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Hidden Cooling Flows in Clusters and Groups of Galaxies

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Half of all clusters of galaxies have a cool core in which the temperature drops inward and the density rises as expected from a cooling flow. Over 20 years ago, High Resolution XMM RGS Spectra showed little evidence for the cooling flow continuing below 1 keV at the rates inferred from higher temperatures. We have now re-examined the RGS spectra of over 20 clusters and groups and 4 early-type galaxies and find that an intrisically-absorbed (HIdden Cooling Flow) model allows for significant continuous mass cooling rates to 0.1 keV and below at the level of 15-50% of the expected rates from above 1 keV. The rates range from 1-20 Msun/yr in groups to 15 -100 in regular clusters. Several highly luminous clusters have mass cooling rates of 1000 Msun/yr or more. Where available the Far Infrared flux is compatible with that expected from X-ray absorption. AGN feedback can account for 50-85% of the reduction in mass cooling rates but the remainder is significant. We discuss these results and outline the possible fate of the cooled gas, including Very Cold Gas Clouds, Low-Mass Star Formation, outward dragging by rising bubbles and non-luminous swallowing by the central black hole.

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