

Unravelling the physics of the ICM with cold fronts

Stephen Walker

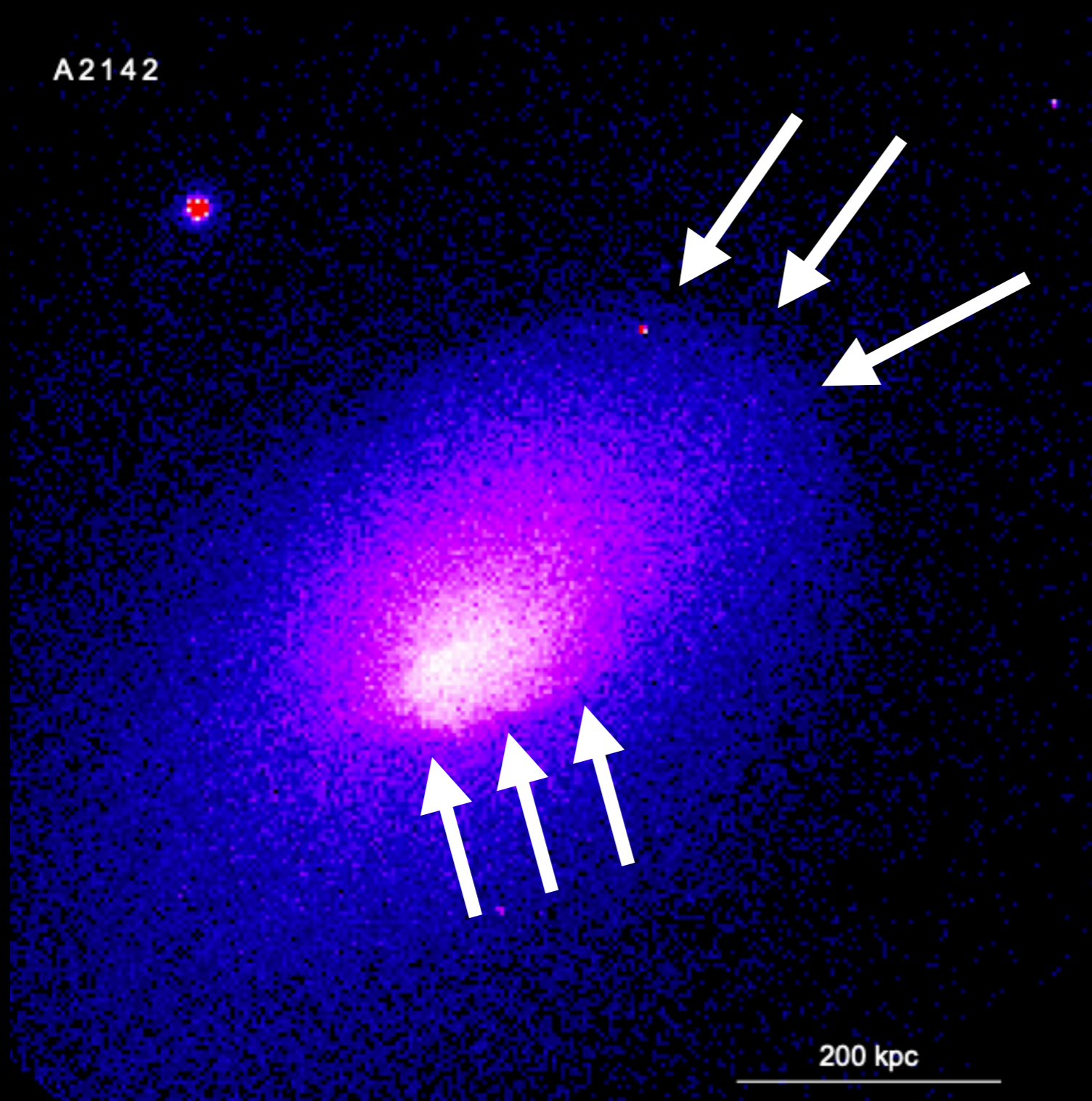
University of
Alabama in
Huntsville

J. ZuHone
A. C. Fabian
J. S. Sanders

J. Hlavacek-Larrondo
M. Gendron-Marsolais
H. Intema
J. T. Bamford

Early Chandra observations of galaxy clusters

A2142



Found strange edges in X-ray surface brightness

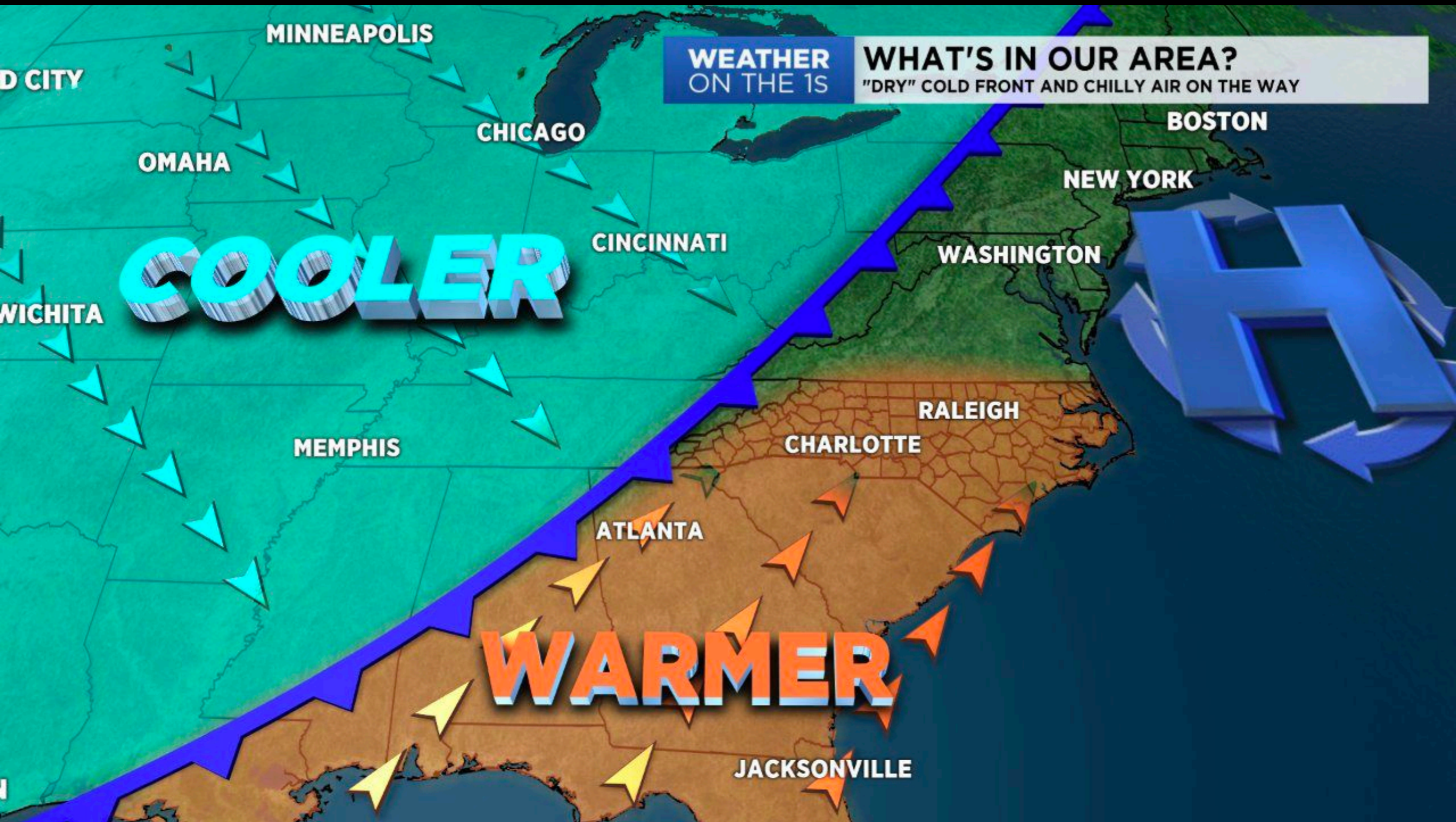
Temperature lower on more dense side - the opposite of a shock!

Incredibly sharp edges - something must support them against instabilities

How can they survive?

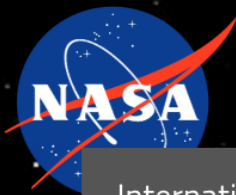
Markevitch+2000

Named 'cold front' after the (very annoying) weather phenomenon



Caused by 'sloshing' of the cool core of the cluster in response to minor merging.





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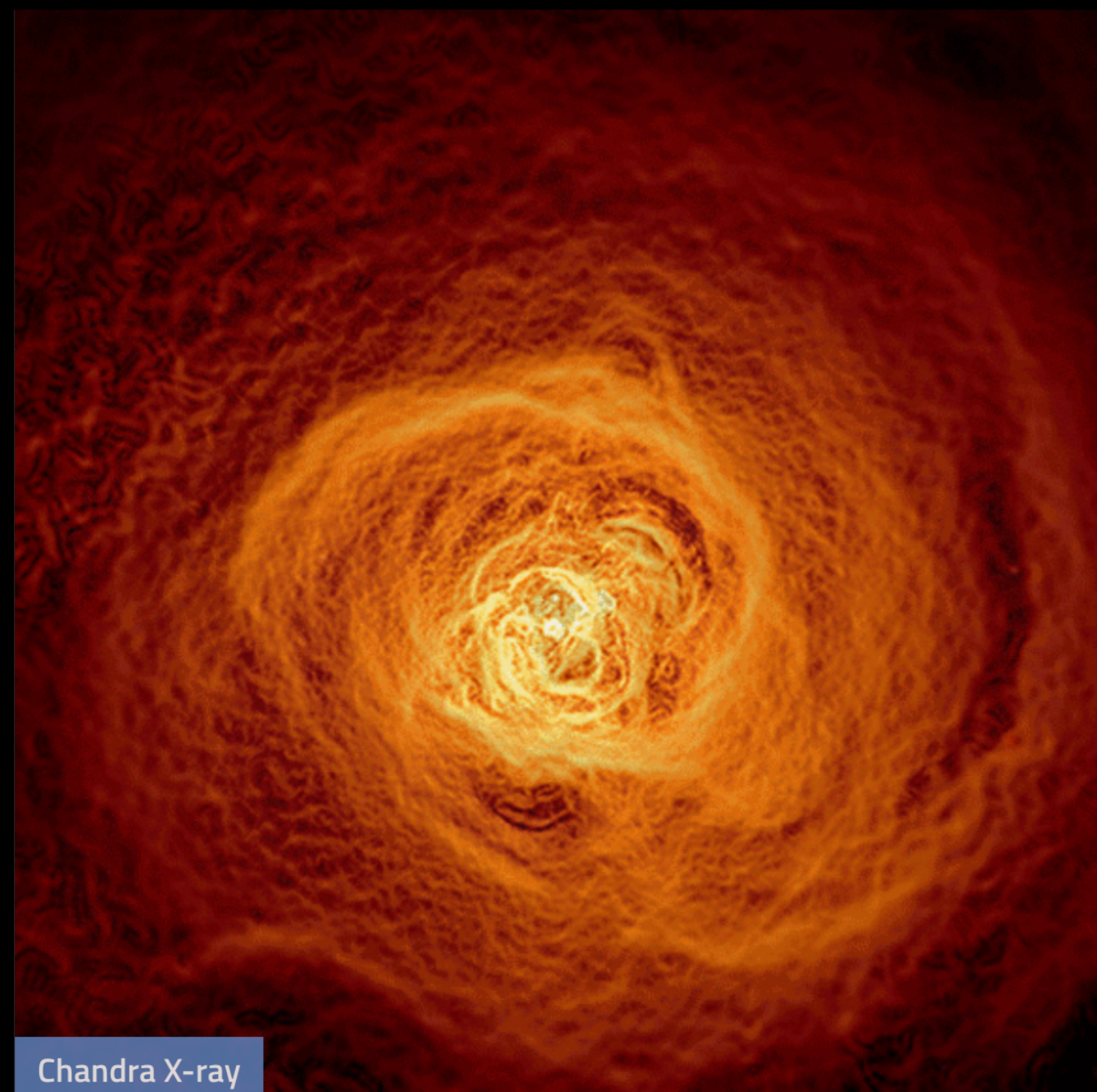
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Chandra X-ray

Scientists Find Giant Wave Rolling Through the Perseus Galaxy Cluster



SOFIA

SOFIA Confirms Nearby Planetary System is Similar to Our Own

NASA Events

Friday, May 12: Expedition 51 Spacewalk

Calendar

Launches and Landings



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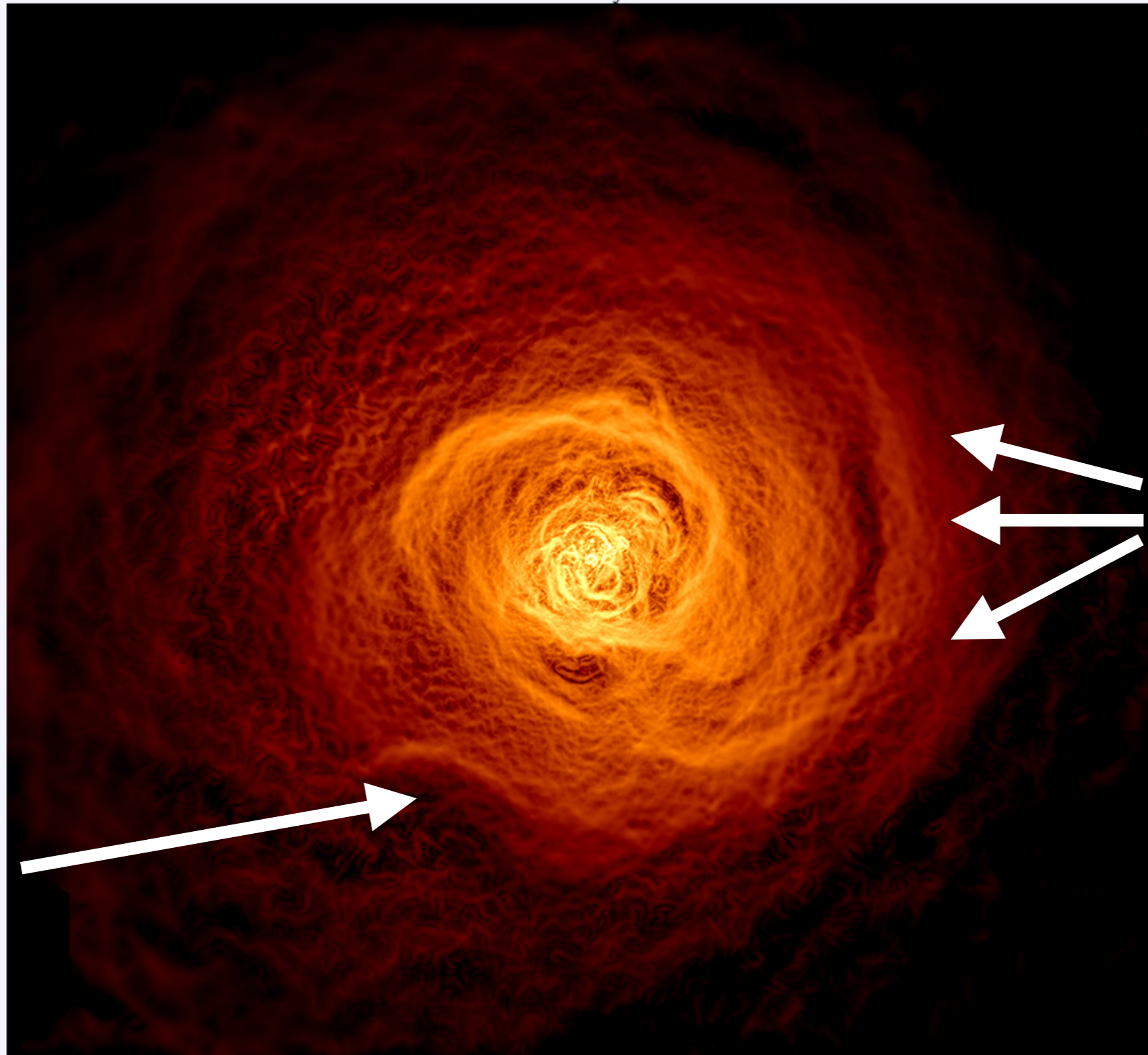
NASA to Measure Greenhouse Gases Over the Mid-Atlantic Region in May

Walker et al. 2017, MNRAS 468, 2506, arXiv:1705.00011

Astronomy Picture of the Day

[discover the cosmos!](#) Each day a different image or photograph of our fascinating universe is featured, along with a brief explanation written by a professional astronomer.

2017 May 4



**Mystery
'bay'
feature**

Cold front

The Perseus Cluster Waves

Image Credit: [NASA](#), [CXC](#), [GSFC](#), [Stephen Walker, et al.](#)

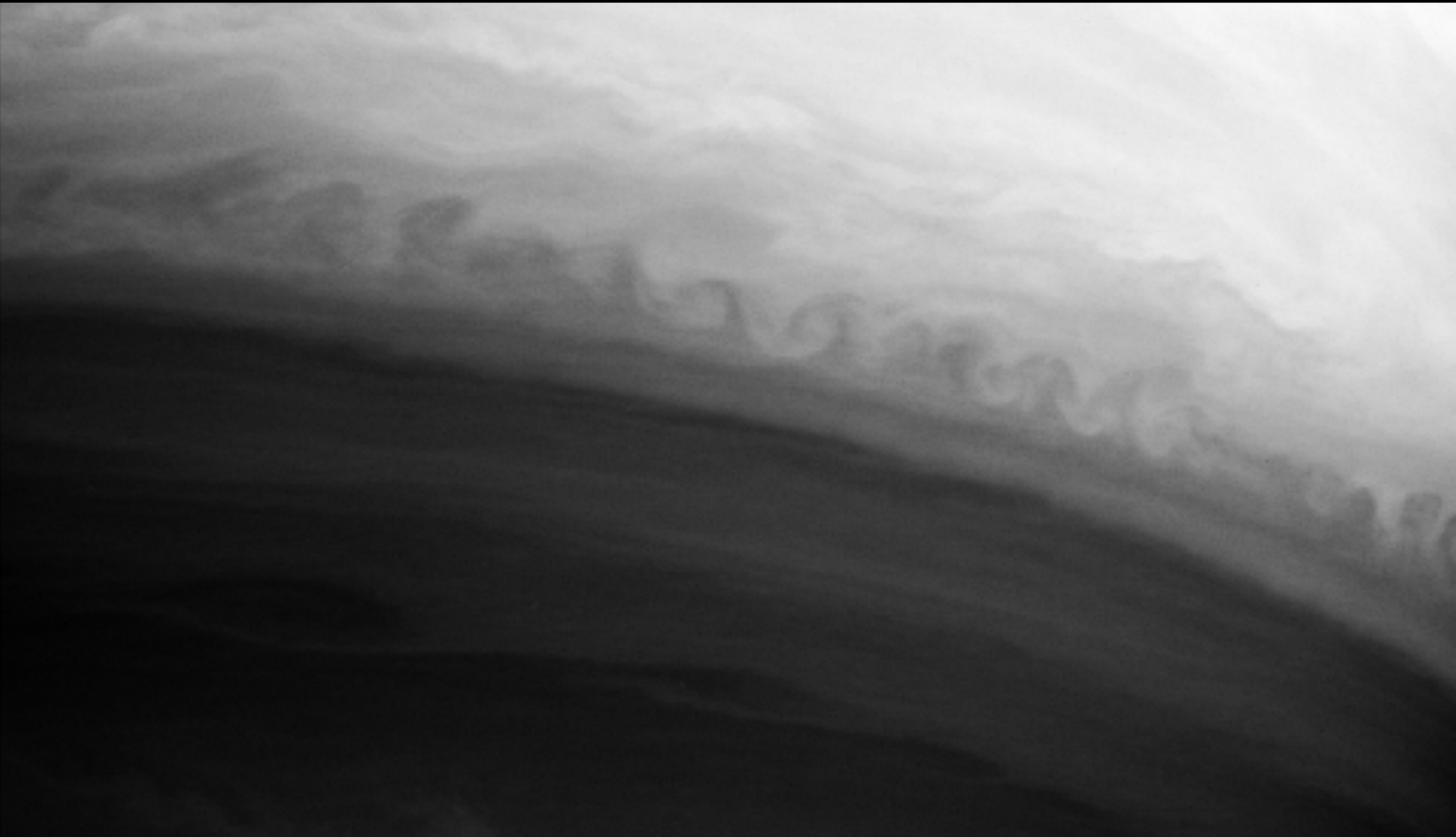
Kelvin-Helmholtz instabilities (KHI)



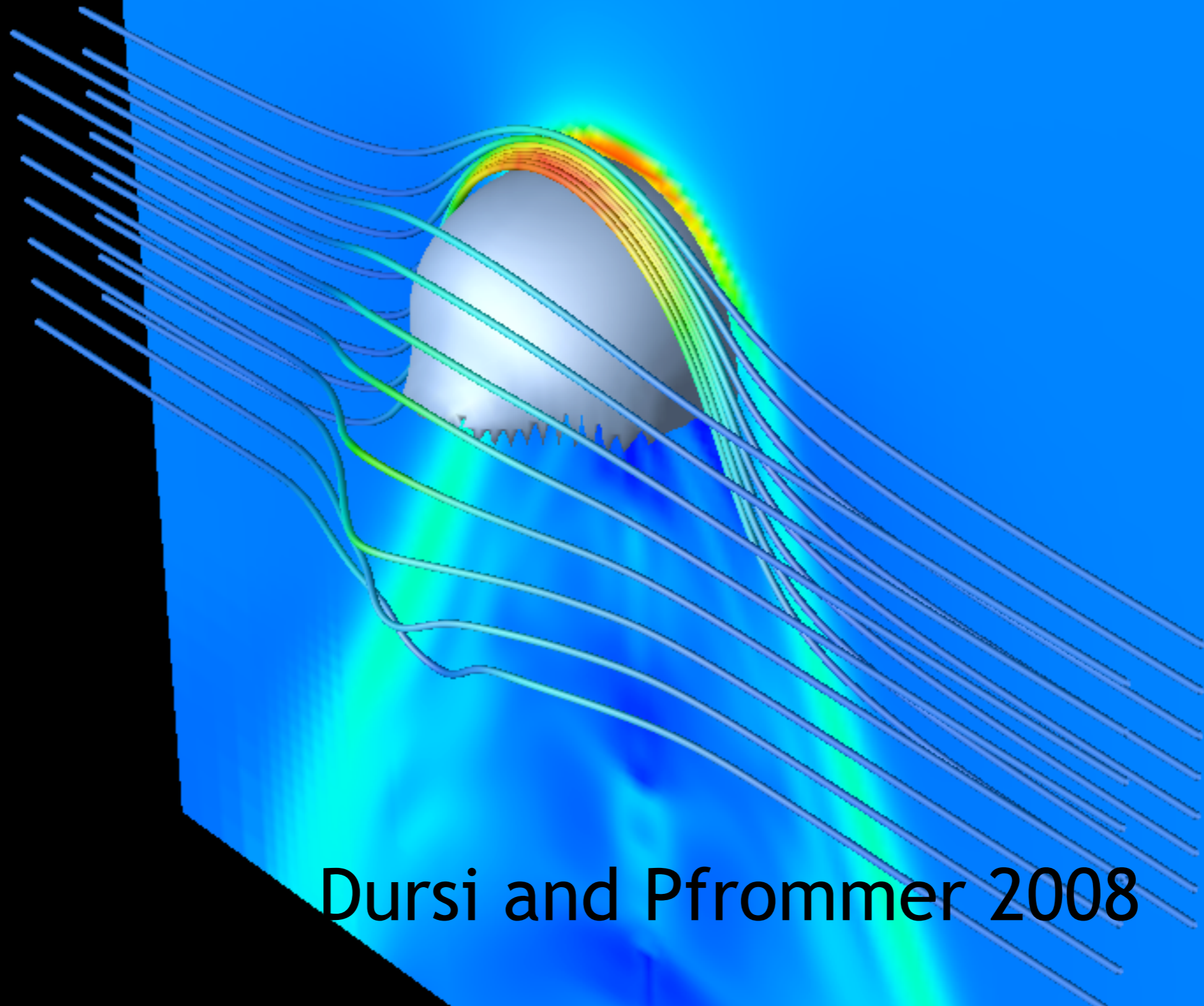
Kelvin-Helmholtz instabilities (KHI)



Kelvin-Helmholtz instabilities (KHI)



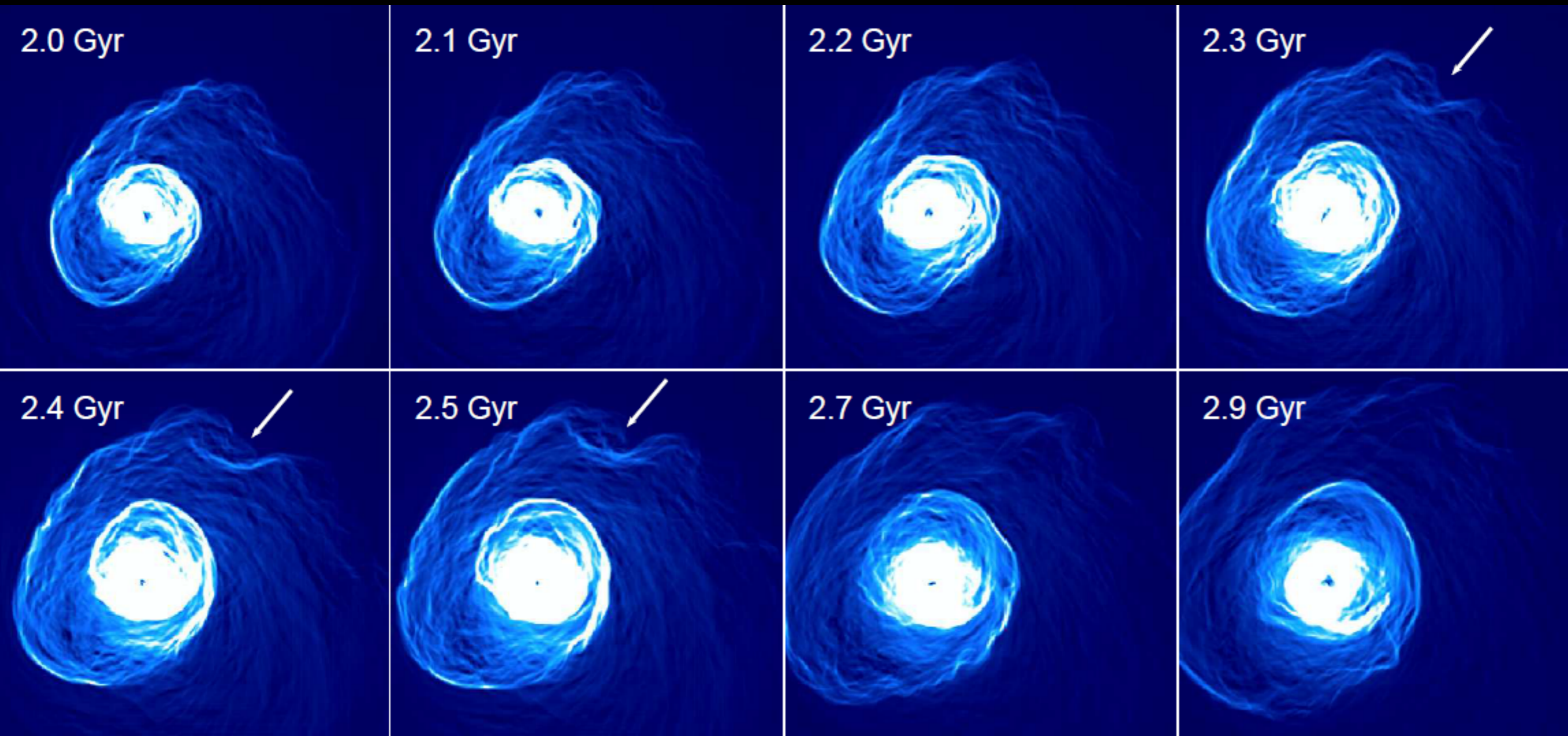
Magnetic draping can inhibit instabilities



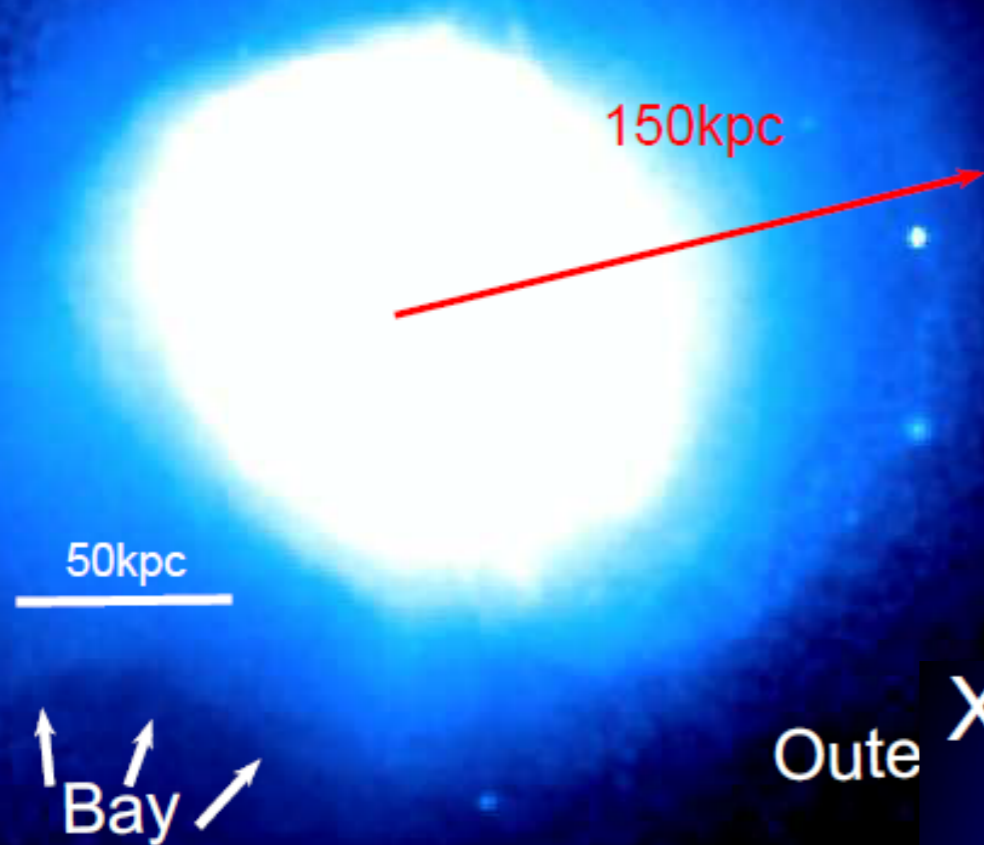
Magnetic Energy Density
0.1
0.1
0.0
0.0
0.0
0.0

Dursi and Pfrommer 2008

Comparing to simulations

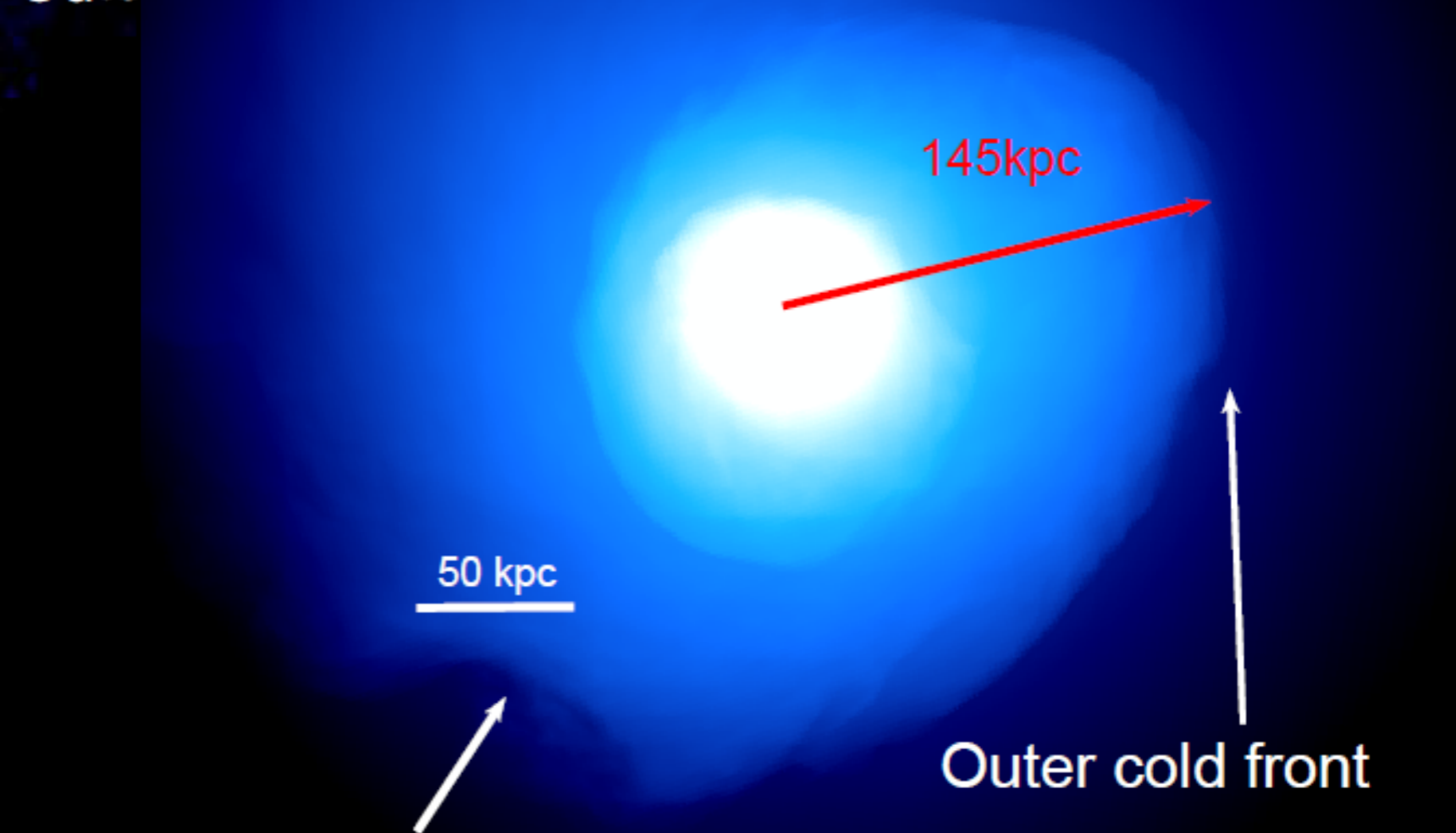


Perseus, Chandra



Sloshing simulation reproduces mysterious 'bay' very well as a KHI

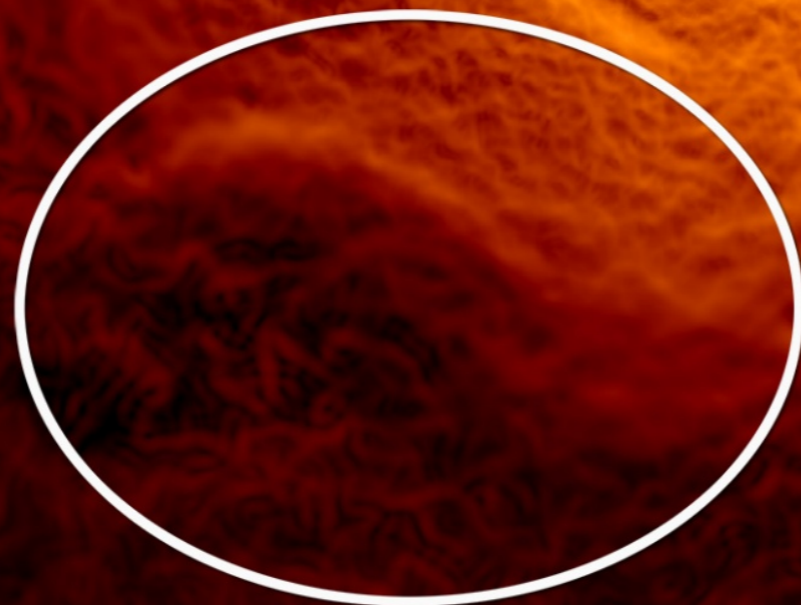
X-ray emissivity, simulation, beta=200



Walker+17

Showing that the bay is not a cavity

1. Bay is only on one side of cluster - AGN cavities should come in pairs

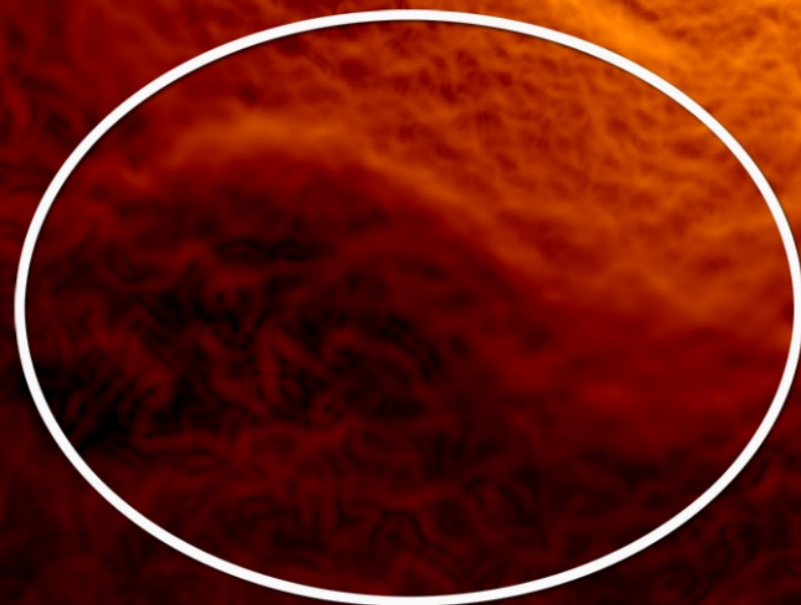


Walker+17

250,000 light-years

Showing that the bay is not a cavity

2. Surface brightness and kT profiles agree with sloshing simulations, and are incompatible with being the inner rim of a AGN inflated cavity

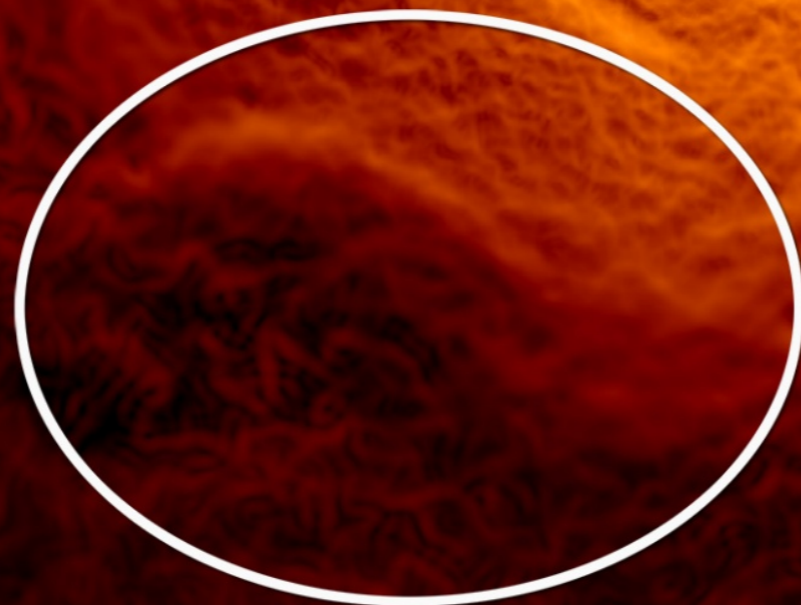


Walker+17

250,000 light-years

Showing that the bay is not a cavity

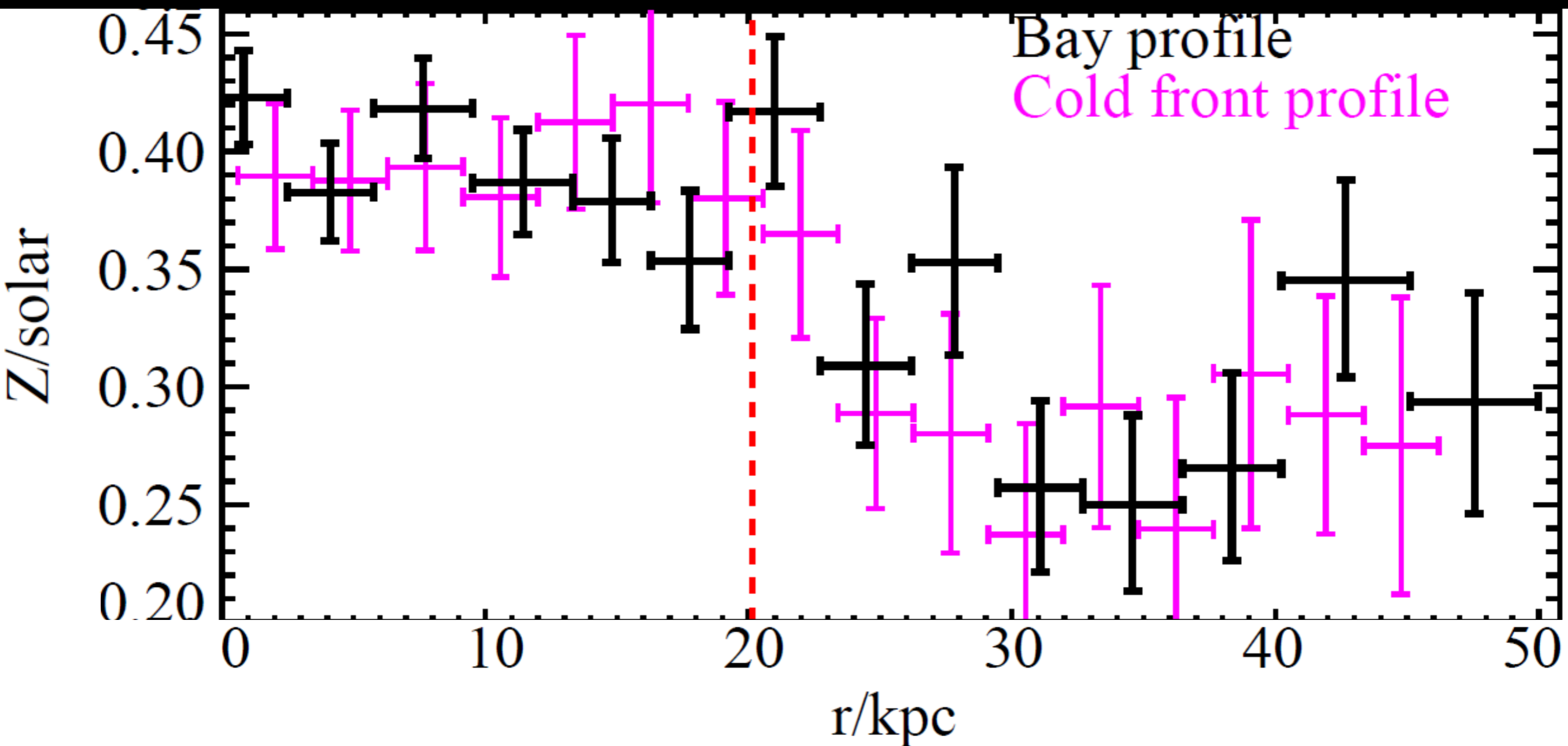
3. Metal abundance also drops over edge, consistent with rest of cold front



Walker+17

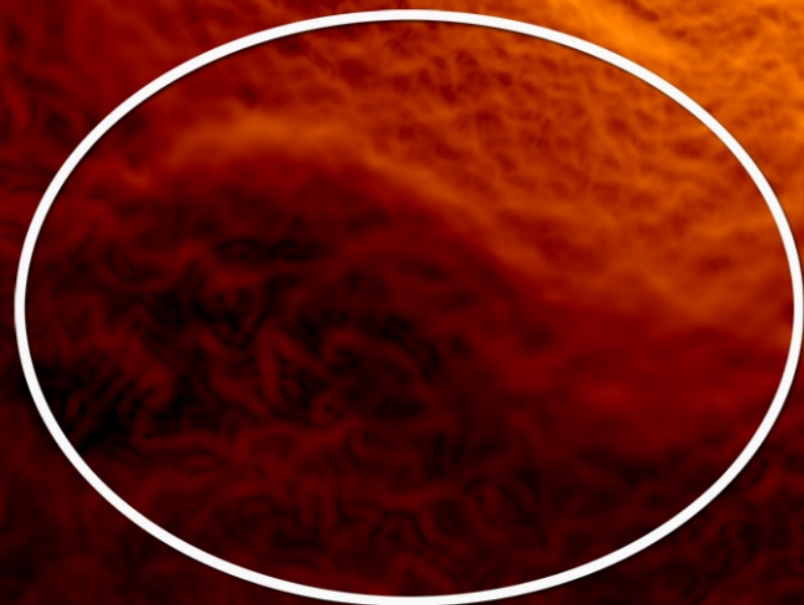
250,000 light-years

Metallicity profiles



Showing that the bay is not a cavity

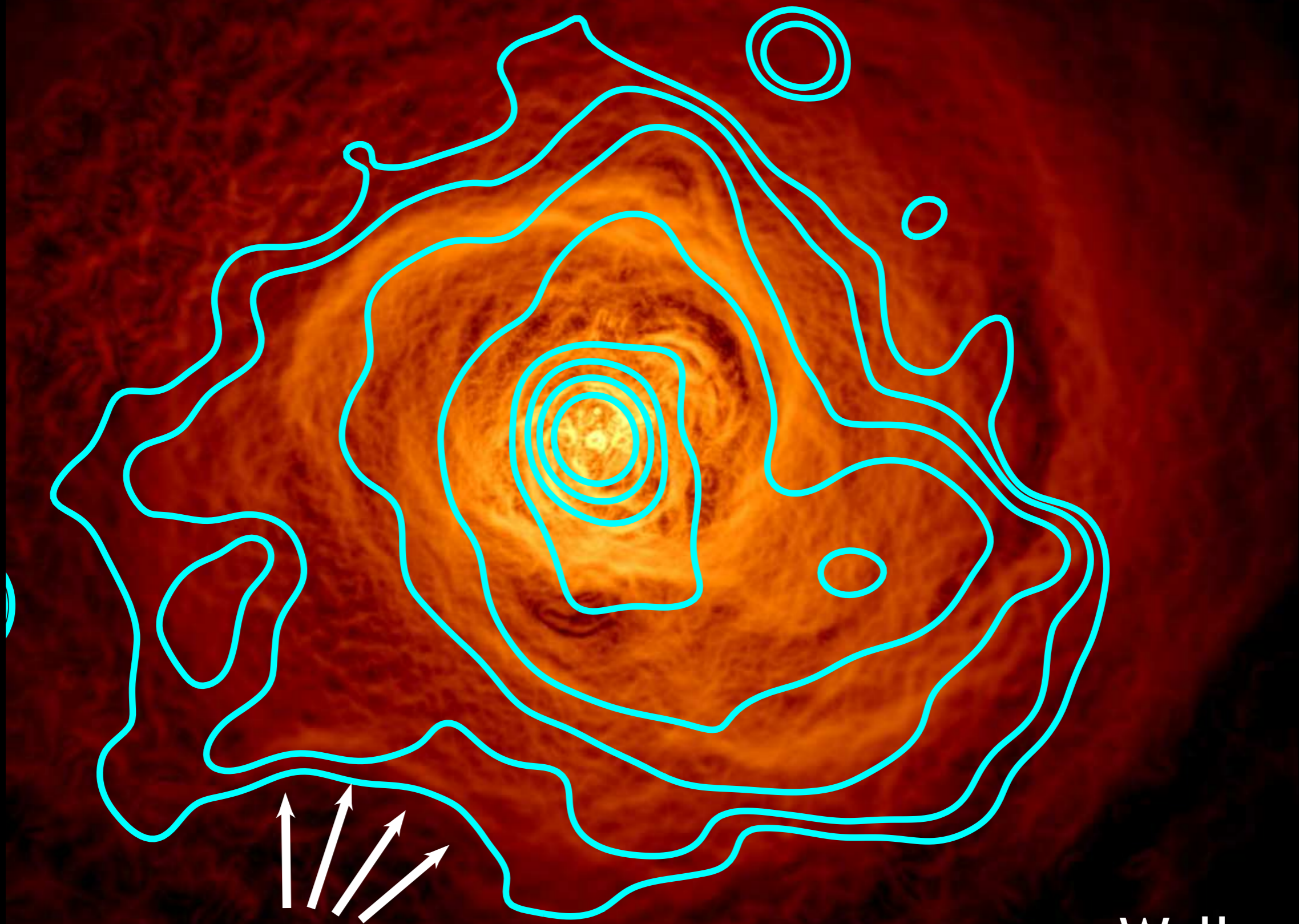
4. Radio halo curves behind the bay



Walker+17

250,000 light-years

JVLA 230-470MHz



Walker+17

Just like in cold fronts, which constrain
radio haloes behind them

RXJ1720.1+26

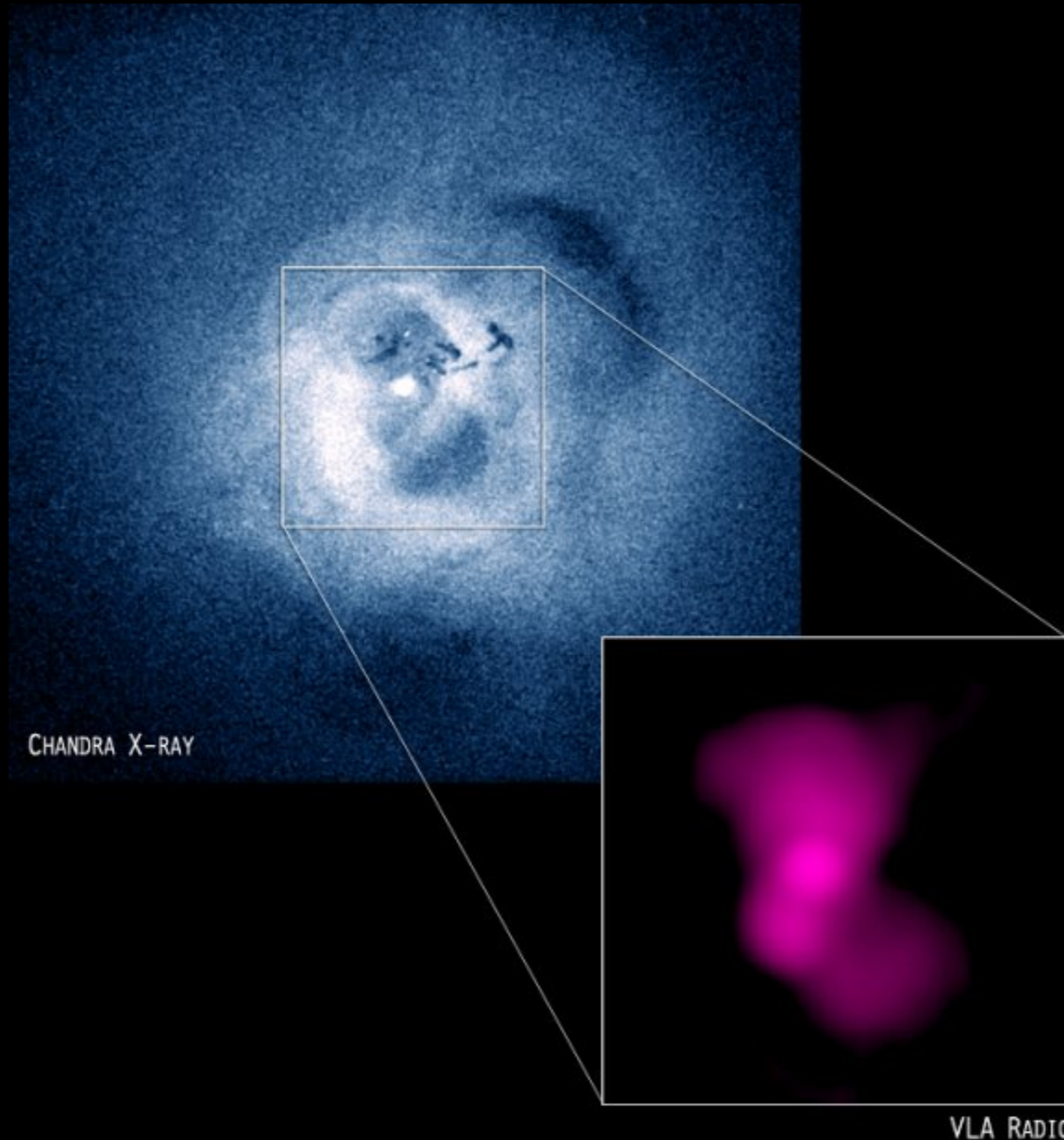
200 kpc

RXJ1720.1+26

200 kpc

ZuHone et al. 2013

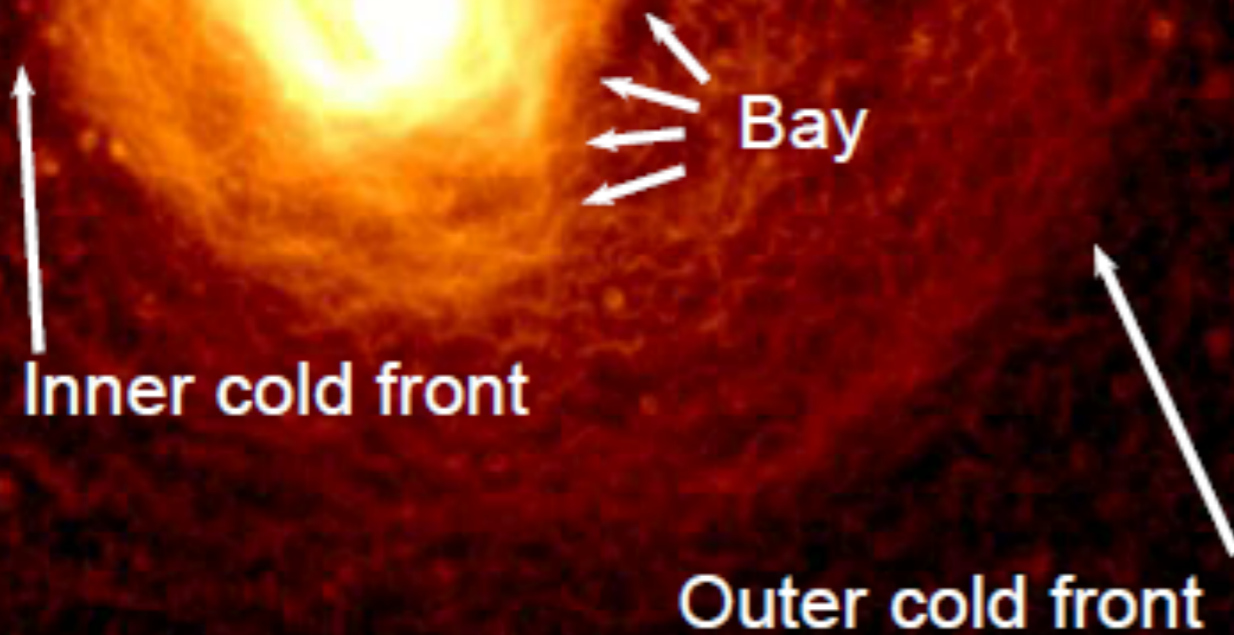
Whereas AGN cavities are *filled* by radio emission



Similar 'bay' in Centaurus

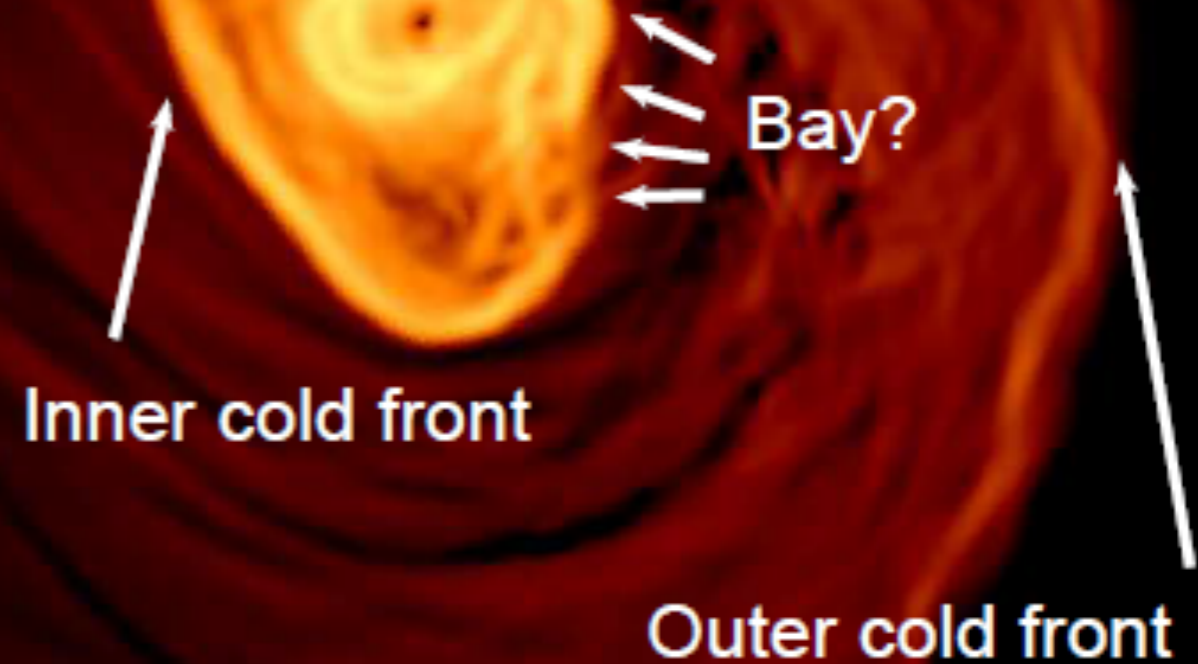
Centaurus, Chandra, GGM

50 kpc



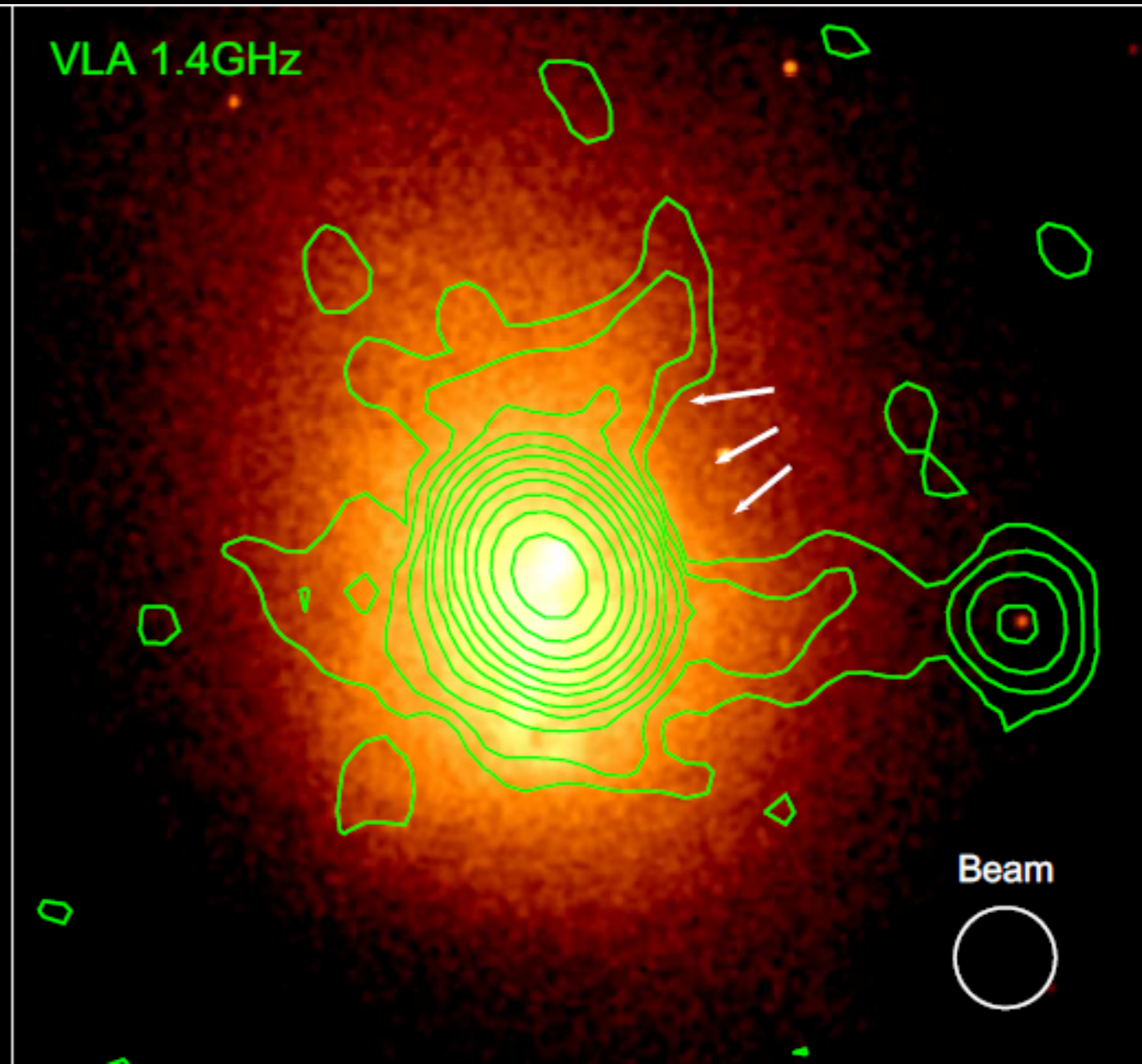
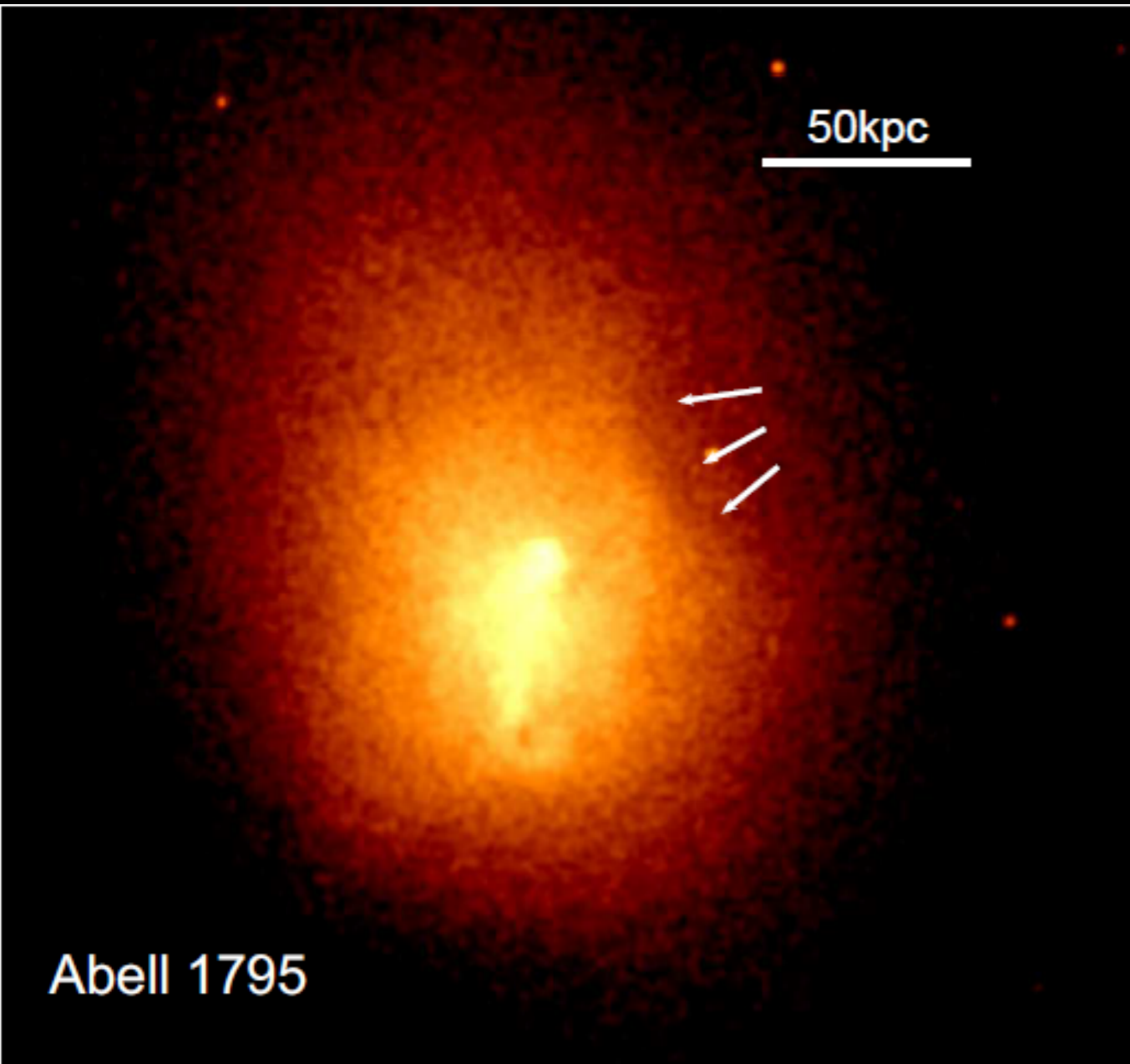
Sim, beta=200, GGM, t=1.5Gyr

50 kpc



Walker+17

And in Abell 1795 (harder to see)



Walker+17

And finally....

We now know that cold fronts can grow to enormous sizes over billions of years!

One in Perseus reaches out to 700 kpc (nearly half the viral radius)

MENU ▾

nature
astronomy

Letter

The split in the ancient cold front in the Perseus cluster

Stephen A. Walker , John ZuHone, Andy Fabian & Jeremy Sanders

Nature Astronomy (2018)

doi:10.1038/s41550-018-0401-8

[Download Citation](#)

[Galaxies and clusters](#)

[High-energy astrophysics](#)

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The image shows a galaxy with a prominent, bright yellow-white central core. The galaxy's structure is primarily blue, with a dense, textured appearance in the central region that transitions into more diffuse, spiral-like structures towards the edges. The overall color palette is dominated by deep blues and purples, with the central core providing a stark contrast in yellow and white. The text 'nature astronomy' is overlaid in the top right corner in a white serif font.

nature
astronomy

Walker et al. 2018

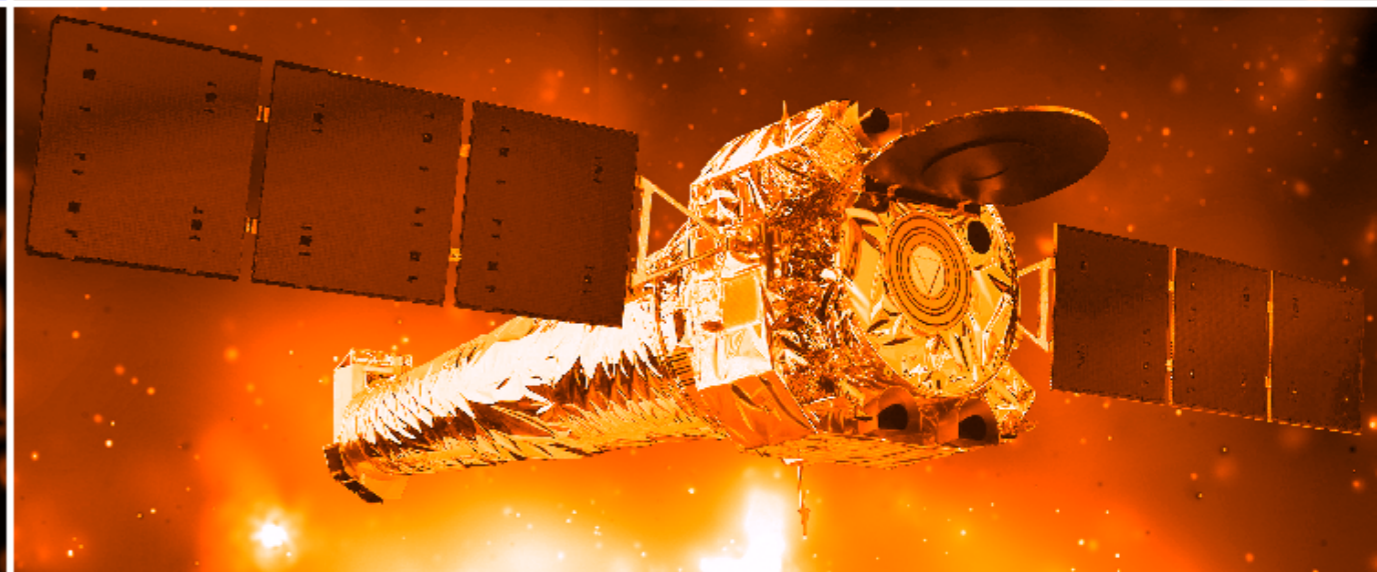
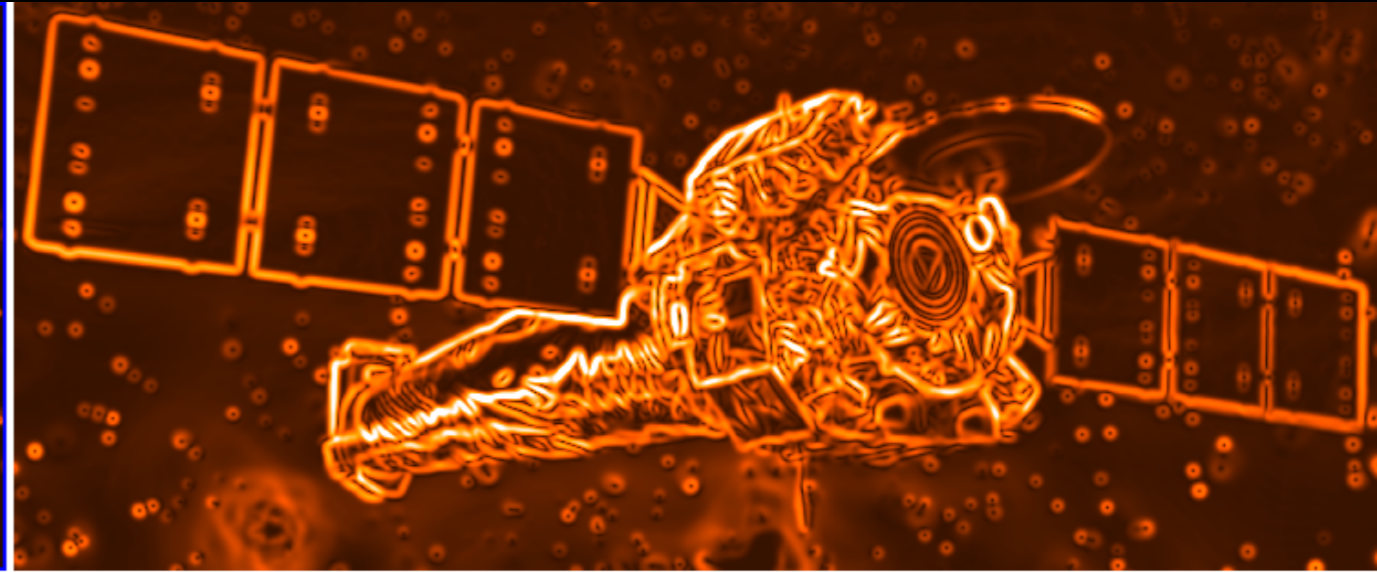
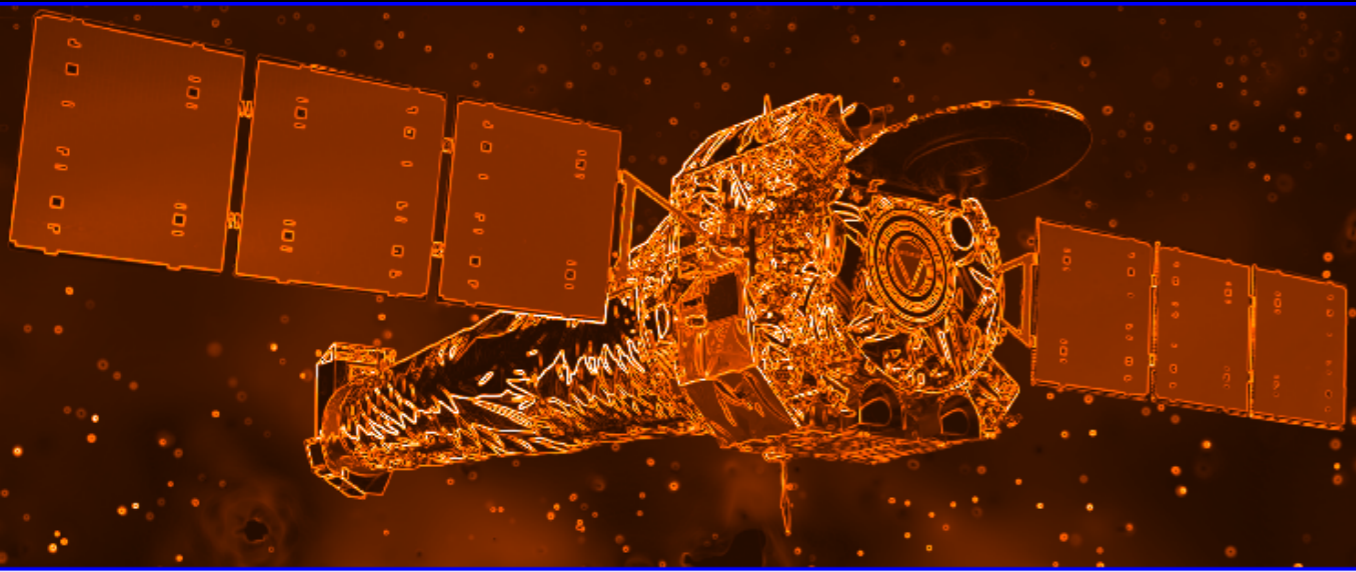


nature
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Perseus's ancient
edge still sharp

Walker et al. 2018

Thank you Chandra!!!



Any questions, please email
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