Correcting and coating thin walled X-ray Optics via a combination of controlled film deposition and magnetic smart materials

Completed Technology Project (2017 - 2019)

Project Introduction

The project goal is to demonstrate that thin walled (<400 micron thick) X-ray optics can be controllably shaped to produce high quality (~1" or better) X-ray optics at an affordable price. Since the desired surface area for the next generation X-ray telescope is >10x that of Chandra, the >10x requirement is then for >200 m^2 of surface area with a surface finish of better than 0.5 nm. Therefore, replication of some sort is called for. Because no replication technology has been shown to achieve ≤1" angular resolution, post fabrication figure corrections are likely going to be necessary. Some have proposed to do this in orbit and others prelaunch including us. Our prelaunch approach is to apply in-plane stresses to the thin walled mirror shells via a magnetic field. The field will be held in by some magnetically hard material such as NiCo. By use of a so called magnetic smart material (MSM) such as Terfenol-D, we already shown that strong enough stresses can be generated. Preliminary work has also shown that the magnetic field can be held in well enough to apply the figure correcting stresses pre-launch. What we call "set-it and forget-it." However, what is unique about our approach is that at the cost of complexity and some areal coverage, our concept will also accommodate in-orbit adjustments. Furthermore, to the best of our knowledge ours is one of two known stress modification processes that are bi-axial. Our plan is first to validate set-it and forget-it first on cantilevers and then to expand this to working on 5 cm x 5 cm pieces. We will work both with NiCo and glass or Si coated with Terfenol-D. Except for the NiCo, substrates we will also coat the samples with NiCo in order to have a film that will hold in the magnetic field. As part of the coating process, we will control the stress of the film by varying the voltage bias while coating. The bias stress control can be used to apply films with minimal stress such as Terfenol-D and X-ray reflecting coatings such as Ir. Ir is a highly desirable coating for soft X-ray astronomy mirrors that can have significant built in stress unless some technique like our is used to apply the coating. An alternative use for the bias stress control coating process is to improve the initially fabricated mirror by applying spatially dependent stresses with a Cr film. We will also expand upon the work we have done that shows this method has promise to reduce the amount of corrections needed by the MSM plus the magnetic field process.

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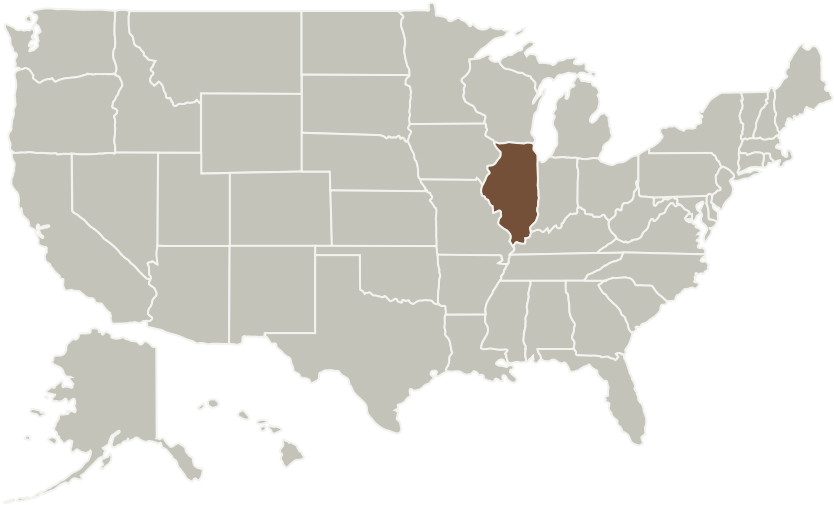
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Northwestern University	Lead Organization	Academia	Evanston, Illinois

Primary U.S. Work Locations
Illinois

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Northwestern University

Responsible Program:

Astrophysics Research and Analysis

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

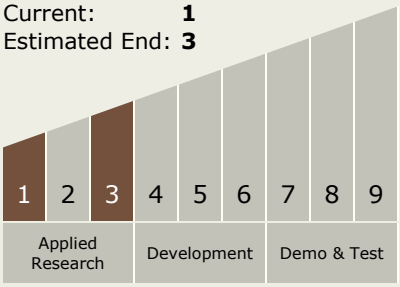
Melville P Ulmer

Co-Investigators:

Yip-wah Chung
Jian Cao
Semyon Vaynman
Joshua J Richards
Lahsen Assoufid
Qiang Zeng

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.2 Observatories
    └ TX08.2.1 Mirror Systems

Target Destination

Outside the Solar System