Tracing Gas Motions in the Centaurus Cluster

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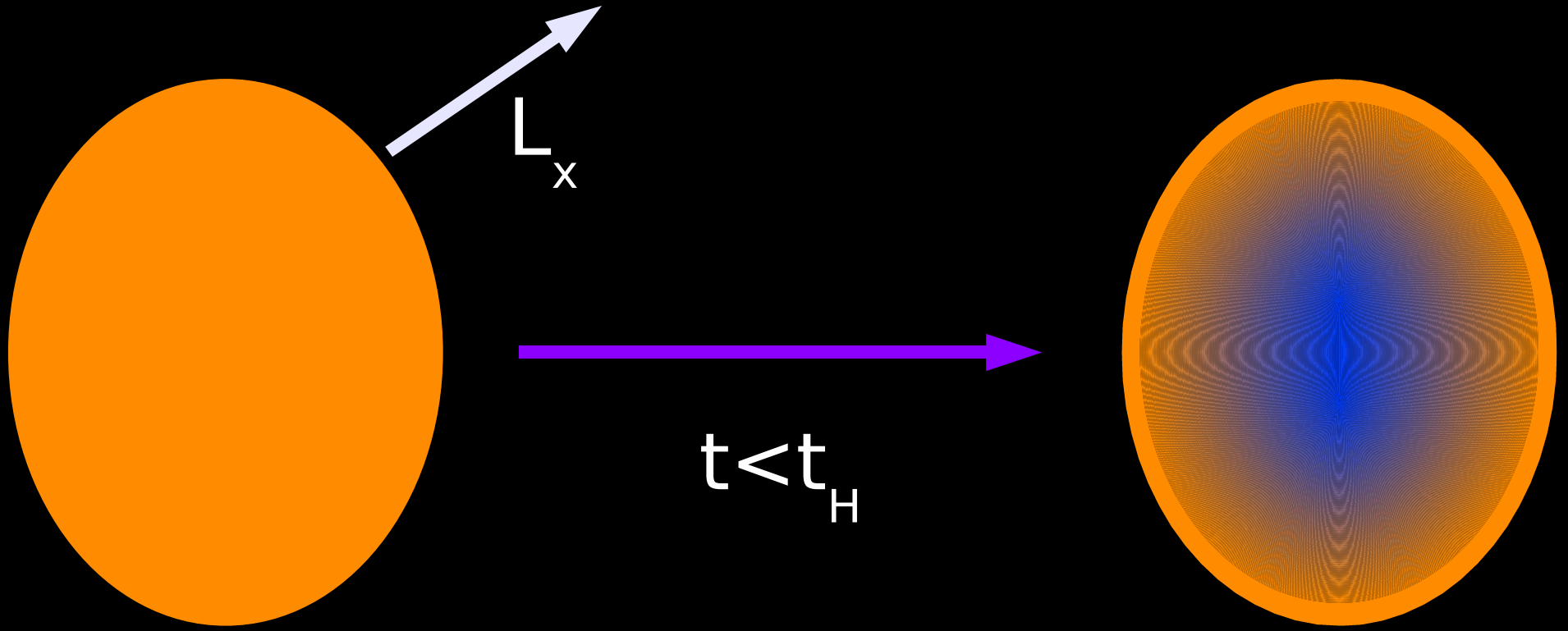
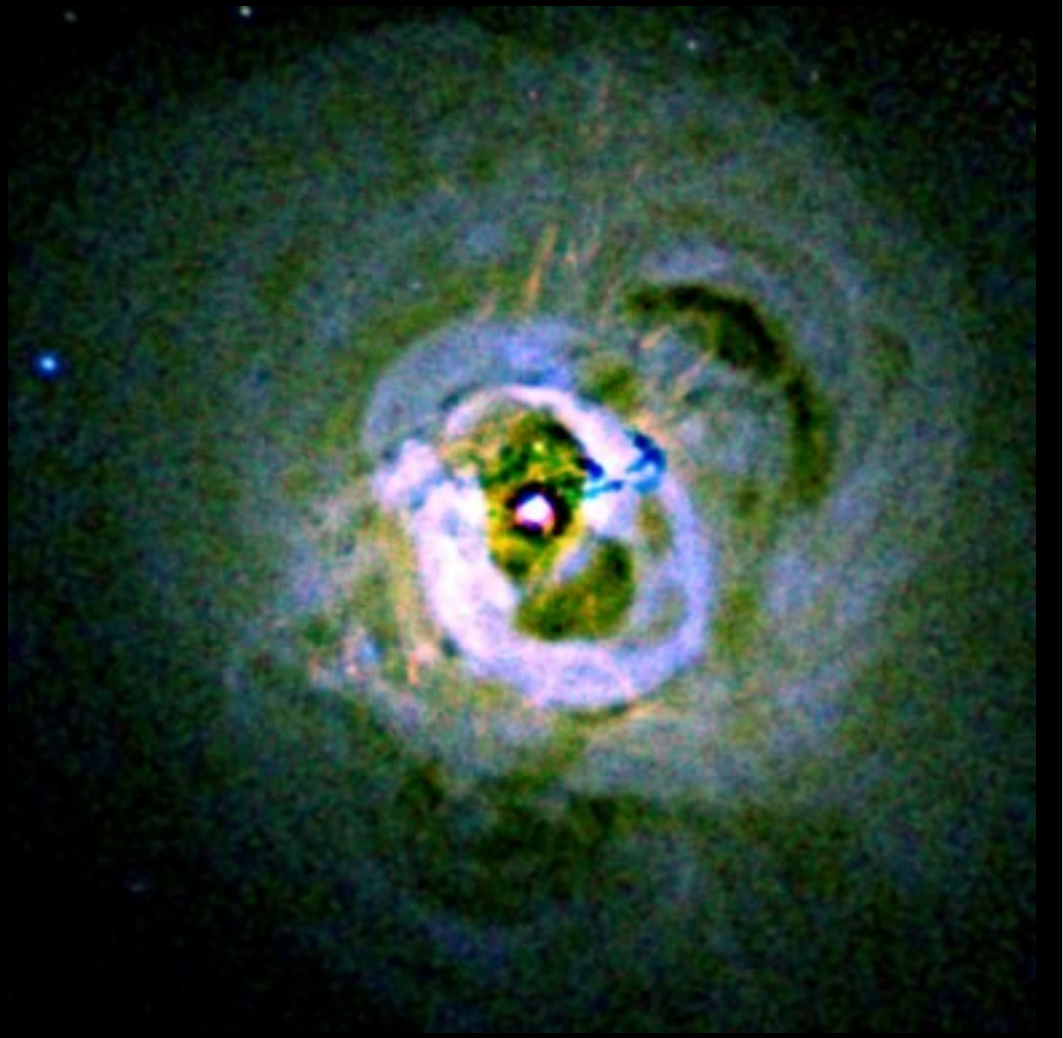
The Cooling Flow Problem

- Clusters emit X-rays with luminosities ~10^{44}-10^{45} erg s^{-1} – many clusters have central cooling times < age of universe
- We don't observe the expected accumulation of cool gas in galaxy cluster cores



Cooling Flow Solutions

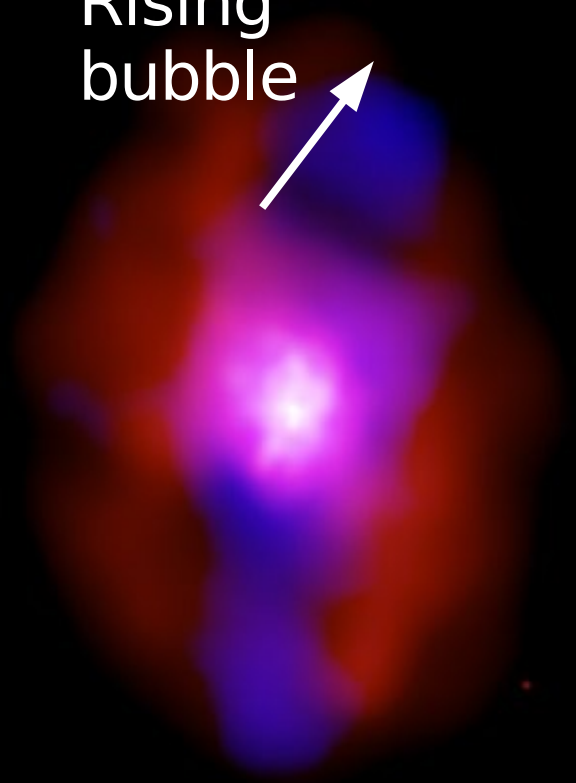
- Evidence suggests that heating is operating to offset the cooling.
- There are many models:
  - Conduction
  - Mergers
  - Cosmic Rays
  - AGN Injection



- AGN heating appears the most promising solution

Turbulence

- Energy injected on some large scale with some velocity
- Energy is eventually dissipated as heat
- The heat dissipated is controlled by the length and velocity scales of injection

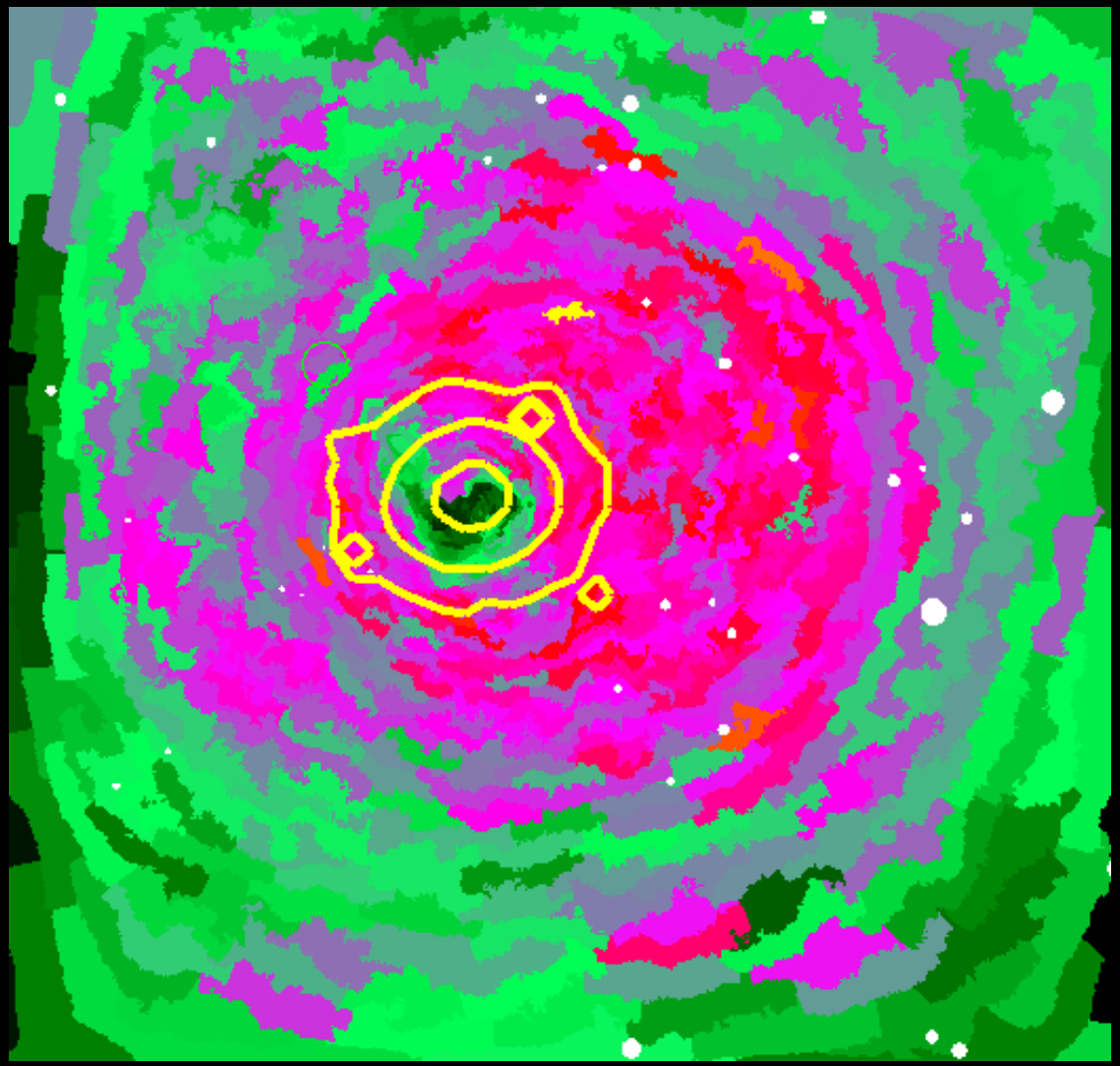


MS 0735.6+7421
(McNamara et. al. 2005)

Cluster Enrichment

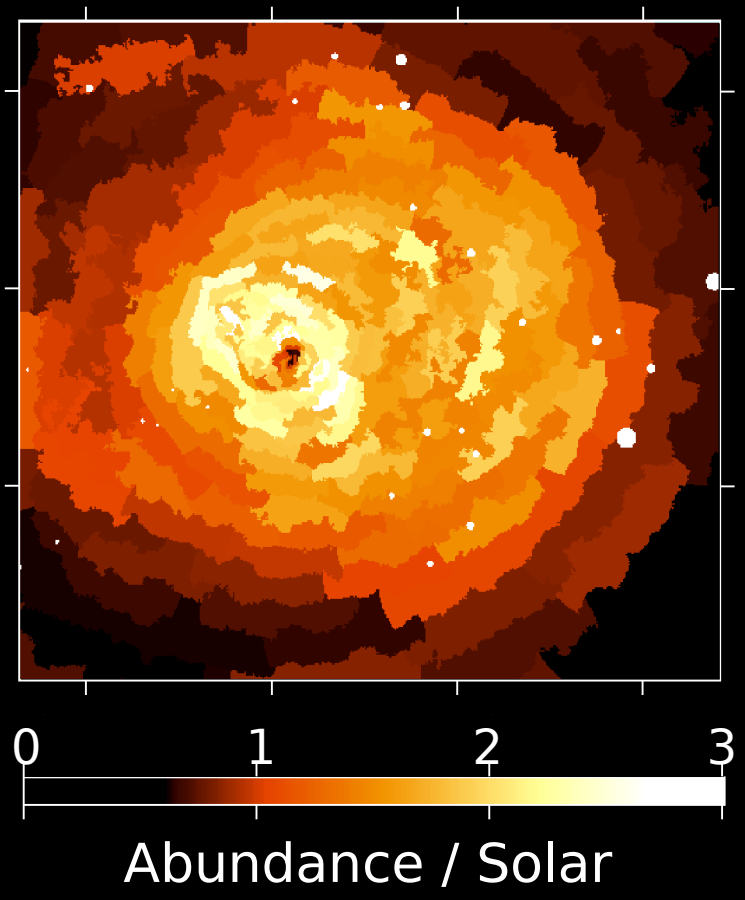
- Intracluster medium has been observed to be enriched with metals
- The central regions of the cluster show a metallicity excess
- We assume that the excess is due to ejection from the central galaxy

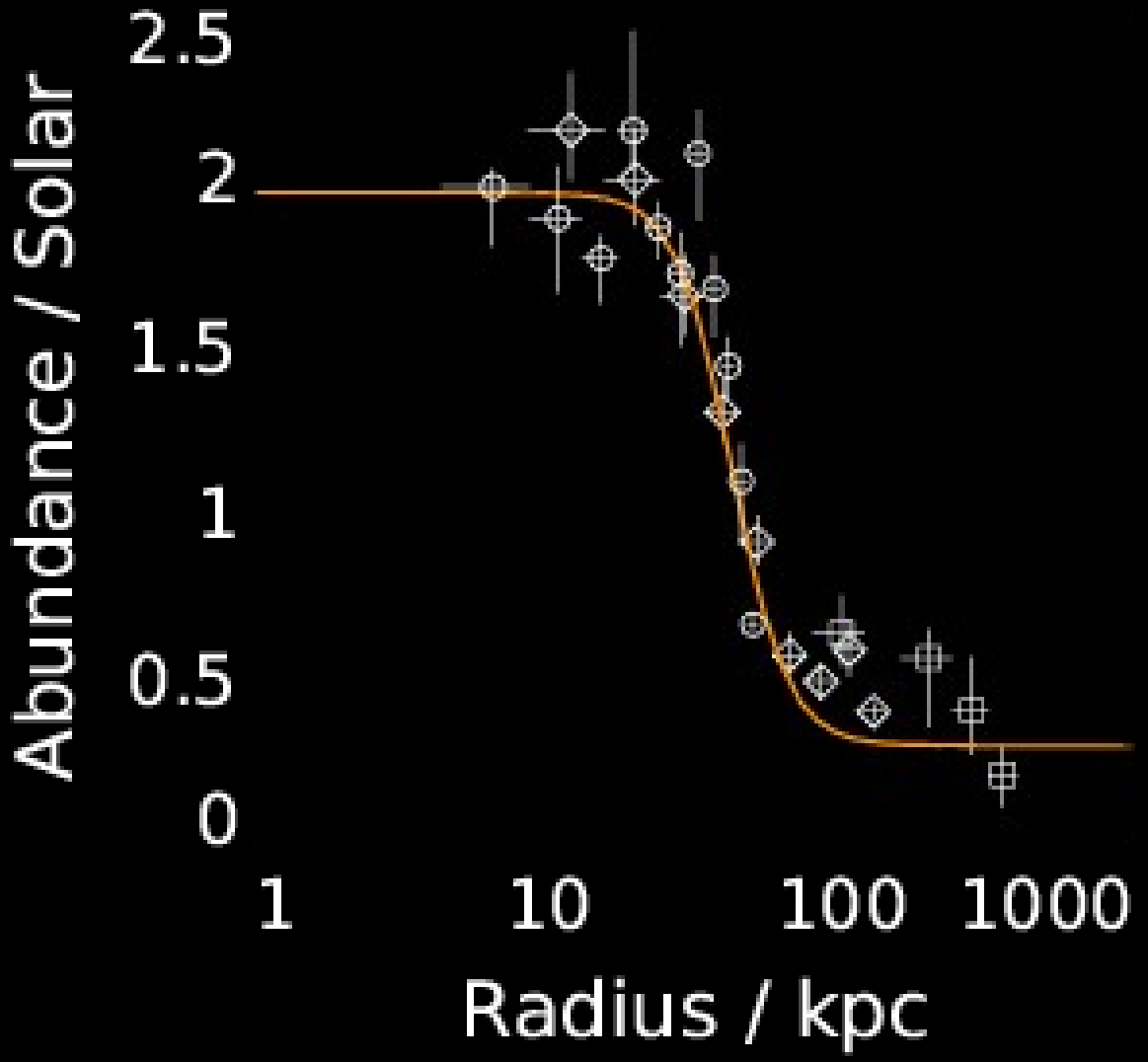
Tracing Gas Motions



- The central iron abundance peak is much broader than the galaxy light profile
- This allows the iron distribution to be used as a tracer for the underlying gas motions

Abundance Profile





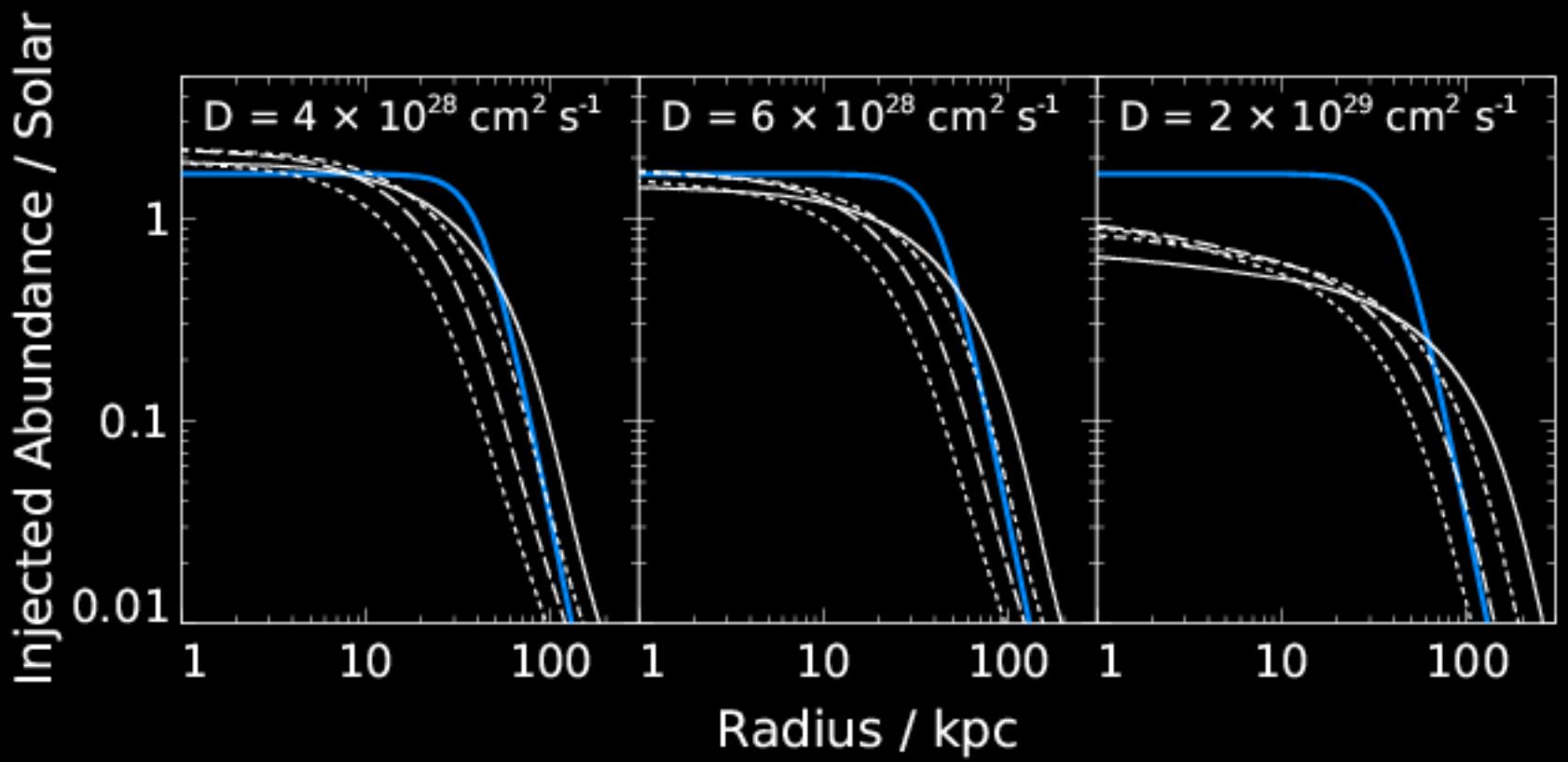
Modelling iron motion

- Following the work of Rebusco et. al. (2005) on the Perseus cluster
- Treat the movement of iron as a diffusion process:

$$\frac{\partial na}{\partial t} = \nabla \cdot (Dn \nabla (a)) + S$$

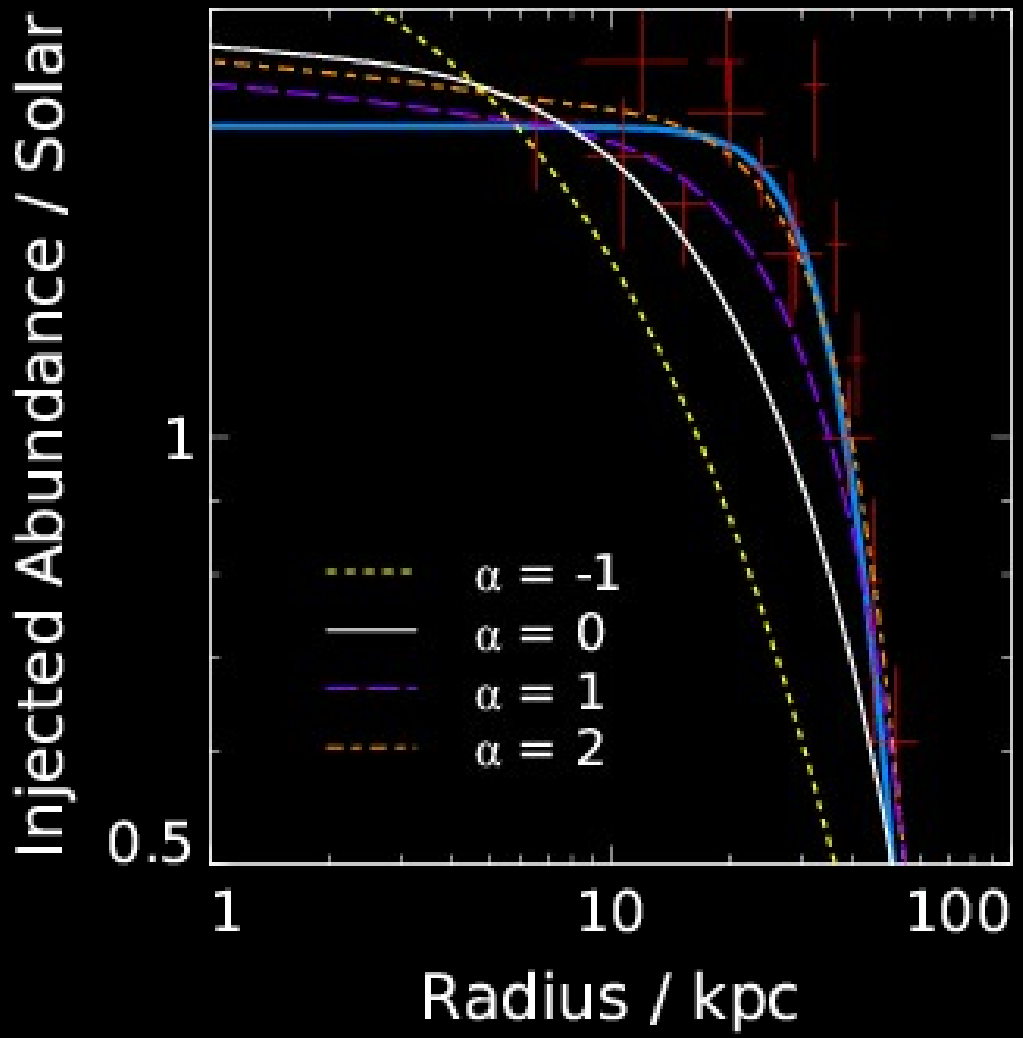
n – Hydrogen density
a – Iron abundance
D – diffusion constant
S – Iron sources

Uniform Diffusion Coefficient



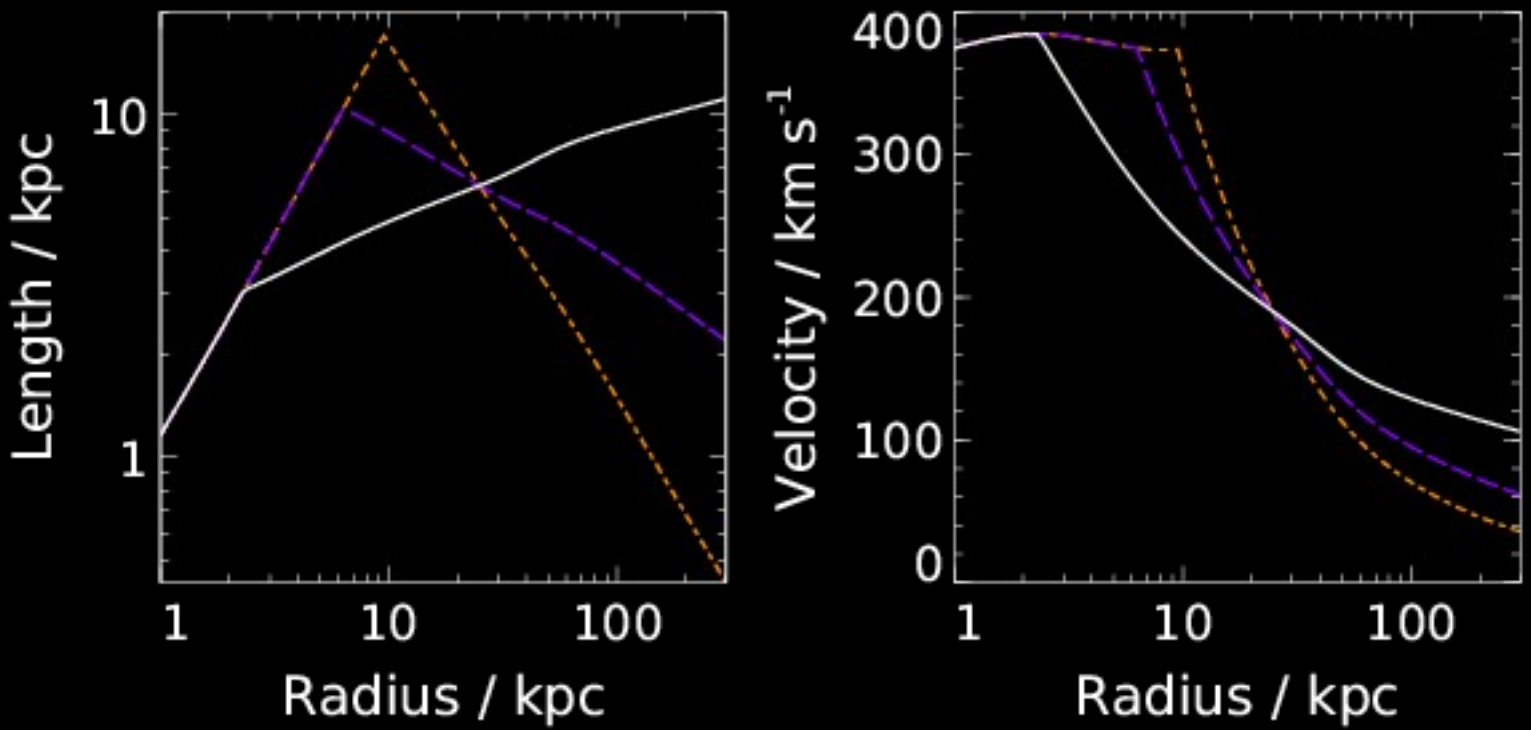
- Best fit is between 4x10^{28} cm^2 s^{-1} and 6x10^{28} cm^2 s^{-1} compared to 2x10^{29} cm^2 s^{-1} for Perseus

Variable Diffusion Coefficient



- Models where the diffusion coefficient decreases with radius are a better fit

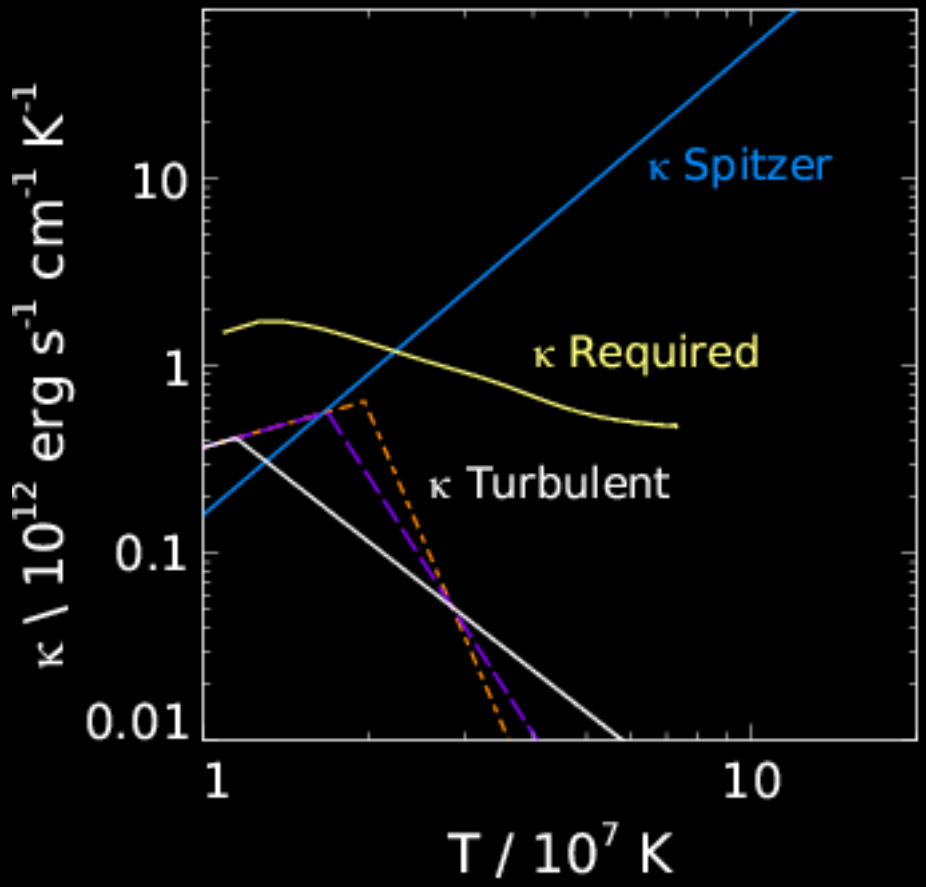
Turbulent Heating



- These length scales seem to be larger than the bubble dimensions

Conductivity

- Turbulent conduction has conductivity=$Dk_B n$
- Turbulent conduction appears unimportant except in the very centre



Summary

- Using the observed iron distribution we can get a handle on the gas motions
- We are confident that the effective diffusion coefficient over the region 30-70kpc must be less than $\sim 4 \times 10^{28} cm^2 s^{-1}$
- The large injection scale requires casts doubt on the bubble-induced turbulence model
- Some other mechanism might be operating – clusters need not be turbulent at all