Presented in this dissertation is an analysis of the X-ray emission from the intracluster medium (ICM) in clusters of galaxies observed with the *Chandra* X-ray Observatory. The cluster dynamic state is investigated via ICM temperature inhomogeneity, and ICM entropy is used to evaluate the thermodynamics of cluster cores.

If the hot ICM is nearly isothermal in the projected region of interest, the X-ray temperature inferred from a broadband (0.7-7.0 keV) spectrum should be identical to the X-ray temperature inferred from a hard-band (2.0-7.0 keV) spectrum. However, if unresolved cool lumps of gas are contributing soft X-ray emission, the temperature of a best-fit single-component thermal model will be cooler for the broadband spectrum than for the hard-band spectrum. Using this difference as a diagnostic, the ratio of best-fitting hard-band and broadband temperatures may indicate the presence of cooler gas even when the X-ray spectrum itself may not have sufficient signal-to-noise ratio (S/N) to resolve multiple temperature components.

In Chapter 2 we explore this band dependence of the inferred X-ray temperature of the ICM for 192 well-observed galaxy clusters selected from the *Chandra* X-ray Observatory's Data Archive. We extract X-ray spectra from core-excised annular regions for each cluster in the archival sample. We compare the X-ray temperatures inferred from single-temperature fits when the energy range of the fit is 0.7-7.0 keV (broad) and when the energy range is 2.0/(1+z)-7.0 keV (hard). We find that the hard-band temperature is significantly higher, on average, than the broadband temperature. On further exploration, we find this temperature ratio is enhanced preferentially for clusters which are known merging systems. In addition, cool-core clusters tend to have best-fit hard-band temperatures that are in closer agreement with their best-fit broadband temperatures.

ICM entropy is of great interest because it dictates ICM global properties and records the thermal history of a cluster. Entropy is therefore a useful quantity for studying the effects of feedback on the cluster environment and investigating the breakdown of cluster self-similarity. Radial entropy profiles of the ICM for a collection of 239 clusters taken from the *Chandra* X-ray Observatory's Data Archive are presented in Chapter 3. We find that most ICM entropy profiles are well-fit by a model which is a power-law at large radii and approaches a constant value at small radii: $K(r) = K_0 + K_{100}(r/100\text{ kpc})^{\alpha}$, where K_0 quantifies the typical excess of core entropy above the best fitting power-law found at larger radii. We also show that the K_0 distributions of both the full archival sample and the primary *HIFLUGCS* sample of [1] are bimodal with a distinct gap centered at $K_0 \approx 40$ keV cm^2 and population peaks at $K_0 \sim 15$ keV cm^2 and $K_0 \sim 150$ keV cm^2.

Utilizing the results of the the *Chandra* X-ray Observatory archival study of intracluster entropy presented in Chapter 3, we show in Chapter 4 that Hα and radio emission from the brightest cluster galaxy are much more pronounced when the cluster's core gas entropy is $\lesssim 30$ keV cm^2. The prevalence of Hα emission below this threshold indicates that it marks a dichotomy between clusters that can harbor multiphase gas and star formation in their cores and those that cannot. The fact that strong central radio emission also appears below this boundary suggests that feedback from an active galactic nucleus (AGN) turns on when the ICM starts to condense, strengthening the case for AGN feedback as the mechanism that limits star formation in the Universe's most luminous galaxies.

References

[1] T. H. Reiprich. *An X-Ray Flux-Limited Sample of Galaxy Clusters: Physical Properties and Cosmological Implications*. PhD thesis, AA(Max-Planck-Institut für extraterrestrische Physik, P.O. Box 1312, 85741 Garching, Germany), July 2001.