# HIGH RESOLUTION STUDIES OF SUNSPOTS AND FLUX TUBES





**Contract NAS8-39747**
**Progress Report for 1 February 1997 to 1 May 1997**

## Introduction and Summary

This contract started as a three-year research study of sunspots and magnetic flux tubes in the solar atmosphere, using tunable filter images collected with a CCD camera during observing runs at the Canary Islands observatories in Spain. Scientific results are reported at conferences and published in the appropriate journals. The contract is being performed by the Solar and Astrophysics Laboratory (S&AL), part of the Lockheed Palo Alto Advanced Technology Center (ATC) of Lockheed Martin Missiles and Space (LMMS). The principal investigator is Dr. Alan Title, and the research is done by him and other scientific staff at S&AL, often in collaboration with visiting scientists and students from other institutions.

An extension to the contract has been awarded for developing the Solar Lite technology demonstration telescope, a 1-meter solar telescope with silicon carbide optics made at the Vavilov Optical Institute in St. Petersburg, Russia.

The highlights during this reporting period included the continuation of the fabrication efforts on the Solar Lite optical components at Vavilov State Optical Institute, including the completion of the Gregorian telescope field stop. A visit was made to the Vavilov Institute to review the progress and inspect the optical components.

## Major Activities During This Reporting Period

Drs. Alan Title and William Rosenberg visited the Vavilov State Optical Institute in St. Petersburg, Russia to review progress on design and fabrication activities. The heat reflection cone and Gregorian field stop is complete. Machined from a single block of copper, it has a hollow hexahedral pyramid to reflect, into space, all but a 4 arc-minute field of view of the solar disk. The faces of the pyramid are polished and coated with silver with aluminum oxide and silicon oxide overcoating layers. These are designed to reflect enough of the incident solar flux so that the tip will remain below 46°C even at the end of the mission lifetime. The radiative surfaces of the cone assembly are painted black.

The one-meter silicon carbide primary mirror was cast in the St. Petersburg facility of the Vavilov State Optical Institute (VSOI) and was sent to Moscow in June 1996 for the carbonization and siliconization phases. A hairline fracture in the silicon carbide matrix developed during the siliconization phase. The fracture line, extending from the outer edge inward towards the center, is filled with silicon as is the inter-granular structure of the entire silicon carbide matrix. The blank was inspected, but little can be determined before further optical processing. The blank will continue through the optical fabrication process until it can be tested interferometrically and shaken to determine the effect of this type of fracture boundary.

The secondary mirror, which had been in the spherical polishing stage during the previous period, continued in its fabrication cycle. Surface pitting was discovered once the surface was smooth enough to see such fine defects. A second blank was cast, using a technique developed specifically to reduce the incidence of bubbles and voids in the blanks. This second blank is currently being polished to a spherical surface and was inspected and appears to be free of significant pitting.

The telescope design was reviewed and fabrication issues for the assembly were discussed. The telescope structure will consist of a corrugated aluminum tube riveted to invar stringers. The tube's corrugations run circumferentially and allow for thermal expansion to be absorbed in the accordion structure without introducing stress on the optics or metering structure. Longitudinal invar stringers provide the precision metering among the primary mirror, secondary mirror and reflecting field stop. The stringers are constrained in the transverse directions by the aluminum tube. The design was reviewed and judged to be at sufficient maturity to begin a fabrication phase.

## Other Activities

There were no significant additional activities during this period.

**Spending Status**

At the end of this quarter, approximately 46% of the contract cost value has been spent and approximately 46% of the work has been completed. This reflects the modified statement of work and contract funding from previous periods.

**Plans for the Period 1 May Through 1 August 1997**

1. Continue fabrication activity on the Solar Lite optical components: primary and secondary mirrors. Continue the design activity for the complete Solar Lite telescope and begin the contractual work for the telescope fabrication.

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An extension to the contract has been awarded for developing the Solar Lite technology demonstration telescope, a 1-meter solar telescope with silicon carbide optics made at the Vavilov Optical Institute in St. Petersburg, Russia.

The highlights during this reporting period included the continuation of the fabrication efforts on the Solar Lite optical components at Vavilov State Optical Institute, including work on the second blank for the secondary mirror and further work on the first primary blank. Work is beginning on the telescope barrel and mechanical structure.

### Major Activities During This Reporting Period

Work continued on the mirrors for the Solar Lite telescope. The primary mirror blank which developed cracks during its siliconization procedure is being ground and polished to a spherical surface. It is believed that the cracks in the silicon carbide matrix are completely filled and joined by silicon. It should, therefore be possible to continue the optical fabrication and then test the mirror's mechanical strength. The mirror fabrication contract was modified to proceed through the spherical polishing step. A new contract is being prepared to start fabrication of a second one meter primary mirror blank.

The secondary mirror developed a surface pitting problem during its polishing stage. It is believed that the pits are the result of micro bubbles in the casting process which do not fill with silicon during siliconization. While they are there all the time, they only become apparent when the surface is polished smooth enough. The casting process has been modified to prevent the formation of bubbles and a second mirror blank is now in optical fabrication.

The first mirror blank was taken to Dr. Jean Bennett at the Naval Air Weapons Laboratory for inspection and analysis of the surface. The conclusion is that the surface pitting could very well be the result of bubbles in the casting process rather than a reaction to the grinding and polishing processes.

Contracts were prepared for the fabrication of the telescope barrel assembly and the secondary mirror housing. Work is beginning with the preparation of shop orders and the purchase of materials.

## Other Activities

We became aware of a different process for fabricating light weight silicon carbide optical mirrors which has been developed by a German firm, IABG. Joint discussions among IABG, Vavilov and Lockheed Martin have begun in an effort to consider alternate solutions to the fabrication problems associated with large aperture mirrors.

## Spending Status

At the end of this quarter, approximately 51% of the contract cost value has been spent and approximately 51% of the work has been completed. This reflects the modified statement of work and contract funding from the previous period.

## Plans for the Period 1 August Through 1 November 1997

1. Continue fabrication activity on the Solar Lite optical components: primary and secondary mirrors. Continue the fabrication of the complete Solar Lite telescope. We will continue to investigate the feasibility of using an alternate process to produce the large primary mirror structure.