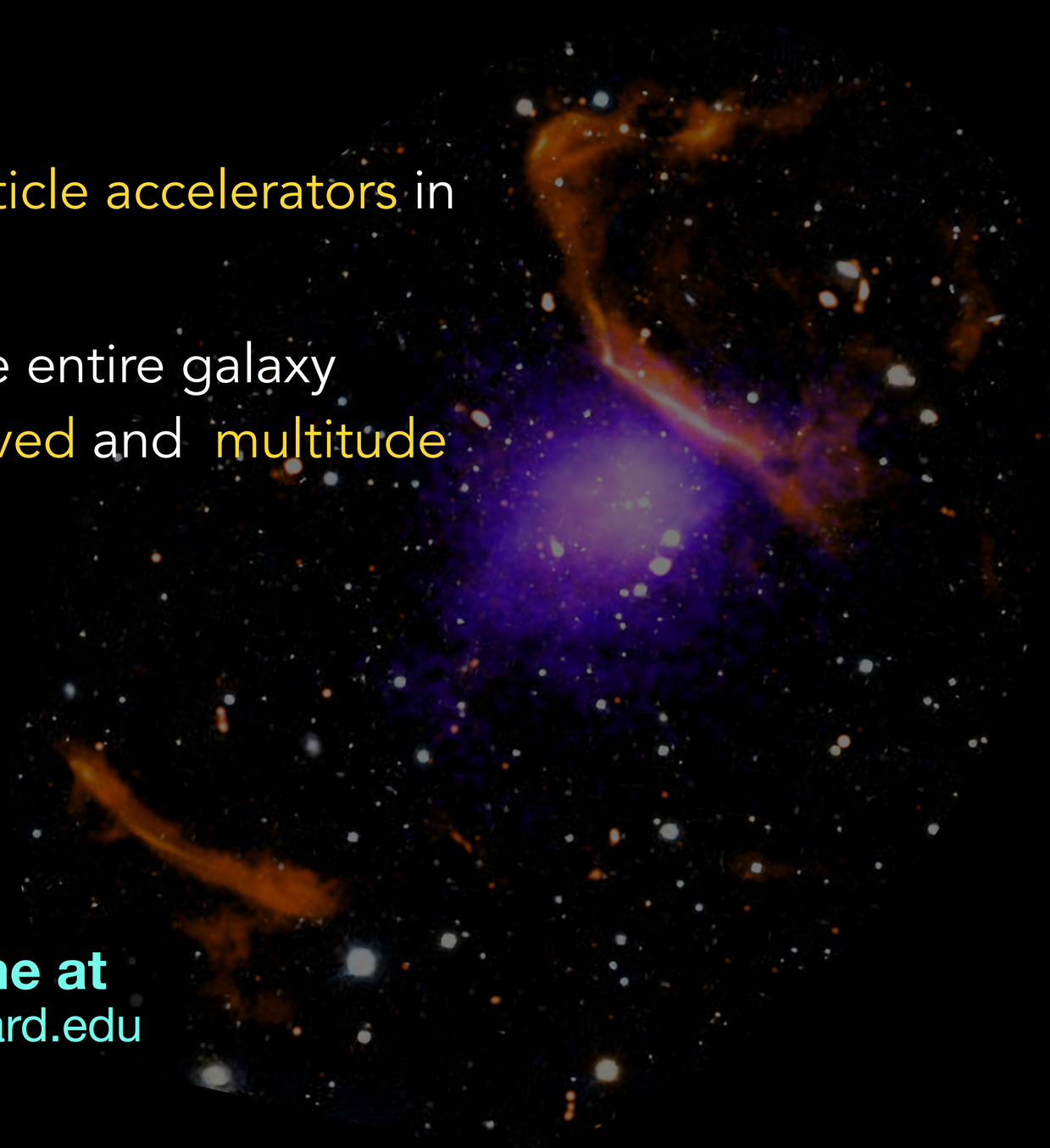
A gigantic radio cloud: largest ever observed





Summary

- Galaxy clusters are home to the largest particle accelerators in the Universe
- We discovered a vast radio cloud filling the entire galaxy cluster PLCKG287— the largest ever observed and multitude of substructures both in X-ray and radio



Press Release

Questions? Contact me at

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