Intracluster medium contd..

- The ICM in addition to being at thermal equillibrium, is also in hydrostatic (Pressure) equillibrium.This means that any disturbance created in the medium is propagated at the speed of sound.So the travel time of sound to the outer edge of the cluster will give an estimate of the timescale in which it achieves equillibrium

$$t_p = \frac{R}{C_s} \tag{1}$$

$$t_p = \frac{Mpc}{\sqrt{\frac{\gamma Kt}{\mu m_H}}} \tag{2}$$

- Therefore,

$$t_p = 6.5 \times 10^8 \times \frac{T}{10^{-4}}^{-0.5} \times \frac{D}{Mpc} \tag{3}$$

An estimate of mass

- The condition for Hydrostatic Equillibrium will give the Mass enclosed within a radius r provided that the density and temperature profile are known.

$$\frac{dp}{dr} = -\frac{GM(r)}{r^2} \tag{4}$$

- From the ideal gas equation, $\frac{dp}{dr}$ can be expressed in terms of $\frac{d\rho}{dr}$

$$\frac{dp}{dr} = \frac{KT}{\mu M_H} \times (T\frac{d\rho}{dr} + \rho\frac{dT}{dr}) = -\frac{GM(r)}{r^2} \tag{5}$$

- Finally,

$$M(r) = \frac{KT}{\mu G m_H}(\frac{dln\rho}{dlnr} + \frac{dlnT}{dlnr})r \tag{6}$$

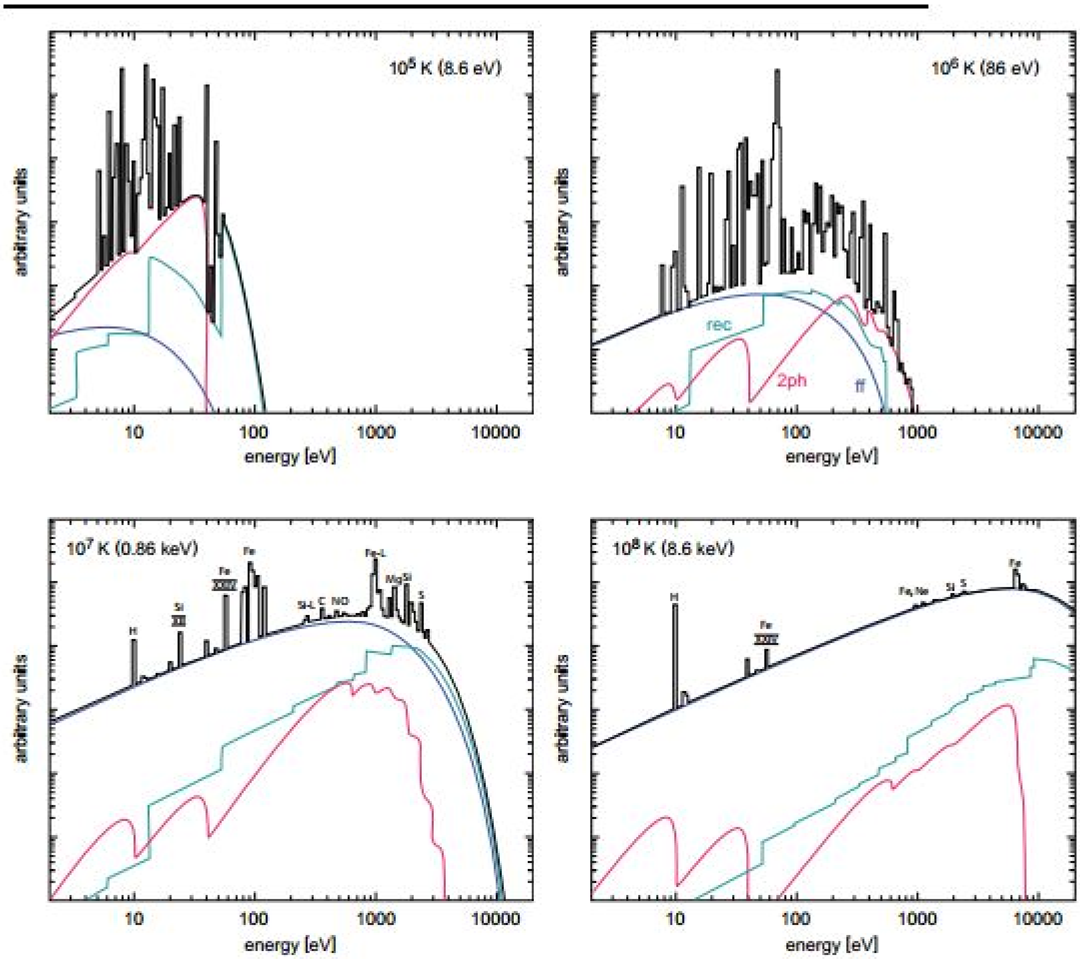

Figure 1: X-ray spectra for solar abundance at different plasma temperatures. The continuum contributions from bremsstrahlung (blue), recombination radiation, characterized by the sharp ionization edges (green), and 2- photon radiation (red) are indicated

- From the figure it is evident that at the highest temperatures relevant for massive clusters of galaxies bremsstrahlung is the dominant radiation process The major emission lines in the panels for the higher temperatures relevant for galaxy clusters are designated by the elements from which they originate.
- Heavily ionized metals are present in the ICM.As temperature decreases the strength of lines increases.So from the Xray spectral energy distribution one can find the temperature of the plasma.

ICM temperature and virial mass scaling relation

- By measuring the temperature the mass can be directly obtained from the scaling relation obtained from the figure below

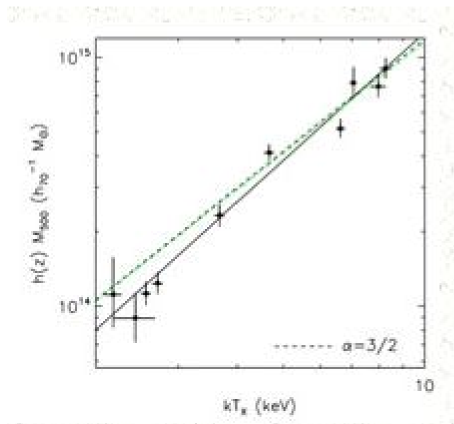

Figure 2: The mass - temperature relation of a sample of regular clusters

Virial Temperature

- Virial temperature corresponding to gravitational potential energy which keeps the gas at 10^8K bound together i.e it does not reach escape velocity

$$\frac{\mu m_H \sigma^2}{2} = \frac{3K_B T_{vir}}{2} \tag{7}$$

$$T_{vir} = \frac{\mu m_H \sigma^2}{3K_B} \tag{8}$$

- For an isothermal sphere of gas,

$$T_{vir} = 3.6 \times 10^5 (\frac{\sigma}{100kmps})^2 \tag{9}$$

- Velocity dispersion of galaxies in group is smaller so temperature between groups is lesser than clusters.