Are Coronal Loops Real?

Coronal loops are perhaps the most commonly observed extreme ultraviolet (EUV) features in the solar atmosphere. Understanding them is critical to understanding solar flares and coronal mass ejections, some of the primary drivers of space weather.

Interestingly, the underlying geometry of these structures is still actively debated. It is often taken for granted that the line-like loops are one-dimensional. However, the loops could also be line-of-sight projections of a more complicated geometry such as a warped two-dimensional layer of hot plasma (the “coronal veil”). Resolving this geometric ambiguity is critical to understanding coronal heating and eruptions in solar active regions.

Recently, a data-driven reconstruction of loop geometry was made based on EUV images obtained with the High-Resolution Coronal Imager. The results strongly suggest that the coronal loops could be influenced, but definitely not caused, by the projection effects. These effects can be isolated by properly chosen data analysis techniques, and what remains as the most likely underlying geometry is a collection of quasi-one-dimensional luminous structures. These results also indicate that the cross-sections of the coronal loops cannot be highly noncircular, and that the size distribution of the cross-sections should be close to a power-law shape indicative of solar nanoflares.

While the new results clearly show that the coronal loops and veils are distinct phenomena, the relationship between the two remains to be understood. It is possible that coronal loops are embedded into a large-scale veil, or that they contain micro-veils at the smallest scales. Future high-resolution coronal imaging missions will be needed to testing these possibilities.

One of the most famous coronal loop images from the NASA/TRACE spacecraft. This was the first image showing the detail and complexity of coronal loops observed in extreme ultraviolet light.

V. Uritsky and J. Klimchuk, 2024: “Are Coronal Loops Projection Effects?” The Astrophysical Journal Letters, 961:222.