Polarimeter for Low Energy X-ray Astrophysical Sources (PLEXAS)

NASA Grant NAG5-5219

Final Report

For Period From 11 January 1999 through 10 January 2002

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August 2002

Prepared for:

National Aeronautics and Space Administration
Goddard Space Flight Center
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The Smithsonian Astrophysical Observatory
is a member of the
Harvard-Smithsonian Center for Astrophysics

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1 PLEXAS

The Polarimeter for Low Energy X-ray Astrophysical Sources (PLEXAS) is an astrophysics mission concept for measuring the polarization of X-ray sources at low energies below the C-K band (<277 eV). PLEXAS uses the concept of variations in the reflectivity of a multilayered X-ray telescope as a function of the orientation of an X-rays polarization vector with respect to the reflecting surface of the optic. By selecting an appropriate multilayer, and rotating the X-ray telescope while pointing to a source, there will be a modulation in the source intensity, as measured at the focus of the telescope, which is proportional to the degree of polarization in the source.

1.1 Development Program

In order to achieve the needed polarization modulation, we must first demonstrate that a mutilayer will reflect linearly polarized X-rays with different efficiency depending on the orientation of the polarization vector with the reflector. Thus, we were given a grant to build a laboratory test facility that would measure the reflection of polarized X-rays off of a multi-layers surface.

1.1.1 Experimental Set Up

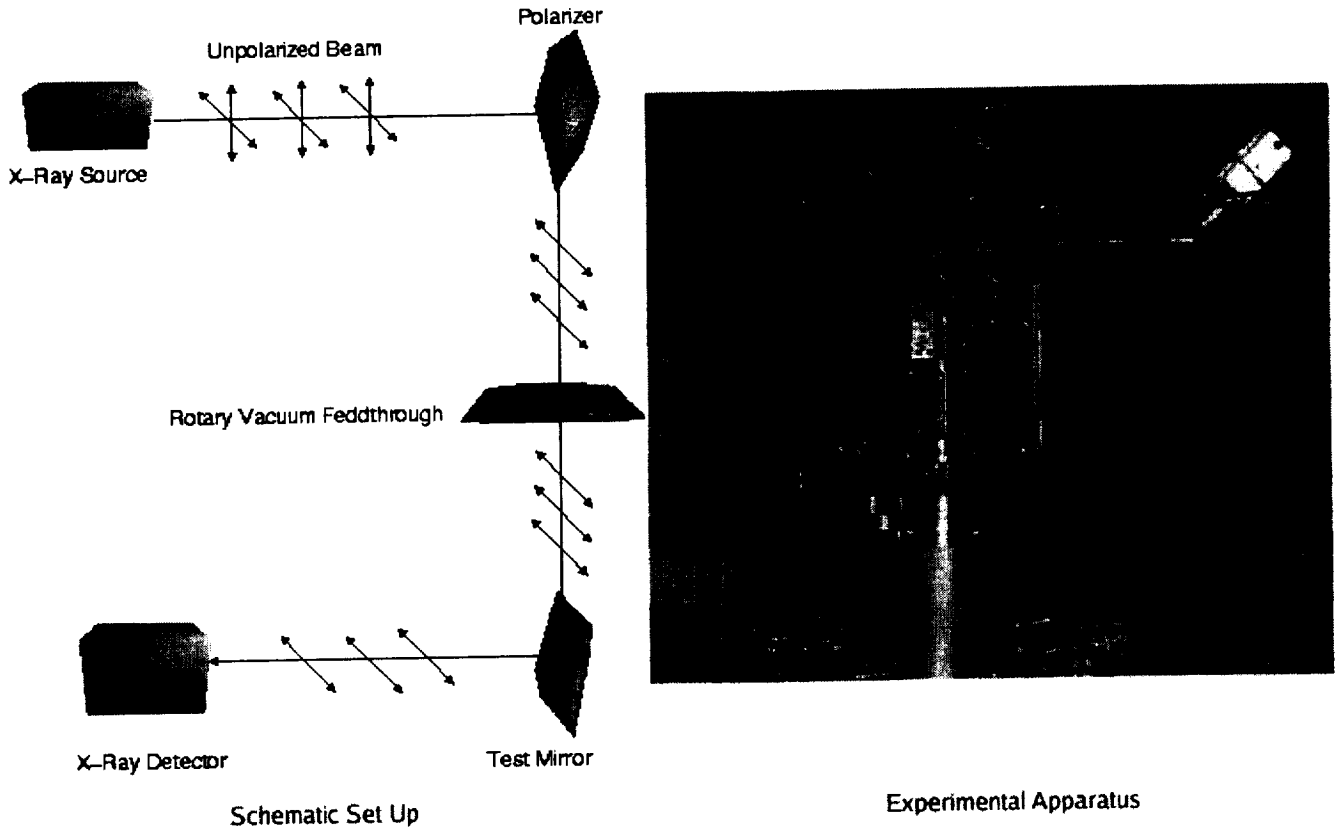

Figure 1: PLEXAS Experimental Set Up

The experimental set up consists of an electron bombardment X-ray tube with a Boron target to generate a flux of low energy unpolarized X-rays. The X-rays were then reflected off of a Nickel/Carbon multilayer flat at 45 degrees to produce a fully

linearly polarized beam (analogous to passing an unpolarized visible light beam through a polarizer). Then a second Ni/C multilayer flat also at 45 degrees to the polarized beam will reflect the X-rays on to a thin window gas proportional counter. The second multilayer optic and X-ray detector can be rotated through 360 degrees in azimuth to analyze the polarized beam and produce a modulation curve.In Figure 1 we illustrate the design of the experimental setup on the left, and show the realization of the experiment on the right.

1.1.2 Multilayer

The polarizer multilayer was deposited on a 1 inch diameter silicon substrate (highly polished) with a period $D = 51.36$Å, with $d_{Ni} = 17.77$Å and $d_C = 33.59$Å which is tuned for the Bragg condition at 45° for 0.18 keV X-rays.

The analyzer multilayer was deposited on a 2 inch diameter silicon substrate (also highly polished) with a period $D = 50.00$Å, with $d_{Ni} = 17.30$Å and $d_C = 32.70$Å. It is also tuned for the Bragg condition at 45°.

1.2 Results

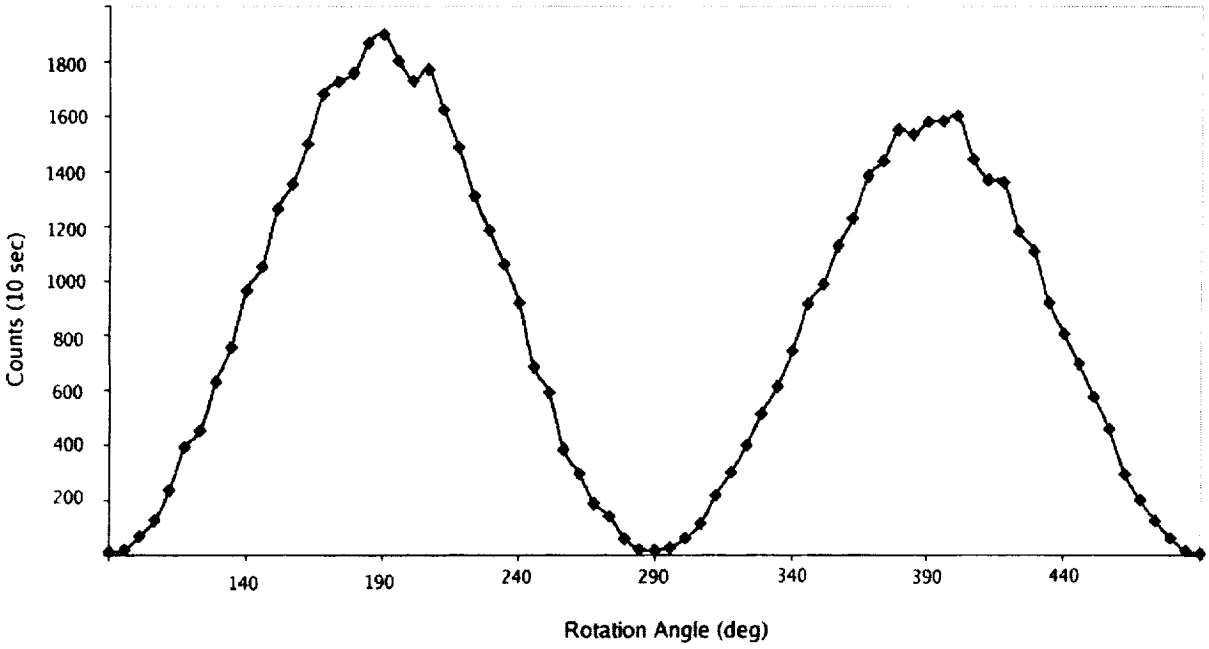

Figure 2: Modulation Curve for Ni/C Multilayered Optic

Using this apparatus we obtained a modulation curve for the Ni/C multilayered optic as shown in Figure 2. The expected modulation is a sinusoidal curve with 100% variation in the observed intensity as the optic is rotated with respect to the polarization vector of the X-rays. As seen in Figure 2, this is what is observed. The two minimal show that there is essentially no reflected radiation at these angles, and the maxima indicate the reflectivity of the multilayer. The slight difference in amplitude of the maxima is due to slight misalignment of the polarized X-ray source with respect to the rotation table.

1.3 Conclusions

We have successfully demonstrated the underlying technology for the implementation of the PLEXAS mission. I.e., a multilayered optic using Nickel and Carbon can be used as a linear polarization analyzer.