FINAL REPORT NSG 5131

TITeL: The Multi-Spectral Solar Telescope Array (MSSTA)
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Co-Investigators: Troy W. Barbee, Jr., LNL, Richard B. Hoover, NASA MSFC,

In 1987, our consortium pioneered the application of normal incidence multilayer x-ray optics to solar physics by obtaining the first high resolution narrow band, "thermally differentiated" images of the corona, using the emissions of the Fe IX/Fe X complex at \( \lambda \sim 171 \) Å to \( 175 \) Å, and He II Lyman \( \beta \) at \( 256 \) Å. Subsequently, we developed a rocket borne solar observatory, the Multi Spectral Solar Telescope Array (MSSTA) that pioneered multi-thermal imaging of the solar atmosphere, using high resolution narrow band x-ray, EUV and FUV optical systems. In 1991 and 1994, the MSSTA successfully obtained high quality solar images covering the chromosphere (\( \lambda \sim 1216 \) Å H Ly \( \alpha \)), chromosphere/corona transition region (\( \lambda \sim 1550 \) Å C IV; \( \lambda \sim 304 \) Å He II), and corona (\( \lambda \sim 171-175 \) Å Fe IX/X; \( \lambda \sim 193 \) Å Fe XII; \( \lambda \sim 44 \) Å Si XII; \( \lambda \sim 211 \) Å Fe XIV, \( \lambda \sim 284 \) Å Fe XV). The resolution in the best image is \( \sim 1.0 \) arc seconds. Five completed Ph. D. Thesis (J.F. Lindblom, Max Allen, Ray O'Neal, Craig DeForrest, and Charles Kankelborg) have resulted from the MSSTA program (Previously, five Ph. D thesis resulted from our pre-MSSTA rocket programs). Two current Stanford students (H. Oluseyi, D. Martinez-Galarce) are completing Ph.D. dissertations based on MSSTA observations. Analysis of MSSTA observations has resulted in four significant insights into the structure of the solar atmosphere:

- The diameter of coronal loops is essentially constant along their length.
- Models of the thermal and density structure of polar plumes based on MSSTA observations have been shown to be consistent with the thesis that they are the source of high speed solar wind streams.
- The magnetic structure of the footpoints of polar plumes is monopolar, and their thermal structure is consistent with the thesis that the chromosphere at their footpoints is heated by conduction from above.
- Coronal bright points are small loops, typically \( 3,500 - 20,000 \) km long (5" - 30"); their footpoints are located at the poles of bipolar magnetic structures that are distinguished from other network elements by having a brighter Lyman \( \alpha \) signature. Loop models derived for 26 bright points are consistent with the thesis that the chromosphere at their footpoints is heated by conduction from the corona.

The MSSTA images also suggest that thermal conduction from structures at coronal temperatures may play a significant role in heating the chromospheric network; these structures may represent a population of transient loops, such as those recently discovered in SoHO EIT images, or some other phenomena such as coronal funnels. We are continuing the analysis of these observations.

There were no patents or inventions that resulted from the above grant.

The following scientific papers were published as a result of investigations carried out under the above grant.

- "The Solar Chromospheric and Coronal Explorer" A. B. C. Walker II et al to be publ. in Proc SPIE, 2804, 1996
- "Fabrication of Multilayer Optics by Sputtering: Application to EUV Optics with Grater than 30% Normal Reflectance" Proc SPIE 2515, 576, 1995
- "Astronomical Observations with Normal Incidence Multilayer Optics II: Images of the Solar Corona and Chromosphere" (A.B.C. Walker, Jr., T.W. Barbee, Jr., R.B. Hoover) invited review, in Proc. of the Tenth IAU International Colloquium on Laboratory and


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"The Sun," invited contribution to the 1992 Yearbook of the Mc


**Conference Proceedings:**


Selected Earlier Publications: