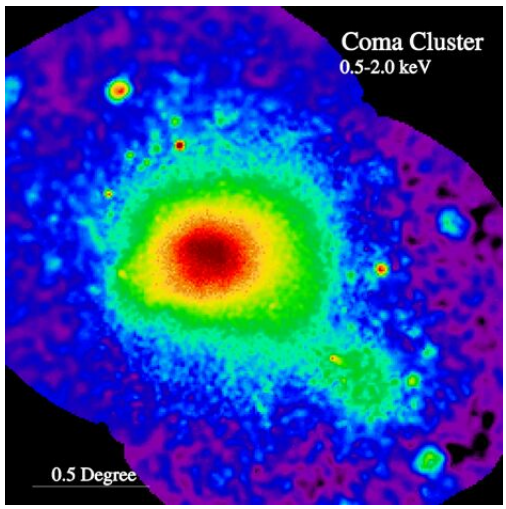
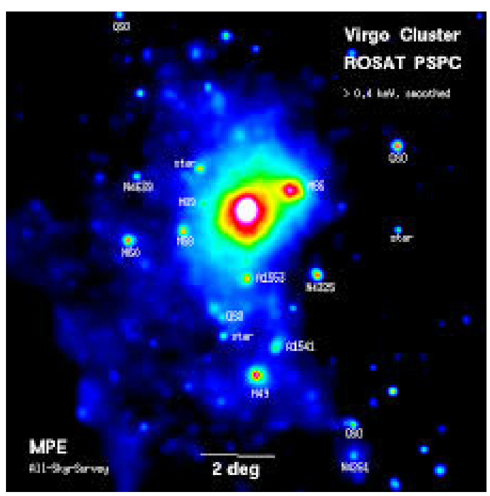
- AGNs are the brightest X-ray sources in the universe,while galaxy clusters being second brightest in the band.
- Diffused X-ray emission from galaxy clusters-It was first reported by Meekins et al(1971) that there is diffused X-ray emission from the galaxy cluster.This region is called Intracluster medium.It emits prominently in X-ray.Usual luminosity in x-ray region being of the order of $Lx = 10^{43} 10^{45} ergs/s$.
- ROSAT image of COMA cluster shows that emission is rather spread across the cluster and does not seem to originate from any particular point.But it does show that the emission is stronger in the core of the cluster.



ROSAT image of COMA cluster



ROSAT image of Virgo Cluster

Intracluster Medium

- **ICM:**Intracluster medium -Galaxy clusters are huge accumulation of X-ray luminous hot gas.The mass of hot gas is roughly equal to that in stars in a poorer cluster like Fornax;while rising to a ratio of 10:1 in richer cluster like Coma.Its seen that larger clusters have a very poor efficiency in converting the gas in the cluster to stars.The hot gas fills the entire cluster,and can often be traced to larger radii than can the stellar population.Typical temperature in ICM ranges from $10^7 10^8 K$,and density $n_e \sim 10^3$
- Thermal Equilibrium-If the cluster gas is virialised,then we can say that a proton has a velocity same as a galaxys.Thus it can be expressed as thermal maxwellian distribution.
- **Equilibrium Timescale:**

$$t_{eq} = \frac{1}{v_{rms}}$$

$$l = \frac{1}{n\sigma}$$

n is the number density σ is the interaction cross section area.

$$v_{rms} = \sqrt{\frac{3kT}{m_p}}$$

For Protons:

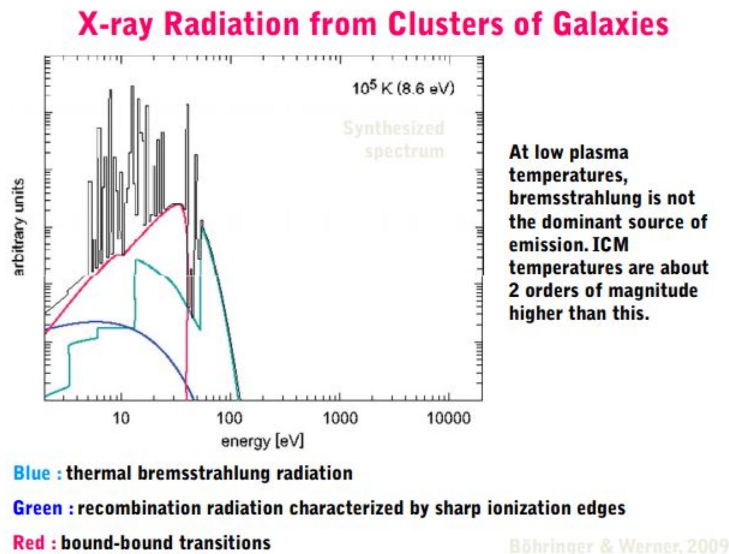
$$t_{eq} = 1.4 \times 10^7 yrs[\frac{T}{10^8}]^{3/2}[\frac{n}{10^{-3}cm^{-3}}]^{-1}$$

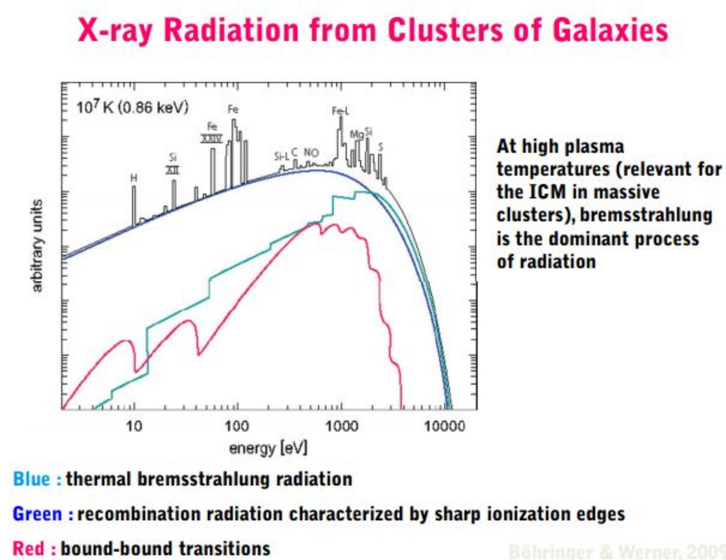
$\Rightarrow t_{eq} << t_H$

This means that if the gas would have existed for sufficiently long time,itd have achieved thermal equilibrium by now.Thus the gas in ICM is in thermal equilibrium.

Cooling Timescale

- Cooling mechanisms-Three possible cooling mechanisms can be responsible for the ICM cooling:
  1. Recombination-Cooling rate is inversely proportional to velocity,thus recombination doesnt seem to be the dominant process responsible for cooling.
  2. Collisional Cooling-At such high temperature in ICM it is unlikely that neutral hydrogen can exist.Thus this mechanism of cooling is also ruled out.
  3. .Bremsstrahlung-The spectra obtained from ICM resembles the spectra of Bremsstrahlung.This process can be accounted for the cooling mechanism that take place in ICM.





- Volumetric emissivity due to thermal Bremsstrahlung-

$$\epsilon_{ff} = 3 \times 10^{-27} T^{1/2} n^2 erg/cm^2/sec$$

Luminosity $L_x = \epsilon_{ff} \times \frac{4}{3}\Pi r^3$
Internal Energy $E = \frac{3}{2}nkT$

$$\frac{dE}{dt} = \frac{3}{2}nk\frac{dT}{dt}$$

$$t_{cool} \sim \frac{T}{dT/dt} = (\frac{dlnT}{dt})^{-1}$$

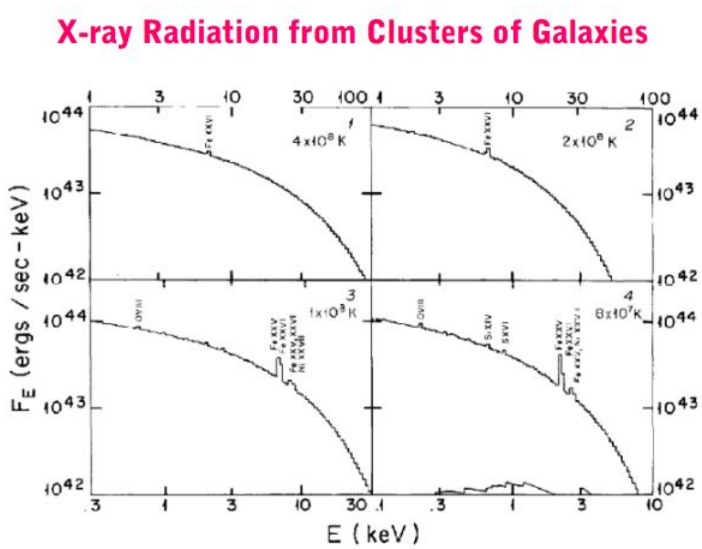
$$t_{cool} \sim 2 \times 10^{10} yr [\frac{T}{10^8}]^{1/2} [\frac{n_e}{10^{-3} cm^{-3}}]^{-1}$$

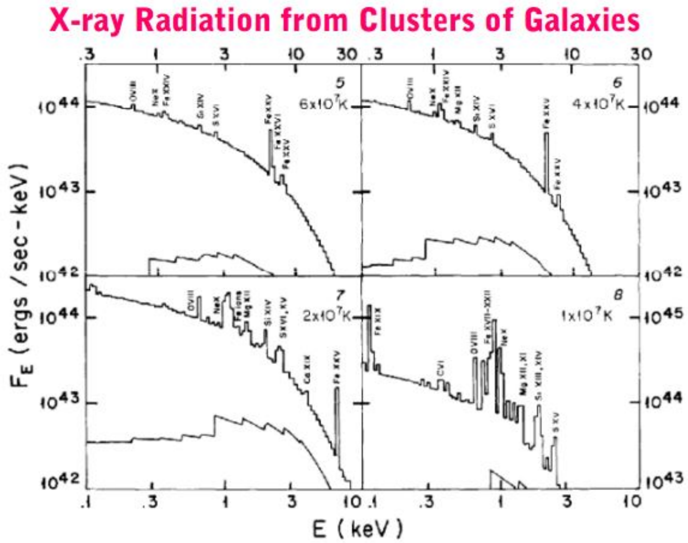
This expression holds true for ICM having solar metallicity.

$$t_{cool} > t_H$$

Thus the gas is still thermalised as we see it.

- Some spectrum of galaxy cluster X-ray emission:





- The spectra of ICM is superposition of X-ray spectrum and line emission spectrum.As the temperature of the ICM increases,the line emission becomes less pronounced.This is because as the temperature increases the molecules becomes more and more ionized,such that no more ionization is possible at higher temperatures.