Athena's discovery potential for nearby X-ray emitting large-scale filaments

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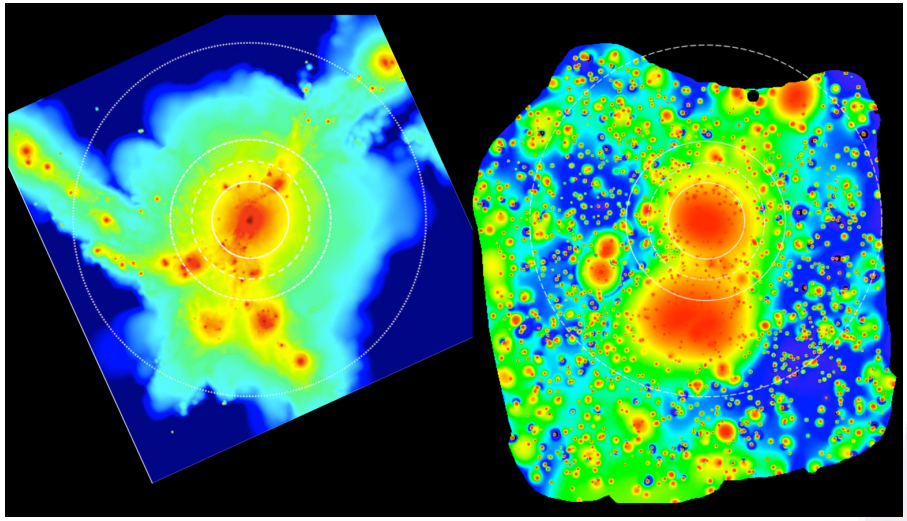

Left: This image shows the gas density distribution in a simulation. (Reiprich et al. (2013), Space Science Reviews, 177, 195). Right: A wavelet-filtered eROSITA image of the A3391/95 system presented with a color scaling to highlight faint regions (~15 Mpc size from the upper right corner to the lower left corner at the cluster redshift). (Reiprich et al. (2021), Astronomy & Astrophysics, 647, 2).

Almost half of the normal matter in the local Universe is still hidden from us. Simulations predict it to reside in thin warm/hot filaments connecting galaxy clusters. But the hot phase has been difficult to robustly detect as spatially-resolved emission around individual systems – until recently: with eROSITA a ~15 Mpc long filament has now been discovered. The left panel of the figure shows the environment around a simulated galaxy cluster. The innermost white circle indicates the region of a galaxy cluster typically observable with previous X-ray telescopes (the so-called r500), as well as other radii of interest, also expressed in units of the radius where the total matter densisy exceeds the avarage by a certain factor. One notes the large amount of structure outside that innermost circle. Those are the cluster outskirts where many interesting physical effects are expected to occur. The right panel of the figure shows an eROSITA image centered on a nearby galaxy cluster system. The same characteristic radii as on the left are indicated as white circles for the cluster A3391. The X-ray emission can be traced much further than previously possible: from the "Northern Clump" in the upper right corner, through A3391, the bridge, A3395, and the "Little Southern Clump," down to a known galaxy cluster just outside the field of view in the lower left corner. Such a continuous ~15 Mpc long emission strip including filamentary emission beyond the characteristic radii of clusters has never been observed before for an individual system, but it confirms our expectations from simulations.

Athena is the ideal mission to discover and study X-ray emitting filaments around nearby large galaxy clusters systematically. Its tremendous effective area at soft X-ray energies and its large field-of-view (WFI) will allow us to discover many more such filaments and trace their morphology, assuming that an efficient scanning mode to homogeneously cover few tens of square degrees is implemented. *Athena*'s spatially resolved high-resolution spectroscopy (X-IFU) will allow us to quantify density, temperature, and metallicity structure in the most interesting regions;, enabling *Ahena* to shed light on currently poorly understood enrichment and feedback processes in the warm/hot filaments.