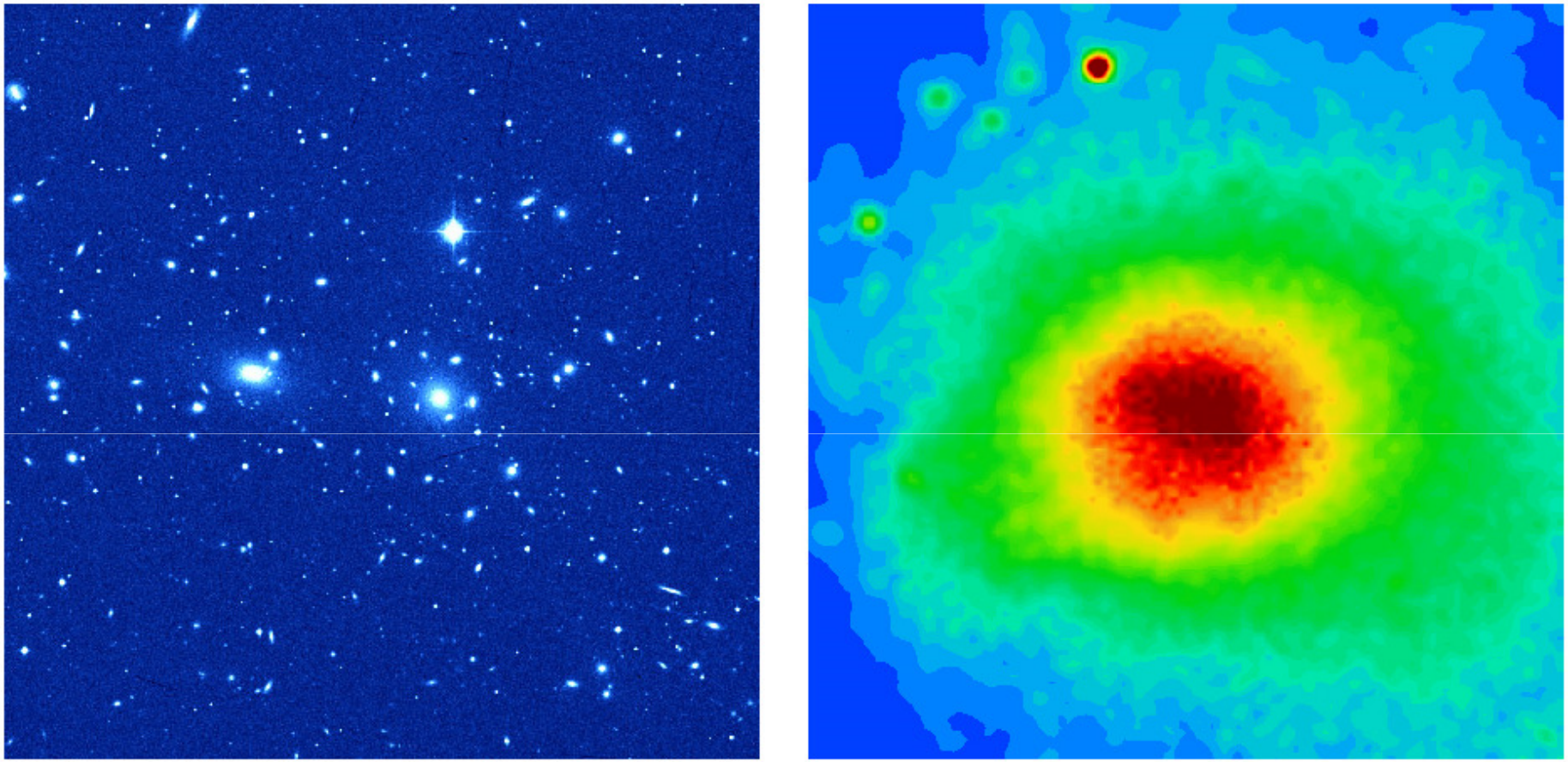
X-ray Radiation from Clusters of Galaxies



Coma cluster of galaxies. Optical (left image) and in X-ray (right image). The X-ray emission is spread out over a large area and is not concentrated in any one galaxy. The intensity of X-ray radiation is maximum around the luminous giant elliptical galaxy NGC 4874 which is approximately at the cluster core.

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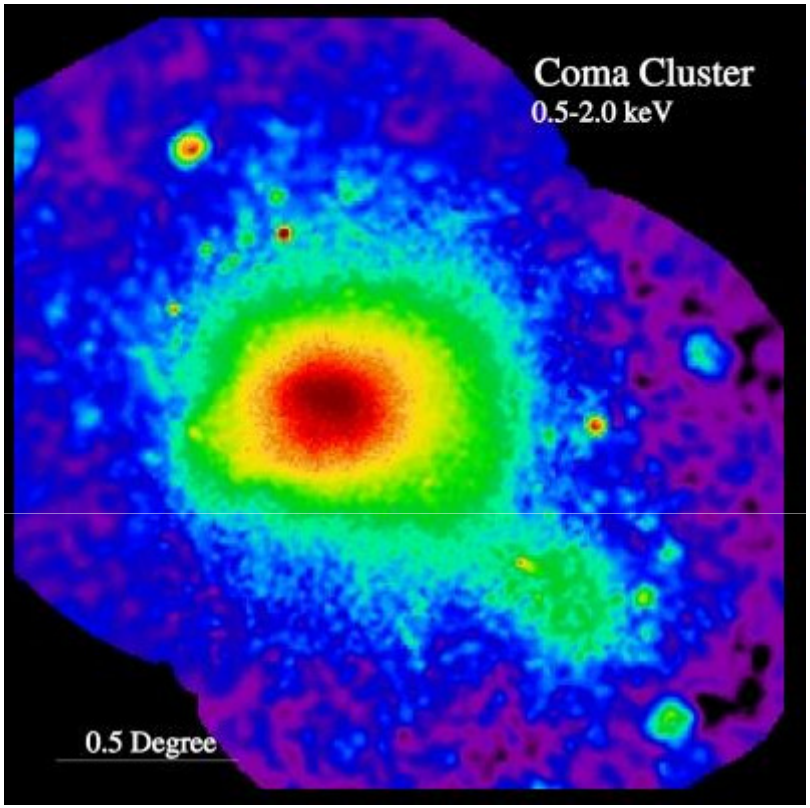

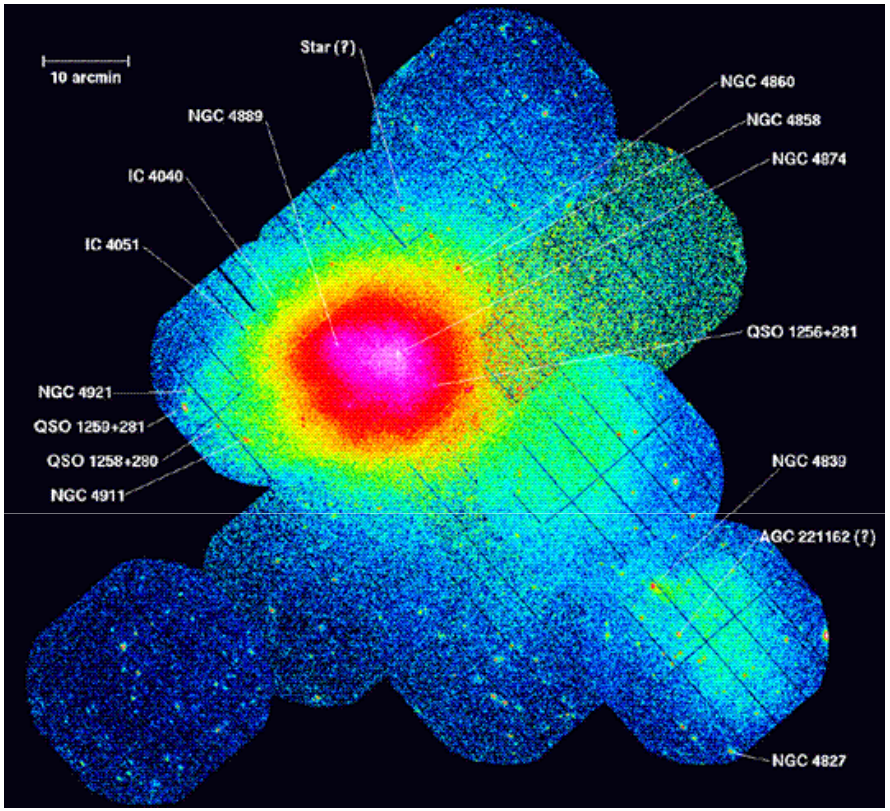

X-ray images of the Coma cluster, taken with ROSAT (left) and XMM (right). The image is color-coded to show the intensity of the X-ray radiation with red color showing regions of high X-ray intensity and violet regions of low intensity. The central region of the cluster is dominated by the giant elliptical galaxy NGC 4874. In the XMM image other galaxies of the Coma cluster are labeled.

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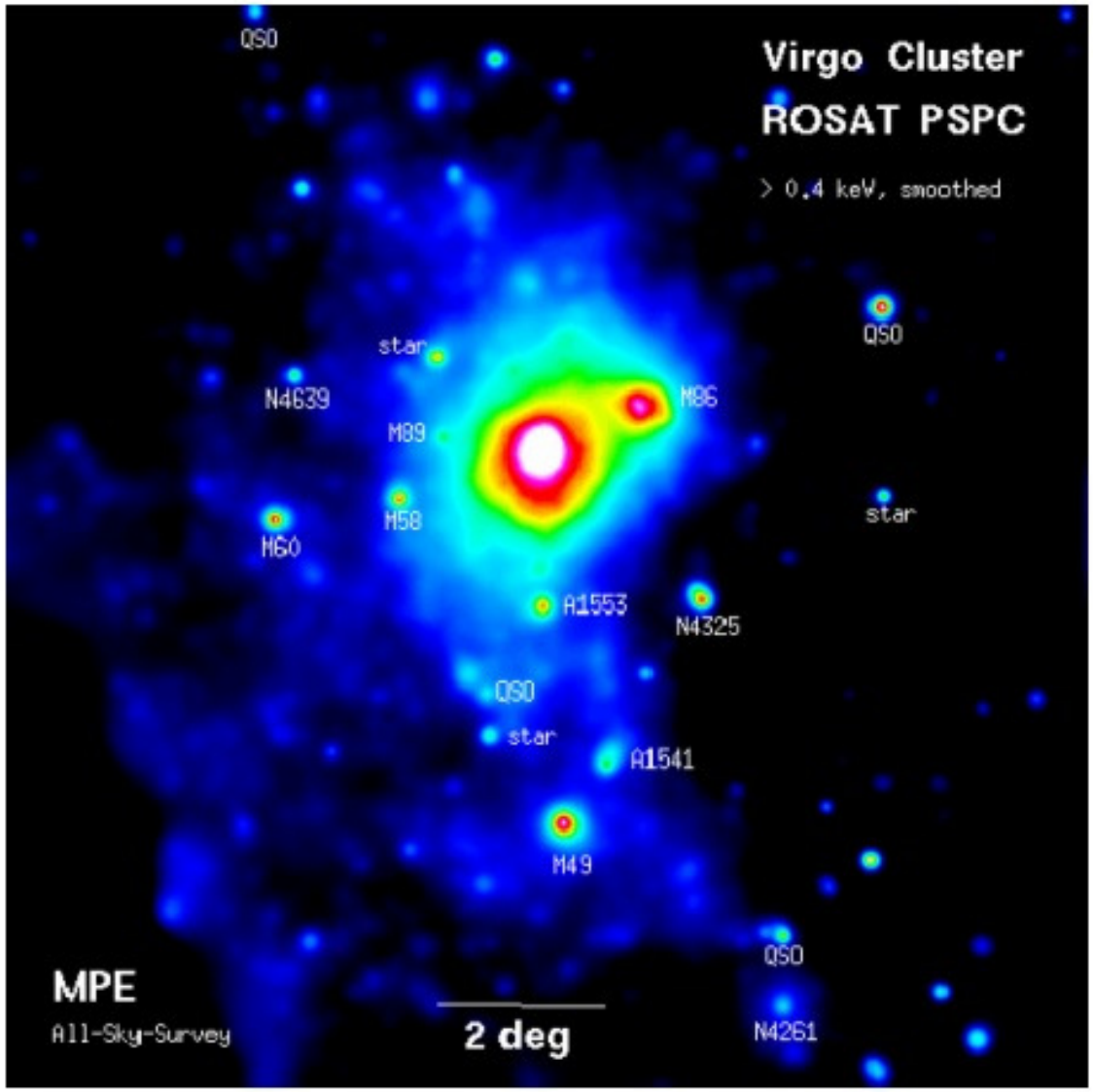

ROSAT image of the Virgo Cluster. The field is about 3 Mpc across at the location of the cluster. Individual labeled sources are galaxies in the cluster, foreground stars and background galaxies. The bright central object is the massive and lumious cD elliptical galaxy in the M87 in the Virgo cluster. The diffuse X-ray emission from the ICM is spread across the cluster.
(Bohringer et al. 1994)

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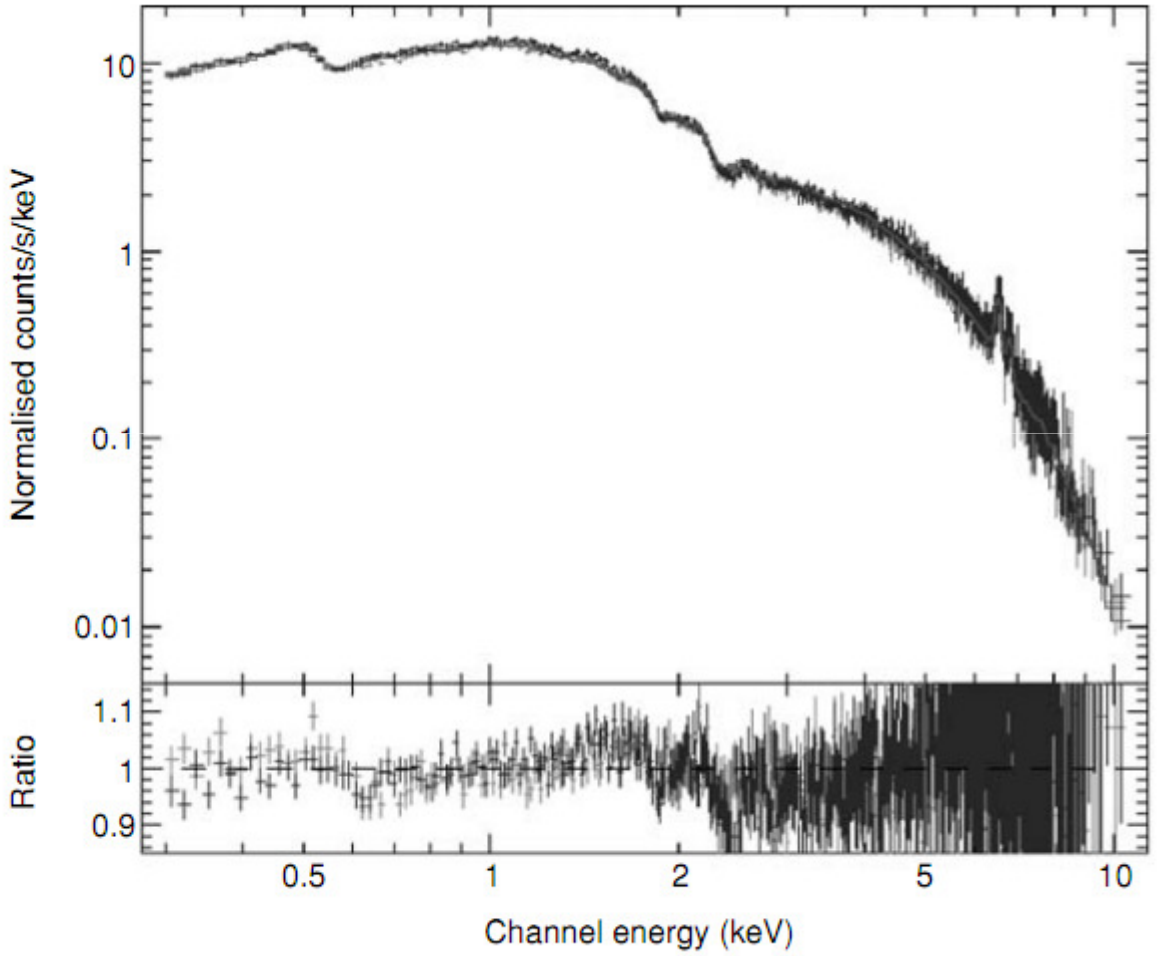
Fig 15.3 Spectrum from the centre of the Coma Cluster measured by the XMM EPIC detectors. Spectrum is a thermal continuum with Fe emission lines at ≈6.7 keV. (bottom) Residuals between data and the best-fit model with kT = 8.25 keV (from Arnaud *et al.*, 2001).



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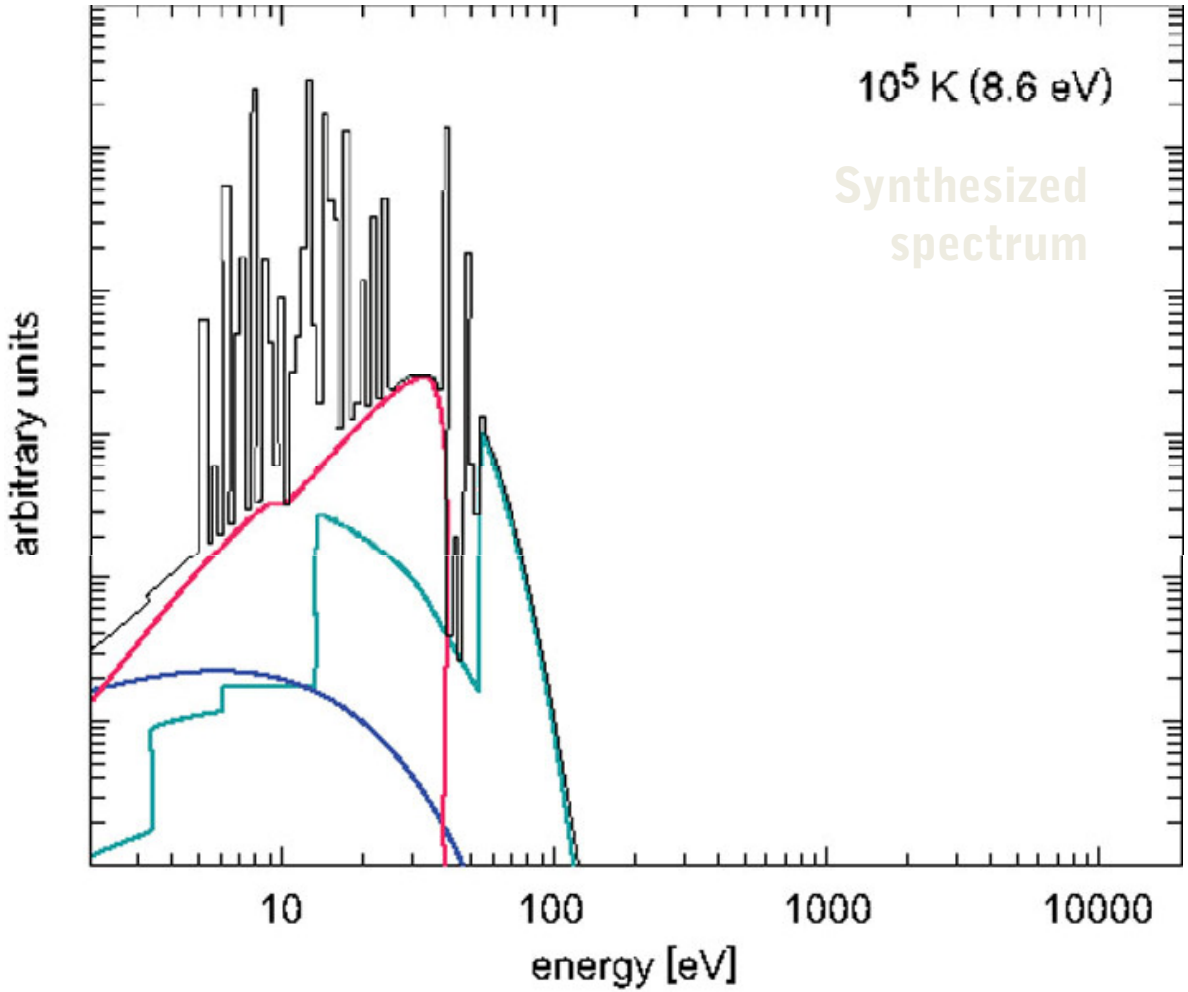

At low plasma temperatures, bremsstrahlung is not the dominant source of emission. ICM temperatures are about 2 orders of magnitude higher than this.

Blue : thermal bremsstrahlung radiation

Green : recombination radiation characterized by sharp ionization edges

Red : bound-bound transitions

Böhringer & Werner, 2009

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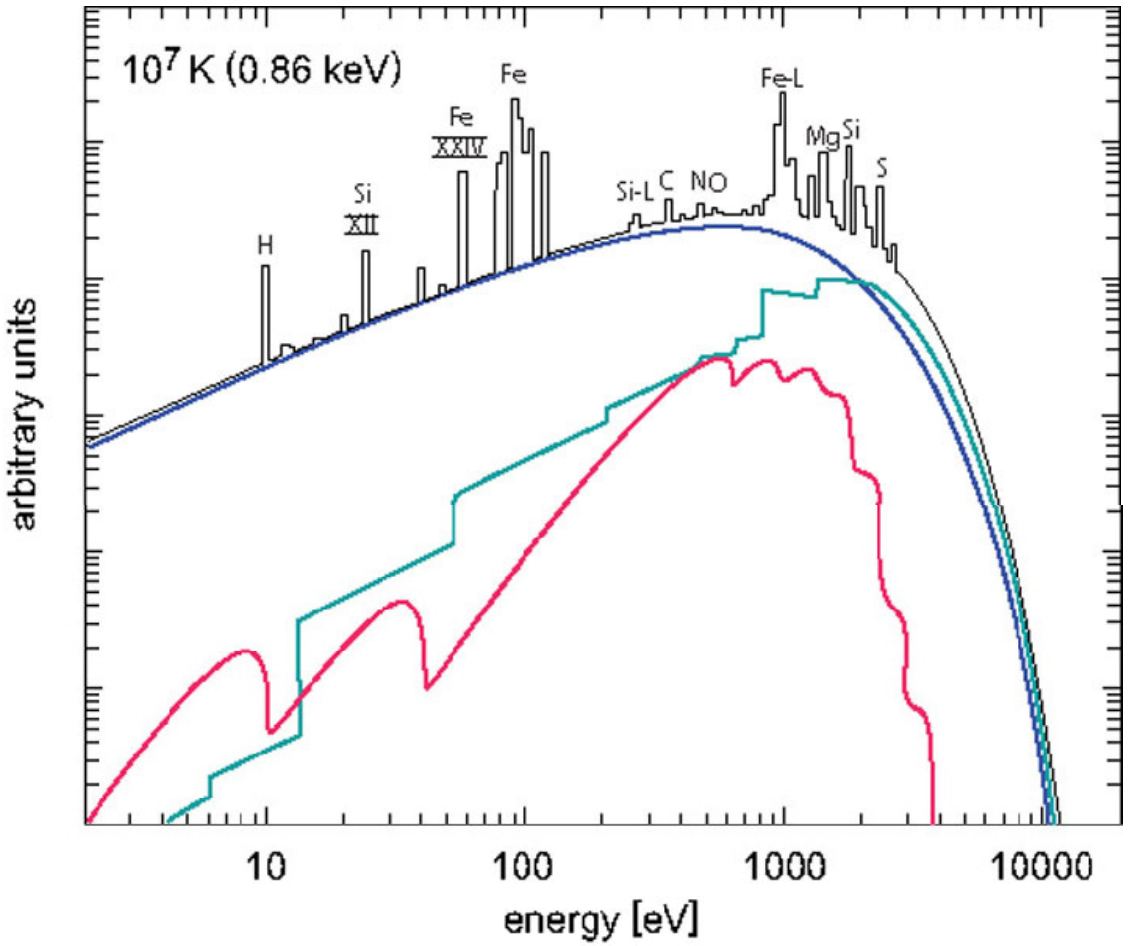


At high plasma temperatures (relevant for the ICM in massive clusters), bremsstrahlung is the dominant process of radiation

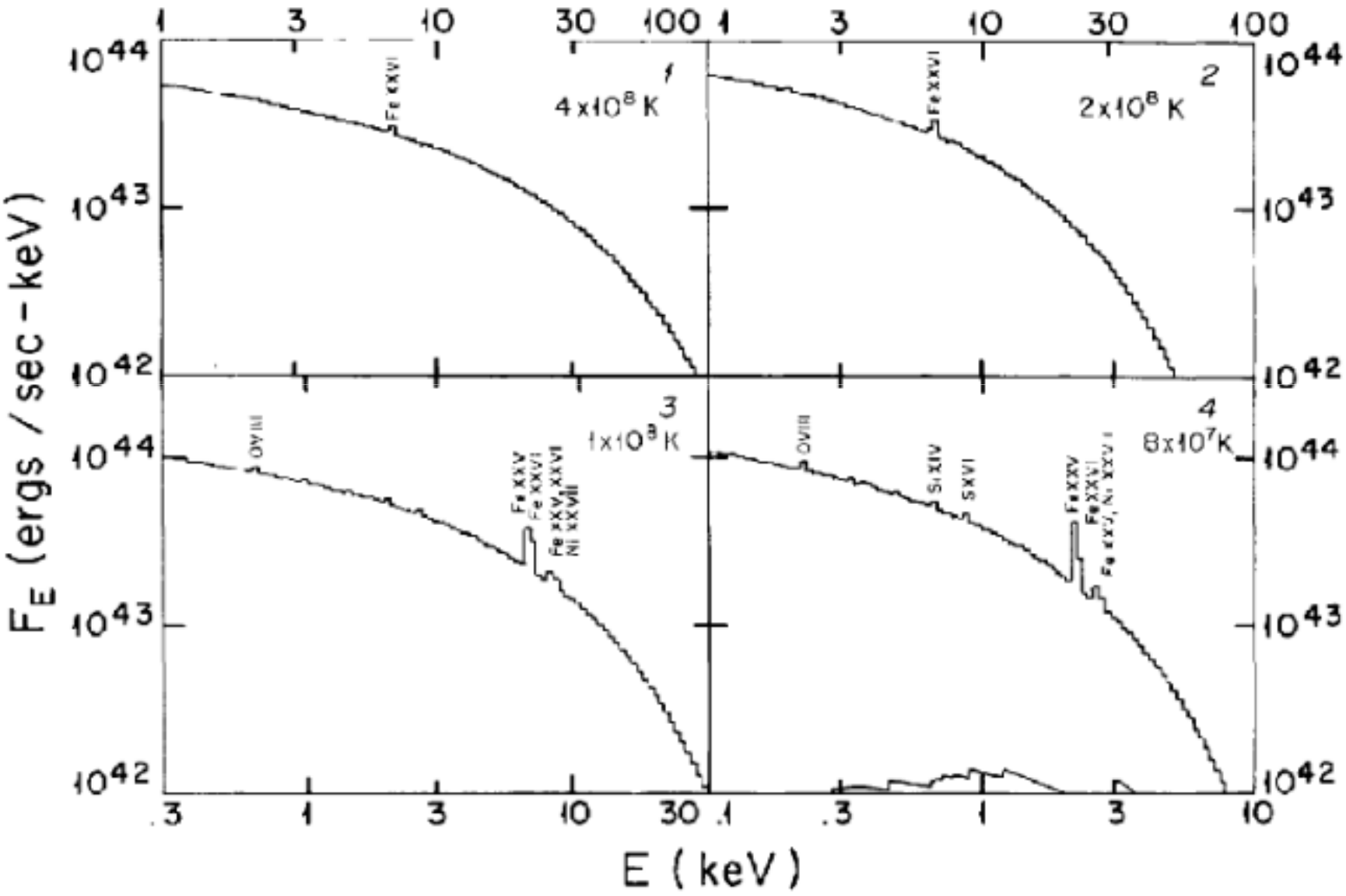
Blue : thermal bremsstrahlung radiation

Green : recombination radiation characterized by sharp ionization edges

Red : bound-bound transitions

Böhringer & Werner, 2009

X-ray Radiation from Clusters of Galaxies



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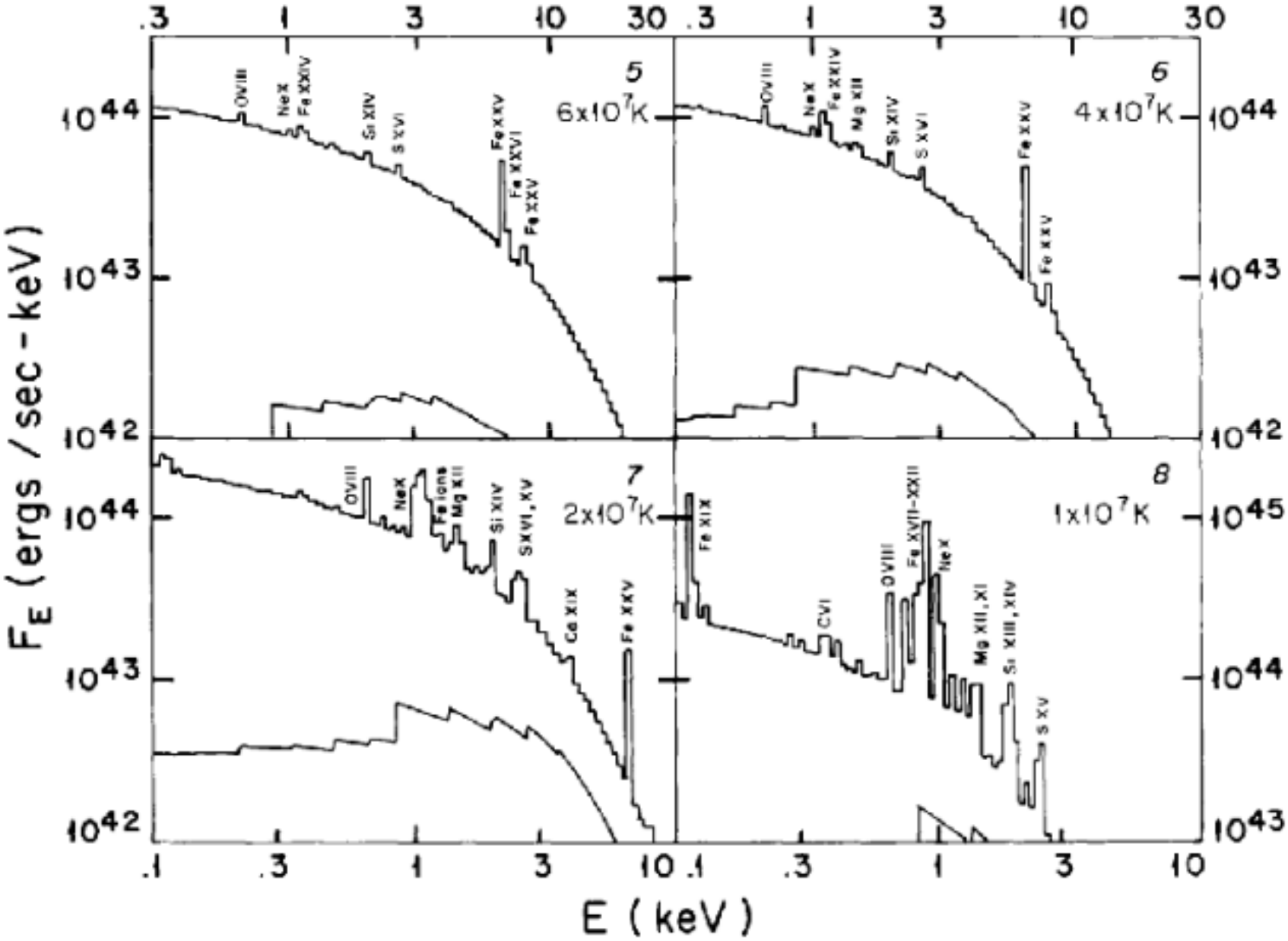
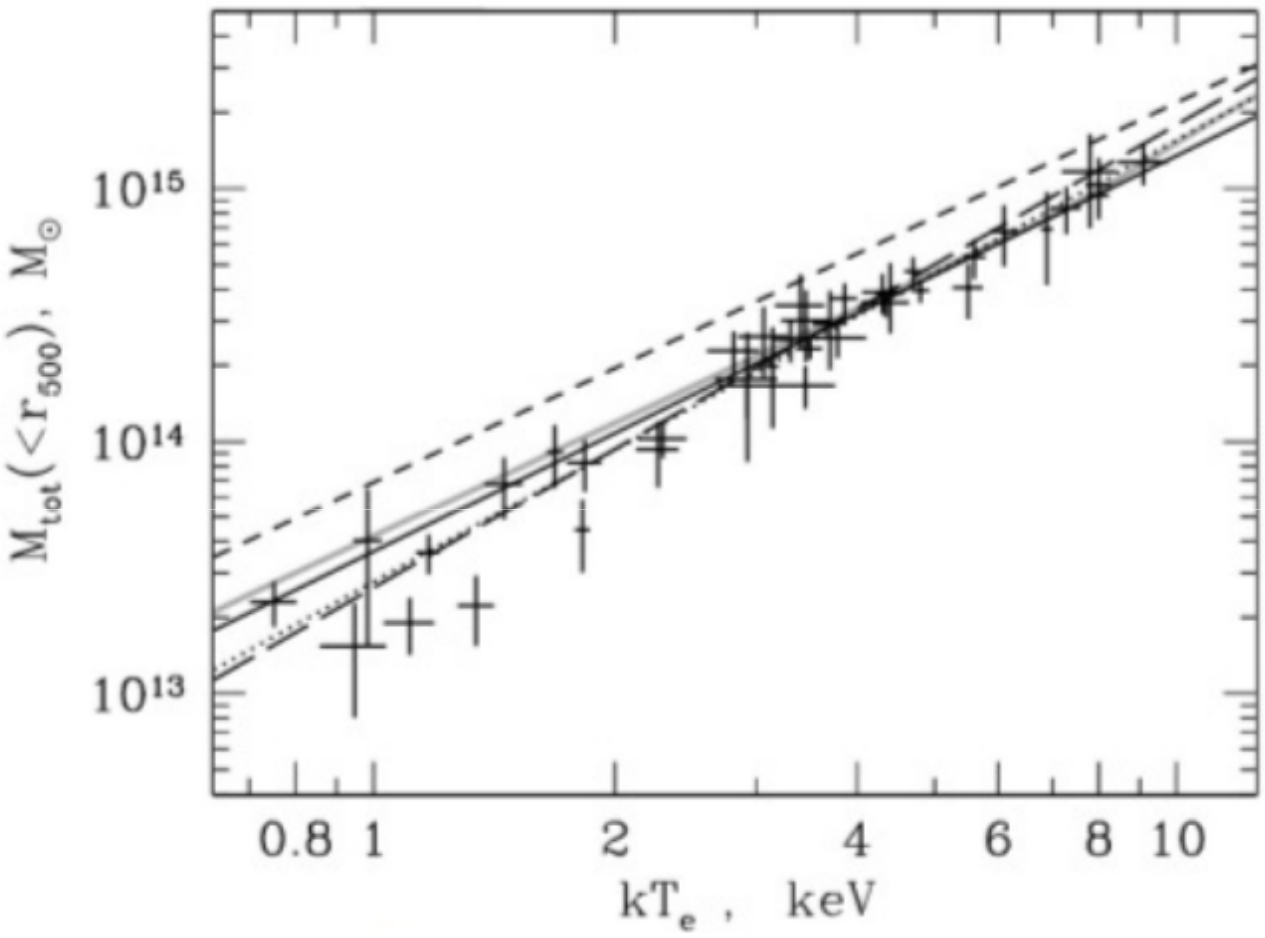


ICM Temperature and Virial Mass Scaling Relationship



Bigger clusters are hotter and brighter (in X-rays) than smaller clusters. Temperature of the ICM seems to be scaling with the gravitational potential (M/R) of the cluster. Useful scaling relationship to determine virial mass of clusters from ICM temperature.

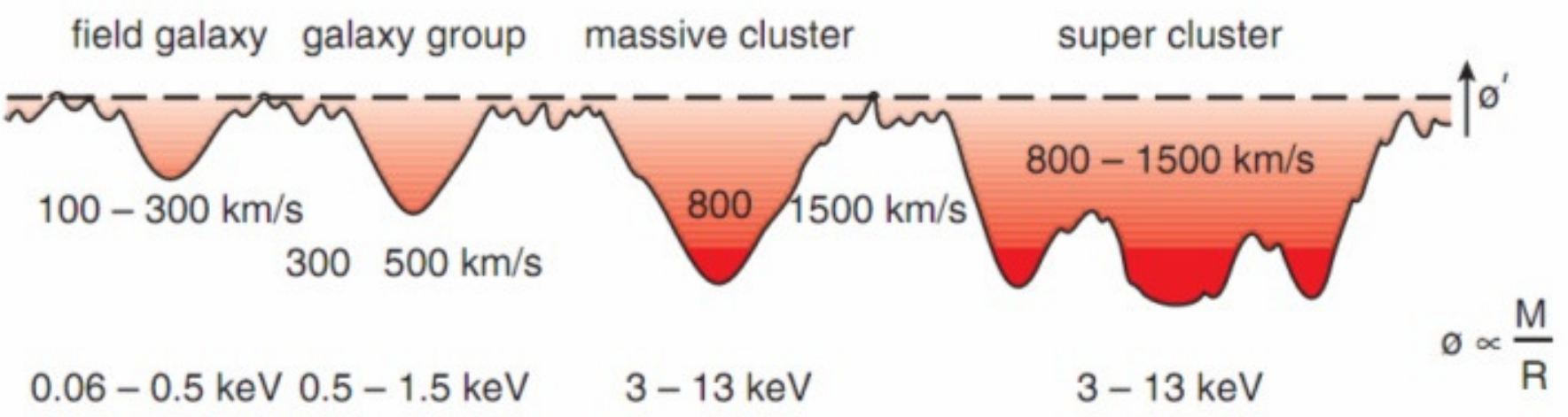


Figure shows a schematic of the depth of gravitational potential in various mass systems (starting from the level of galaxies) in our universe. The depth of the gravitational potential can be probed by studying the velocity dispersion of stars or galaxies and the temperature of the interstellar or intracluster medium, which are observables.