Talking Points for J. Cirtain

Our sounding rocket mission was designed to develop the technologies capable of observing the solar high-temperature atmosphere with high spatial and time resolution. The solar atmosphere is much hotter than the solar surface and this fact has been a 50-year old problem for astrophysics-the so-called coronal heating problem. The sun's photosphere, or surface, is roughly 5000 degrees, where the atmosphere above quickly increases to several millions of degrees.

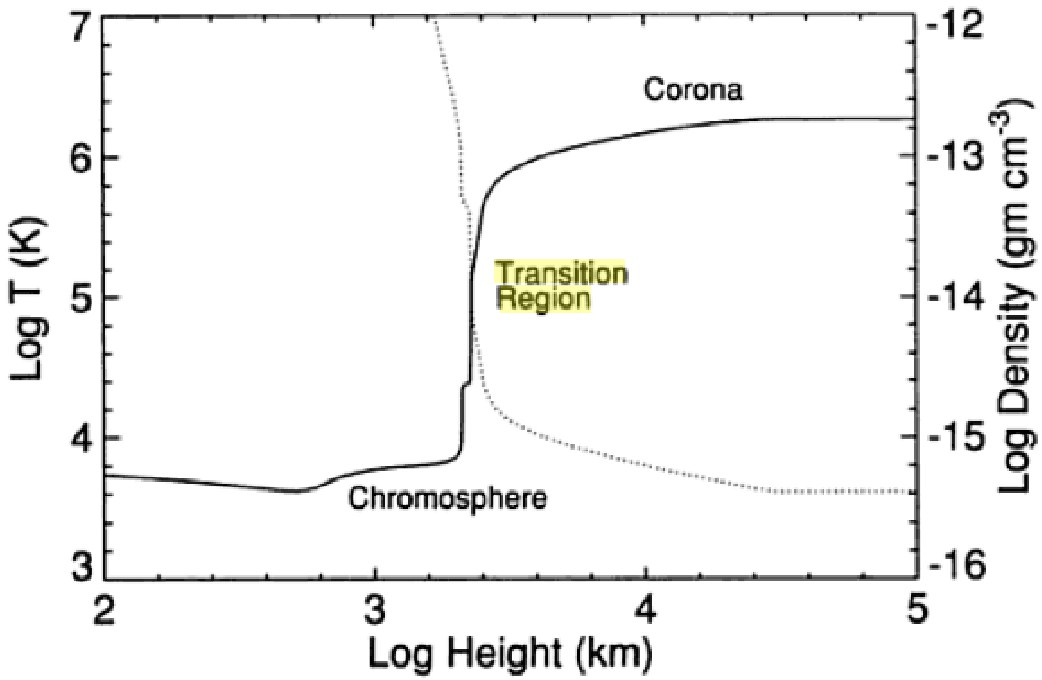
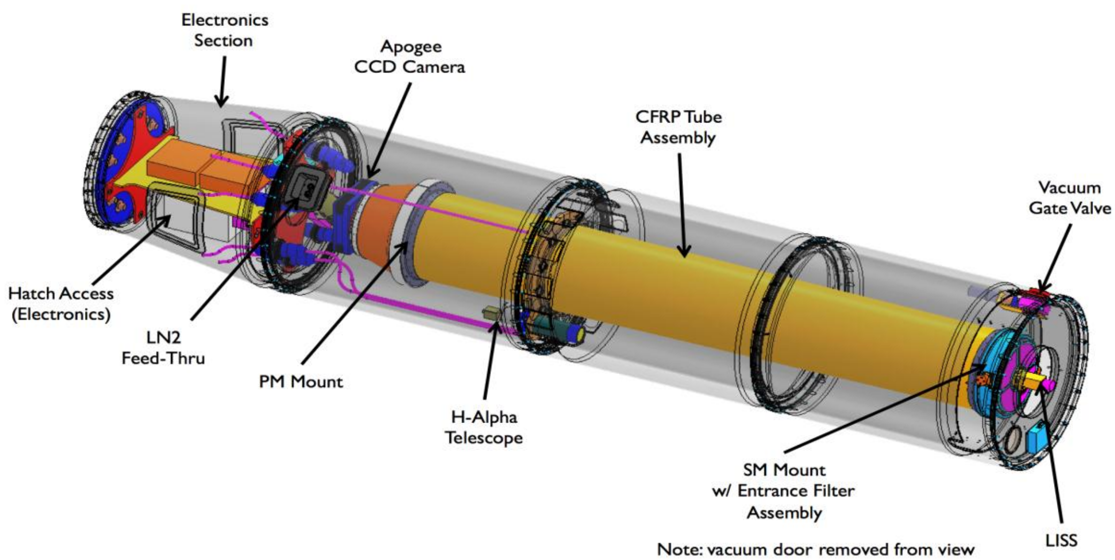


Figure 1: An average temperature-density structure of the quiet solar chromosphere, transition region and corona. The solid line is temperature and the dashed line is the density. Curtosey Mariska 1992.

The Coronal Heating problem, simply stated, is "What energy source is heating the solar atmosphere to such high temperatures?" This high temperature atmosphere is where space weather is initiated and where energetic events like flares and coronal mass ejections can originate. So understanding the energy supply for the corona has implications across the science of stellar structure and heliophysics, in general. In 1983, Dr. Gene Parker put forth the idea that twist and braiding of the solar magnetic field could supply sufficient energy that, when dissipated, could heat the corona and fuel flares and CMEs. This relaxation of the curvature of magnetic field had never been directly observed in the corona; the likely reason was assumed to be that the images were not at the resolution needed to see this evolution occur.

Our instrument, the High resolution Coronal Imager –HiC- was designed to capture an image of the solar atmosphere at a spatial and time scale we believed was relevant for the dissipation of magnetic field. Hinode and other observatories had imaged magnetic elements in the photosphere and found the scales there to be of order 200km, and so we built Hi-C to image the corona at that same resolution. This resolution is the equivalent of resolving a dime from 10 miles away.



Shown in Cirtain Video 1, the Hi-C mission was flown July 11, 2012 on a NASA sounding rocket from White Sands Missile range and we collected not just one, but around 50 images at this resolution. The data set has provided what we feel are a glimpse of energy storage and release in the sun's atmosphere. In Cirtain Video 2, we highlight our *Nature* paper results with two such events. In one event, we clearly see the evolution of a few strands of magnetic loops that are initially parallel and eventually appear to intersect. Subsequently, at the intersection location a large intensity increase is observed by the Atmospheric Imaging Assembly on SDO, indicative of energy release. AIA can observe the corona in several different temperature passbands, and these different channels provide conclusive evidence of plasma heating and followed by cooling associated with this small flare.

Another example is a small loop bundle.[1] In Cirtain Video 3 we show this in more detail. This bundle of magnetic loops appears to be twisted around each other, or braided. These 'braided' loops seem to slowly unravel over the course of the Hi-C observations and simultaneously increases in emission are observed. This is again an observation of magnetic field dissipation and a corresponding temperature increase in the associated plasma.

Although we have only these two examples of magnetic field dissipation in the results presented in the *Nature* article, there are a few other examples in the five-minute Hi-C data set. In addition to these results on magnetic field dissipation and energy release there are other compelling science results the science team are working to complete. In total, I personally feel like we have crossed into a new era in solar coronal research and look forward to the development and deployment of a satellite-borne version of Hi-C. We can tie these high spatial and temporal resolution observations into the global observations of missions like SDO and truly begin to address the problems of coronal heating, solar wind formation and variability, flare formation and so on. As our understanding of these complex astrophysics problems increases, our ability to forecast space weather and mitigate its economic and societal impact will provide enormous benefit to our nation and humankind.

I would like to now introduce Dr. Karel Schrijver. He will tell us about the global implication of these results and the broader impacts for space weather and future instrumentation.

Final thoughts.

NASA's Sounding rocket program, and the LCAS initiative more generally, complete compelling science investigations through the development of new instrument concepts. The Hi-C mission embodies the spirit of the sounding rocket program through science, technology and career development achievements. Our results are the culmination of more than 30 years of instrument and science development and these results provide the first tantalizing evidence of the applicability of the theory postulated by Dr. Gene Parker in 1983; the theory that the solar corona is heated, at least in part, by the dissipation of curvature in magnetic fields and the resulting energy release process. So-called braiding may be a standard process occurring within active regions on the sun and may finally solve the coronal heating problem. Only a space-based version of the Hi-C instrument in collaboration with other

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[1] Supplemental Video 3

instruments can close that open question. Resolution of the mechanisms that heat the solar corona and invariably drive space weather will herald a new era in Heliophysics where scientists can better predict space environmental conditions in a way that saves spacecraft, save the lost revenues of energy companies, airlines, and other economic sectors, and, inevitably, saves lives. These smaller mission archetypes offer NASA a cost-effective way to develop these advances in innovative instrumentation in cooperation with government agencies, Universities and the private sector. While doing so, our next generation of explorers, science leaders and engineers are developed and trained to execute the grand ideas of tomorrow. Speaking for us all, I thank you in sharing with us our success today and hope this excites you about the opportunities of our science tomorrow.

Mr. Brown, I turn it back to you.