https://ntrs.nasa.gov/search.jsp?R=20180005629 2019-08-31T15:11:03+00:00Z

Abstract to be submitted to:

32nd Annual Small Satellite Conference / August 4-9, 2018 / Logan, UT

https://smallsat.org/

Session: Science/Mission Payloads:
"Innovative technologies or systems that enable cutting-edge missions to be formulated."

CubeX: A compact X-ray telescope enables both X-ray fluorescence imaging spectroscopy and pulsar timing based navigation

This paper describes the benefits of a miniaturized X-ray telescope payload in the context of a lunar mission. The first part describes the payload in detail, the second part summarizes a small satellite mission concept that utilizes its compact form factor and performance.

The CubeX instrument can be used for both X-ray fluorescence (XRF) imaging spectroscopy and X-ray pulsar timing based navigation (XNAV). Using our recent technological advances in X-ray optics and sensors, CubeX combines high angular resolution (<1 arcminutes) Miniature Wolter-I X-ray optics (MiXO) with a common focal plane consisting of high spectral resolution (<150 eV at 1 keV) CMOS X-ray sensors and a high timing resolution (< 1 usec) SDD X-ray sensor. This novel combination of the instruments enables both XRF measurements and XNAV operations without moving parts. The high angular resolution of the MiXO opens a wide range of orbital configurations for observation. Given that performance, the instrument has unprecedented small volume (~1×1×6U), mass (<6 kg), and power (<9W) requirements and opens a wide range of applications for a variety of targets and missions including NEOs and Martian moons.

In this paper we illustrate one potential application for a lunar mission concept: The elemental composition of the Moon holds keys to understanding the origin and evolution of both the Moon and the Earth. X-ray fluorescence (XRF), induced either by solar X-ray flux or energetic ions, carries decisive signatures of surface elemental composition. X-ray observations, therefore, give a unique, powerful diagnostic tool for remotely determining elemental abundances including major rock forming elements such as Mg, Al, Na, Si, Fe, and Ca. Through high-resolution XRF imaging spectroscopy, CubeX searches for small patches of elusive lower crust and mantle material excavated within and around impact craters. CubeX identifies regional compositional variations and allows straightforward comparison of elemental distributions with the surface topography from LRO and the gravity data from GRAIL. The elemental compositions of the lower crust and the mantle are sensitive to the conditions of the giant impact which led to the Moon's formation and the subsequent lunar magma ocean (LMO), and thus they are key missing pieces in understanding the formation and early evolution of the Moon.

In between XRF observations, CubeX also leverages the technology of high resolution X-ray imaging and time series measurements to conduct XNAV operations and evaluate their

performance. Deep space navigation is a critical issue for small planetary missions. XNAV can enable low-cost autonomous deep-space navigation, and has the potential to greatly assist, or even outperform, NASA's Deep Space Network (DSN) or ESA's European Space Tracking (ESTRACK). CubeX is designed to perform sequential observations of 3-4 millisecond pulsars (MSPs) to solve the spacecraft trajectory for absolute navigation, and explore the remote sensing capability of XNAV. In the presented mission concept, the Moon's relative proximity enables a straightforward evaluation of the XNAV performance through DSN.