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A Quantitative Analysis of Lunar and Planetary Fluorescence Modelling

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Abstract

X-ray spectography is a viable way of determining the surface composition of non-atmospheric planetary bodies from orbit[1]. Instruments aboard spacecraft such as SMART-1, SELENE and Chandrayaan-1 use this method to map elemental and mineralogical abundances of the lunar surface in particular[2].

X-ray fluorescence of a given surface is caused by, and is proportional to, the amount of incident x-rays. This can be provided artificially or by using solar output. The instrument C1XS on Chandrayaan-1 uses the fluorescence produced by the solar x-ray flux[3][4].

Accurately modelling the response of an instrument in different situations is important. Factors such as the instrument parameters, solar illumination, spacecraft positioning and surface composition can all affect the spectra measured. Knowing in advance what the instrument is capable of can help to provide mission planning parameters, calibration data, and give realistic expectations of its performance over the course of a mission. To this end, code written for D-CIXS was adapted to model the response by C1XS, and a graphical user interface (GUI) named Lunarbob was created to make large scale studies easier. The underlying modelling code uses equations from Clarke et al.(1997) [5] to calculate fluorescence.

Using the modelling code and the Lunarbob GUI the response of C1XS to lunar fluorescence was tested under a range of surface conditions and illuminations (fig. 2). The simulated measured flux is displayed by the modelling program as raw data (in units of counts/seconds/cm^2/steradions). It is also plotted against energy (in KeV).

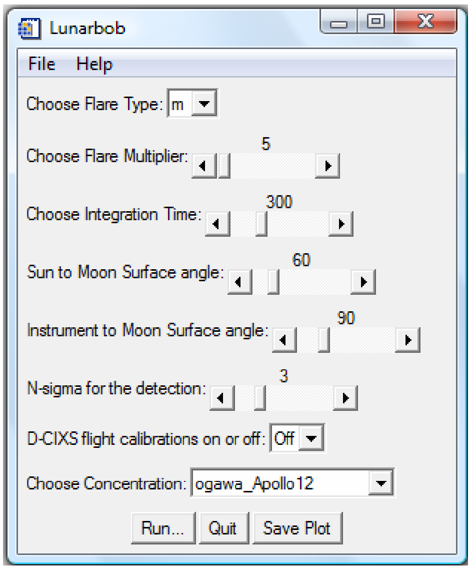

Figure 1: A screenshot of the Lunarbob GUI, showing the different input parameters that can easily be altered using it.

For comparison with previous simulations, the original modelling code was expanded to include the mineral concentrations tested elsewhere. The values from Ogawa et al. (2008)[6] and its study of SELENE responses were used, as well as values from Owen et al. (2008)[7], which looked at modelling planetary fluorescence for a range of materials (fig 3.). Tables were produced comparing the measured values of a series of elements (Al, Mg, Si, Ca, Fe) for the surface concentrations used in the other studies. The results of these separate studies are compared and explanations for any disparities are examined. These include the use of different solar input spectra, instrument parameters and satellite operating conditions.

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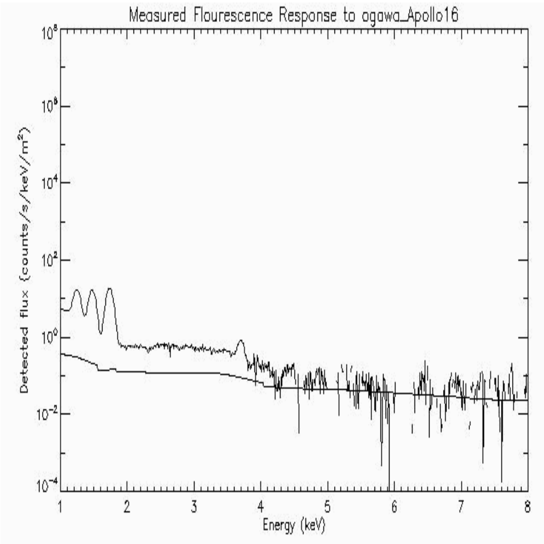

Figure 2: The modelled instrument response to lunar fluorescence using our code, under M1 GOES flare conditions, measuring an Apollo 16 basalt. The peaks on the left represent Mg, Al and Si, and a Ca peak is visible at 3.7 keV

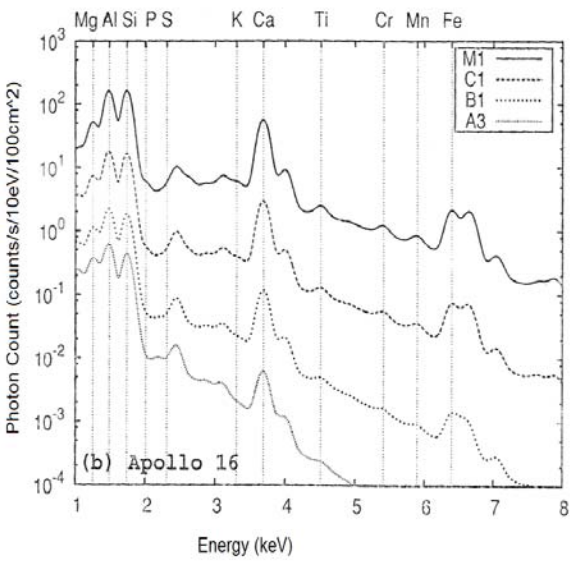

Figure 3: Estimated spectra detected by the XRS onboard SELENE, for a range of GOES flare conditions, measuring an Apollo 16 basalt. (Ogawa et al. 2008)[5]

These results allow conclusions to be drawn with regard to the validity of the modelling software, and of the functionality of C1XS under different conditions. Methods for improving the accuracy of the model are suggested: these include using more accurate solar input spectra.

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