PROCEEDINGS OF SCIENCE

Detection of virial shocks in stacked Fermi-LAT clusters

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In the hierarchical paradigm of structure formation, galaxy clusters are the largest objects ever to virialize. They are thought to grow by accreting mass through large scale, strong virial shocks. Such a collisionless shock is expected to accelerate relativistic electrons, thus generating a spectrally flat leptonic virial ring. However attempts to detect virial rings have all failed, leaving the shock paradigm unconfirmed. Here we identify a virial γ-ray signal by stacking Fermi-LAT data for 112 clusters, enhancing the ring sensitivity by rescaling clusters to their virial radii and utilizing the anticipated spectrum. In addition to a central unresolved, hard signal (detected at the nominal 5.8σ confidence level), probably dominated by active galactic nuclei, we identify (5.9σ) a bright, spectrally flat γ-ray ring at the expected shock position. It corresponds to $\sim 0.6\%$ (with an uncertainty factor ~ 2) thermal energy deposition in relativistic electrons over a Hubble time. This result validates the shock paradigm, calibrates its parameters, and indicates that the cumulative emission from such shocks significantly contributes to the diffuse extragalactic γ-ray and radio backgrounds.

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