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Structure of solar coronal loops: from miniature to large-scale

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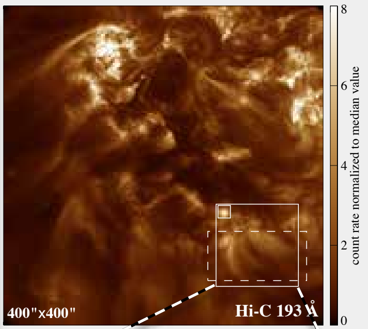
More information in Peter et al. (2013) A&A 556, A104: Click here for link to ADS.

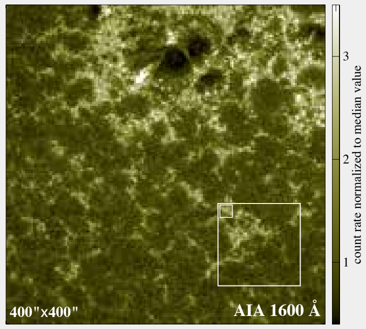
We use data from the High-resolution Coronal Imager (Hi-C) with its unprecedented spatial resolution of the solar corona to investigate the structure of coronal loops down to 0.2″.

During a rocket flight, Hi-C provided images of the solar corona in a wavelength band around 193 Å that is dominated by emission from Fe XII showing plasma at temperatures around 1.5 MK. We analyze part of the Hi-C field-of-view to study the smallest coronal loops observed so far and search for the possible substructuring of larger loops.

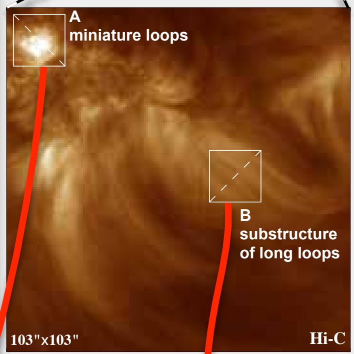
We find tiny 1.5 MK loop-like structures that we interpret as miniature coronal loops. Their coronal segments above the chromosphere have a length of only about 1 Mm and a thickness of less than 200 km. They could be interpreted as the coronal signature of small flux tubes breaking through the photosphere with a footpoint distance corresponding to the diameter of a cell of granulation. We find that loops that are longer than 50 Mm have diameters of about 2″ or 1.5 Mm, which is consistent with previous observations. However, Hi-C really resolves these loops with some 20 pixels across the loop. Even at this greatly improved spatial resolution, the large loops seem to have no visible substructure. Instead they show a smooth variation in cross-section.

That the large coronal loops do not show a substructure on the spatial scale of 0.1″ per pixel implies that either the densities and temperatures are smoothly varying across these loops or it places an upper limit on the diameter of the strands the loops might be composed of. We estimate that strands that compose the 2″ thick loop would have to be thinner than 15 km. The miniature loops we find for the first time pose a challenge to be properly understood through modeling.





Full field-of-view of the Hi-C and chromosphere from AIA.



Hi-C shows the emission from Fe XII formed at around 1.5 MK. The core of the active region with several sunspots is located in the top half of the image. The sunspots are clearly seen in the chromosphere (AIA 1600 Å, top right).

The image to the right shows a zoom of the square in the top panels.

Here we concentrate on the periphery of the active region:
- plage-type region with miniature loops.
- substructure of "normal" coronal loops.

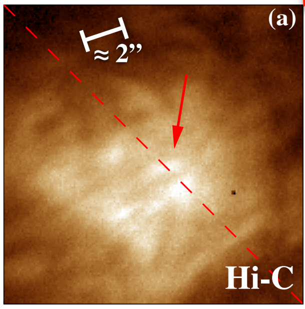
Details are found in Peter, Bingert, Klimchuk et al. (2013) A&A 556, A104.

A – Miniature loops

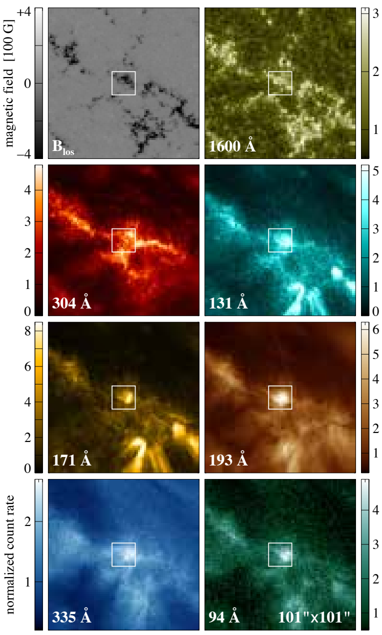
In some plage-type areas there are loop-like structures with lengths below 2" and widths below 0.5".

These loops could be the apex of very short loops.
Their footpoints would be rooted in the inter-granular field, with the footpoint distance being about the diameter of one granule.

They would barely stick out of the chromosphere.



The context images on the left show data from HMI and AIA. The small squares in the middle indicate the region shown in the Hi-C zoom above.



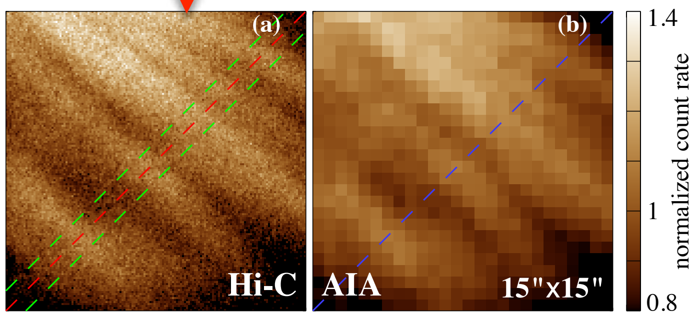
(1) The magetogram looks monopolar.
→ *So how can a tiny loop sit there without a bipole?*

High-res observations (Sunrise) and numerical simulations show that small opposite polarities exist in seemingly monopolar regions.

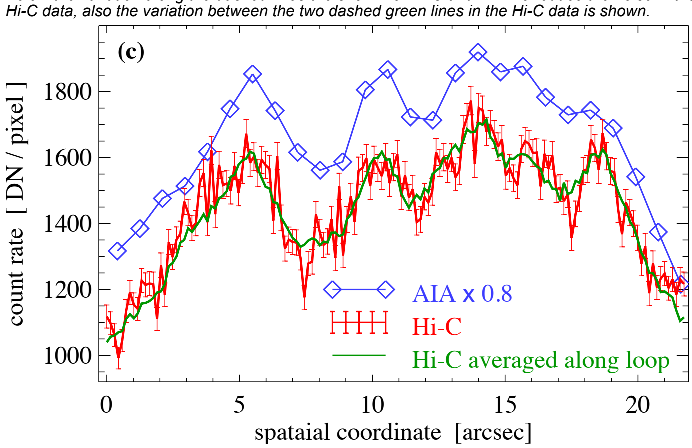
(2) *Could the miniature loop simply be moss?*

→ Probably not !

There is no clear evidence for the existence of a hot structure being rooted in the plage area (see 335 Å & 94 Å). Only then the miniature loop could be the footpoint of a hot loop, i.e. moss.



Below the variation along the dashed lines are shown for Hi-C and AIA. To reduce the noise in the Hi-C data, also the variation between the two dashed green lines in the Hi-C data is shown.



B – No substructure in large coronal loops

Hi-C shows a smooth variation across the loops. The loop cross section is samples by >12 pixels with no indication of a substructure.
(This applies to these large coronal structures, smaller, presumably lower-lying structures show sub-features, e.g.).

Coronal loops are either (based on numerical experiments and analytical estimations, see Peter, Bingert, Klimchuk et al. (2013) A&A 556, A104.)

– consisting of very small strands.

2" loop:
→ consists of $N \approx 7500$ strands
→ strand diameter $d < 15$ km !

or

– truly monolithic structures.

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