Title of Investigation:

The LIGHT Instrument

Principal Investigator:

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Initiation Year:

FY 2004

FY 2004 Authorized Funding:

$31,000

Actual or Expected Expenditures at End of FY 2004:

$26,954 (University of Maryland, Nuclear Engineering Department, for neutron transport/ gamma-ray production modeling)

Status of Investigation at End of FY 2004:

Continued into FY 2005 using remaining FY 2004 funds

Expected Completion Date:

March 2005

Purpose of Investigation:

The purpose of the "Low Energy Intense Neutron Beam for Gamma-Ray High Spatial Resolution Targeting" (LIGHT) project is to develop an instrument design that could use the capabilities provided by the new Prometheus Program, which NASA established in 2003 to develop nuclear technology for the peaceful exploration of space. A Prometheus-type spacecraft would use a nuclear-fission reactor for electrical power and propulsion. The goal of LIGHT is to use the reactor's abundant neutrons in the same way that research reactors on Earth use neutron beam lines. The idea is to collimate the neutrons generated by the reactor to create a narrow neutron beam that could strike a solid body, such as an asteroid. Using gamma-ray detectors, the LIGHT instrument would then perform Prompt Gamma-ray Activation Analysis (PGAA) from the orbiting spacecraft. We consider the NEAR mission to the asteroid 433 Eros as a model for this type of mission. The NEAR spacecraft orbited Eros for more than a year. At the end of the science mission, controllers maneuvered it to land on the asteroid. Our calculations indicate that a similar asteroid mission carrying the LIGHT instrument would result in unprecedented signal strength and spatial resolution for determining the elemental composition of a minor planet.

Figure 1. LEFT Cartoon of basic parts

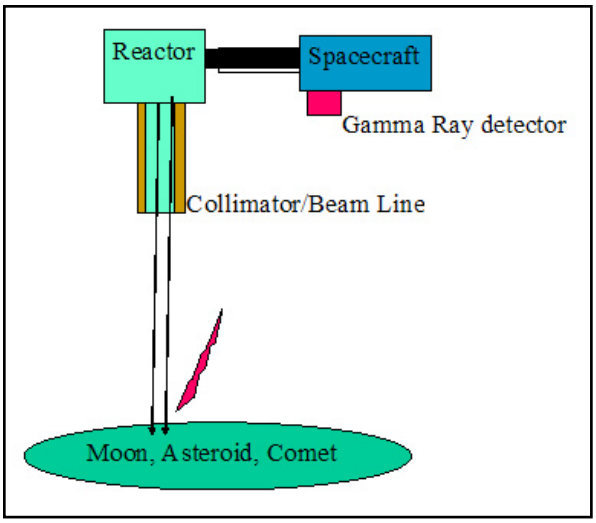
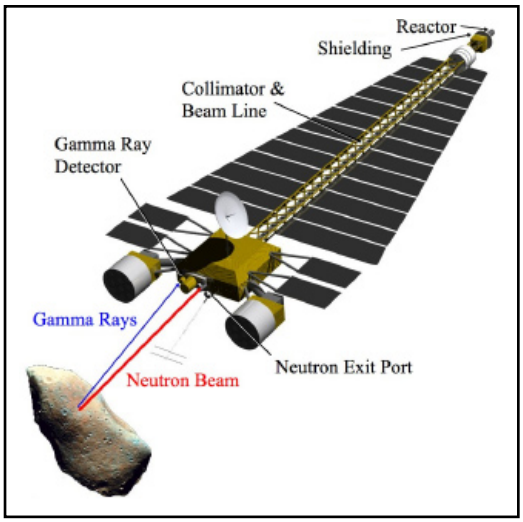


Figure 2. RIGHT Prometheus mission to an asteroid



Accomplishments to Date:

We have researched the space reactor design, which is being developed under a joint effort with the Department of Energy (DOE). Originally, it was indicated that the power system would be a thermal reactor. If this had been the case, the LIGHT design could have used a moderator front end and collimator design similar to those at thermal research reactors. It appears that the fast neutron reactor design will be chosen because of a miscellany of technical and safety reasons. The design of LIGHT is strongly dependent on the power reactor technology, so our neutron transport modeling efforts must incorporate this current knowledge.

We have calculated the signal from a class CM, carbonaceous chondrite-type asteroid for a spacecraft flying in formation with the asteroid at a stand-off distance of 2 km above the surface. We presented our work at the 2004 Lunar and Planetary Science Conference in March 2004. Our abstract is available at www.lpi.usra.edu/meetings/lpsc2004/.

We received a request from the National Academy of Science, Space Studies Board, Standing Committee on Planetary and Lunar Exploration to submit a synopsis of our work. The Space Studies Board and the Aeronautics and Space Engineering Board of the National Research Council are conducting a joint study to update the findings of recent decadal survey reports to take into account new capabilities resulting from Project Prometheus. Since LIGHT represents a unique use of the space reactor, the boards wanted suggestions for long-term future space science missions that would be facilitated by nuclear power and propulsion capabilities. Our input may be seen under Community Comments at http://qp.nas.edu/QuickPlace/ssestrategy/Main.nsf/h_Toc/3811b722b40de5ac85256e94006f19fa/?OpenDocument.

Planned Future Work:

One of the tasks in our proposed research and development plan was to contract with the University of Maryland Nuclear Engineering group to perform the neutron transport and gamma-ray signal production using Monte Carlo modeling. The work began in October 2004 and will be completed by May 2005.

Our original proposal included a plan to conduct testing at the National Institute of Standards and Technology's (NIST) research reactor. We started these tests. However, the NIST reactor needed some unscheduled maintenance and was down through most of November 2004. We have requested time on the neutron beam line and anticipate a May 2005 schedule.

Summary:

LIGHT is an innovative application of an analytical method used routinely at research reactors on Earth. It is the ideal remote-sensing neutron/gamma-ray spectroscopy instrument for analyzing asteroids and other solid bodies from close-in spacecraft orbit. LIGHT is an instrument that should be ready for NASA's Project Prometheus, which the Agency established in 2003 to develop a nuclear propulsion system for planetary exploration. By collimating some of the reactor neutrons into a beam that excites a small surface area for prompt gamma-ray activation analysis (PGAA), it should be possible to determine surface chemistry from an orbiting spacecraft at unprecedented signal strength and spatial resolution. Excellent missions for LIGHT would be to the near-Earth asteroids, main belt asteroids, comets, and Kuiper Belt objects. Small moons, such as Phobos and Deimos, also may be possible targets if the approach altitude is acceptable. These missions are scientifically important because the amount of minerals, organics, and water on small bodies in the Solar System remains a mystery. The ability to map elemental composition of these objects on a small scale would enhance our understanding of how these bodies formed. In addition, it would give us insights into which processes controlled their creation at the origin of the Solar System. Our work has shown that this instrument on a Prometheus-type spacecraft would provide science data never before possible. A major risk factor has been the fact that it is difficult to schedule time for tests on a nuclear reactor, such as the one at NIST, and that this particular study is specific to the choice of a fast neutron power reactor for the spacecraft.