Annual Report for Catholic University Co-Operative Agreement NCC-5-83
1 April 1997 through 31 March 1998

RICHARD STARR, CO-PI

SMALL SATELLITE TECHNOLOGY INITIATIVE (SSTI)

R. Starr is the leader of the science team for the X-Ray Spectrometer (XRS) which will fly on-board the SSTI Clark satellite. This XRS will fly small room-temperature, solid-state detectors that have never been flown in space before. In addition to testing this new technology, this instrument is designed to detect X-rays from solar flares and gamma-ray bursts in the energy region from about 1 keV to 100 keV. The XRS has been through environmental testing and has been integrated to the spacecraft. The Clark spacecraft is scheduled to be launched in August 1998 and the XRS will collect data in orbit continuously for the next three years. R. Starr is the principle investigator for the XRS and has continued to support integration and test throughout this period.

PLANETARY PROGRAM

Near Earth Asteroid Rendezvous (NEAR)

The NEAR spacecraft was launched in February 1996 and will rendezvous with the asteroid Eros in February 1999. R. Starr has supported all phases of design, test and integration of the X-Ray/Gamma-Ray Spectrometer (XGRS). During this time period he has analyzed flight data from both the gamma-ray and x-ray spectrometers in order to verify operations and has continued ground calibrations of the gamma-ray spectrometer using the flight spare instrument.

Planetary Instrument Definition and Development Program (PIDDP)

Under the PIDDP program R. Starr has been part of a team that has as its goal the development of new x-ray and gamma-ray detectors for space flight experiments. The focus has been on small room-temperature solid-state detectors such as mercuric-iodide, cadmium-zinc-telluride, and silicon detectors.

CARL WERNTZ, PI

The previously developed codes that calculate gamma-ray line profiles for directed beams of heavy ions striking ambient hydrogen and helium are being modified to take into account isotropy of the beams in astrophysical settings such as the Orion nebula. The resulting profiles calculated according to our rigorous theory will be compared to more approximate calculations which have appeared recently in the literature as explanation for COMPTEL observations of broad lines. For the first time the linear polarization of gamma rays as a function of energy across the profiles is being calculated through a different modification of existing codes.

The PI acted as laison between students at Goddard taking part in the summer research program and the administration at Catholic University which issued pay checks, reimbursed travel, and carried out other fiscal services.

FRED LANG, POST DOC

HESSI

The **H**igh **E**nergy Solar **S**pectrographic **I**mager (**HESSI**) is a solar satellite that has recently been selected for the coming solar maximum. It builds on the technological heritage developed with the **H**igh **E**nergy **I**maging **D**evice (**HEIDI**) that has been the primary focus of most of the work done by the Post-Doc for the past 8 years. **HESSI** was approved by **NASA** Headquarters for a new start this past October.

Dr. Lang has been the manager for the **HESSI O**ptical **G**rid **C**haracterization **F**acility (**OGCF**), which was originally developed for characterization of the **HEIDI** grids. Lang has continued a program of measurements of prototype grids for **HESSI**. He has worked with other **HESSI** investigators to plan upgrades to the **GCF** that are currently under way. He has worked with other **HESSI** investigators in the design of flight grids. He has been responsible for maintenance of, and two major repairs to, the **OGCF** in the past year.

Summer Student Administrator

Various projects in the Laboratory for Astronomy and Solar Physics (**LASP**) funded Dr. Lang to conduct their Summer Student Program for 1997. He recruited students and maintained a file of applicants. He solicited positions within the **LASP**, arranged interviews for the students with prospective mentors at Goddard, and assisted with matching applicants with prospective tasks. He arranged for students to be paid through this grant. He provided guidance, advice, and sympathetic ears for the students and their mentors.

Naval Academy Program

This past year, Dr. Lang was funded in part by Director's Discretionay Funding to undertake a program to place students from the Naval Academy in Annapolis at Goddard. He worked cooperatively with Naval Academy faculty and staff and with Goddard scientists and engineers to recruit, select, and place six students at Goddard during the Summer of 1997. He has begun the recruitment process for the Summer of 1998.

PAM CLARK, RES. PROF

X-ray Production at, Measurement of, and Compositional Determination for Solar System Objects

Our recent work has resulted in the publication of a series of papers (Clark, 1997; Clark and Trombka, 1997a, 1997b) which present our observations and most current models for soft X-ray production from planetary surfaces, and methodologies for determination of elemental compositions maps from measurements made by orbital X-ray detectors. This effort required modeling solar (source) production, and surface fluorescence and scatter from first principles for remote instruments on given mission trajectories. These models were shown to agree with observations to within 10% in the case of the Apollo (lunar) mission, where the first remote X-ray derived composition maps were obtained. X-ray emission from a surface is strongly dependent on the incident solar spectrum which generates the characteristic secondary X-ray flux at the surface, as well as on the composition. In order to model surface X-ray production, and remove the effect of solar variations, the solar soft X-ray spectrum as a function of solar activity must be known as accurately as possible. We are currently obtaining and in the process of analyzing solar X-ray observations across the entire range of potential solar activity levels with solar monitors on the NEAR mission during its cruise phase.

Laboratory/In-Flight Calibration for NEAR X-ray instruments.

Laboratory calibration work done on flight X-ray instruments for the NEAR mission included measurement of degradation of resolution and gain at different counting rates as a function of time. This was done to allow greater understanding of an effect, thought to result to charging of the insulators in the proportional counter, which was observed in space on the fight detectors. Energy calibration and background monitoring have been routinely done during the cruise phase of the NEAR mission. Proportional counter background has been found to be consistent in the energy range of the detector, allowing routine background subtraction (Clark et al, 1997).

Solar X-ray Production: Instrumental Monitoring

Solar variability in the soft X-ray region is high. In a whole solar cycle of measurements, flux levels can vary by up to 5 orders of magnitude. Variations in background in the range of an order of magnitude may occur over the course of a day, and the background typically varies by more than an order of magnitude from maximum to minimum of a cycle. Thus, in preparation for the NEAR mission, the two solar monitors flying on that mission have been given special design features, in terms of size of window and type of filter, based on calculations by Clark. The solar Si PIN detector is a pinhole detector with Be window. The solar proportional counter has a special graded shield filter designed to enhance output in the higher energy region, where solar output is less. Both solar monitors have been operating during the cruise phase of the NEAR mission. During this time solar output has ranged from very quiescent to major flare, about four or five orders of magnitude. Observations generally agree with our basic models, for both detectors, but with somewhat higher output observed at higher energies than predicted (Clark et al, 1997). Our models are now being refined based on these observations.

Database for NEAR encounter

We are developing user friendly ancillary information capture, analysis software, and mapping product programs in collaboration with NEAR team members at the University of Arizona, which can be used not only for NEAR but future planetary missions as well.

Current and Future Mission and Instrument Development

At present, to support the NEAR mission, Clark has used X-ray production models to determine anticipated results for the range of surface compositions anticipated for the asteroid to be encountered, 433 Eros. Also, Clark has done calculations to support the Phase A level studies for other proposed NASA Discovery Missions, including two Mercury Orbiters and a Mercury fly-by (Clark and Starr, 1998).

Relationship between X-ray, Gamma-ray, and other spectral measurements related to surface iron abundances

X-ray, Gamma-ray, and visual spectral imaging instruments will all be flown on the NEAR mission. Measurements from all three instruments have been used to derive iron abundances. The Moon is the only planet up to now for which both remote geochemical-(Gamma-ray) and mineralogical (spectral reflectance) instruments have made observations are available. Maps derived from these two different datasets, directly from the Gamma-ray data and by inference from the spectral reflectance, have shown striking differences. We have explored causes of

these differences, in terms of any systematic differences in the physical or optical nature of the surface or in data reduction techniques, in order to support the data reduction efforts for the XGRS instrument on the NEAR mission. The chief cause of reported differences in iron appears to be the presence of an additional iron-bearing mineral which is detected by the-gamma-ray experiment, which measures bulk iron in any form, but not by the spectral reflectance experiment, which detects an iron band which results primarily from iron in pyroxene (Clark and Basu, 1998).

Presentations and Papers

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P.E. Clark, L.A. McFadden, A. Basu (1998) "Determination of Iron and Pyroxene Abundances in the lunar crust from Combined Gamma-ray and Spectral Reflectance Measurements", *JGR* (in publication).

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