EPSC Abstracts
Vol. 12, EPSC2018-870, 2018
European Planetary Science Congress 2018

Investigating X-ray fluorescence from the surface of Mercury using MIXS

Rose Cooper (1), Manuel Gande (1), Emma Bunce (2), Adrian Martindale (2)
(1) Aberystwyth University, UK (roc17@aber.ac.uk), (2) University of Leicester, UK

Abstract

We present a model for the expected fluorescence from the exosphere and surface of Mercury, as observed by the Mercury Imaging X-ray Spectrometer (MIXS) on the upcoming BepiColombo mission. Using modified SMART-1 D-CIXS analysis routines for Lunar observations, we model the fluorescence spectra from the surface of Mercury, and compare the different surface regions. Observations of the boundaries between these regions are also conducted. X-ray fluorescence also occurs on the night side of Mercury through particle induced X-ray events (PIXE). We also model the expected fluorescence observable from this region, and consider its connection to the exosphere through surface-exosphere coupling.

1. Introduction

X-ray fluorescence is typically considered to be a laboratory technique, yet has been found to have numerous uses in planetary science. Due to the high solar flux at Mercury, it is considered a prime target for using this method for elemental abundance detection. The main focus of this work is the MIXS detectors on the BepiColumbo Mission, which is due to launch in October 2018. MIXS is comprised of two detectors, a collimated channel MIXS-C and a telescope MIXS-T [1]. Their primary aim is to measure surface elemental abundances. MESSENGER has revealed a lot more information about the geochemical composition of Mercury's, which BepiColombo will build upon.

1.1 Fluorescence model

The model used for this work was originally designed for D-C1XS on the SMART-1 Lunar mission [2], and has been adapted for this new purpose. As the fluorescence calculations originally used will still be correct [3], they require no changes. The alterations required focus mainly on the elemental abundances, proximity to the Sun, and increased solar flux.

2. Surface Fluorescence

Using surface elemental abundances from Wurz et al., (2010) we can produce fluorescence spectra for both MIXS-C and MIXT-T for a range of solar flare intensities. These can be seen in Figures 1 and 2 below.

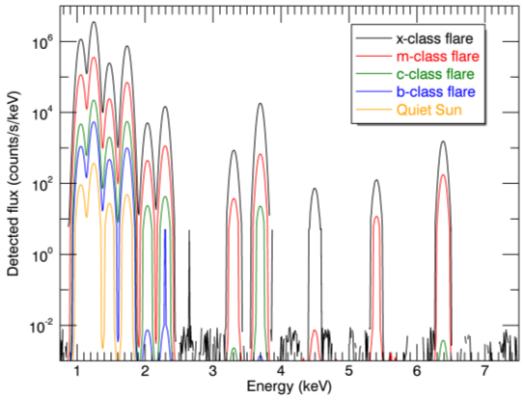

Figure 1: X-ray fluorescence spectra for Mercury's surface seen by MIXS-C during a 209s observation.

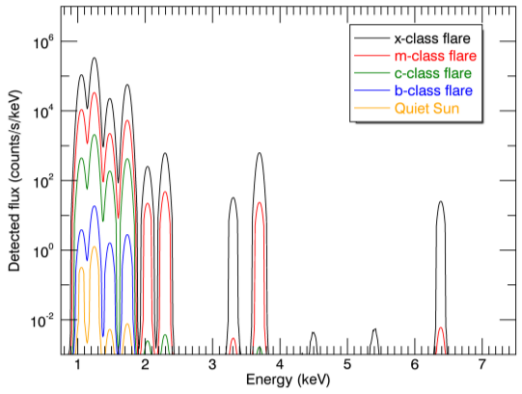

Figure 2: X-ray fluorescence spectra for Mercury's surface seen by MIXS-T during a 22.9s observation.

As the fluorescence spectra obtained by MIXS will be dependent on the composition of the region it is observing, it is possible to identify certain geochemical regions based on the spectra observed. Using the surface abundances from Lawrence et al., (2016), variations in the peak intensities of the lighter elements such as sodium, magnesium, silicon and aluminium can be detected. These are shown in Figure 3 for MIXS-C (a-c) and MIXS-T (d-f).

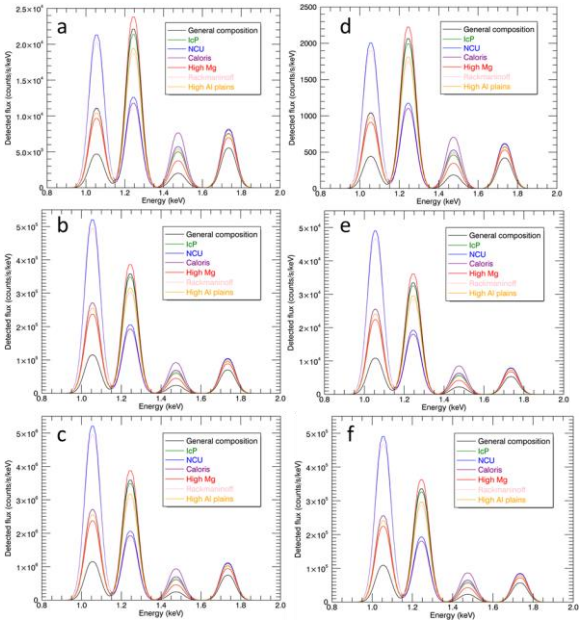

Figure 3: X-ray fluorescence spectra seen by MIXS-C (a-c) and MIXS-T (d-f) for multiple surface regions over a 10 minute observation time for: a/d) C-class flare, b/e) M-class flare, and c/f) X-class flare.

It is worth noting that some elements produce higher intensity fluorescence for a lower class flare, which will have an impact on potential observations. Following this it is also possible to observe the boundary regions between the different geochemical terranes and therefore aid in the general understanding of the geological history and development of Mercury.

3. PIXE events / Surface-Exosphere coupling

On the dayside the fluorescence is caused by solar X-rays interacting the atoms in the surface regolith. However fluorescence is also observed on the nightside of Mercury, thought to be caused by electrons precipitating onto the surface. Due to the location of the PIXE events and their connection to the cusp regions of Mercury's magnetic field, it is possible to also investigate the relationship between the surface and exosphere of Mercury. In particular there are regions of the surface which have a very high abundance of certain elements (e.g. the high Mg region in the northern plains). The model presented investigates the connection between the surface and exosphere to develop our understanding of the coupling mechanisms.

4. Summary and Conclusions

We have developed a program to model the expected fluorescence observations of Mercury's surface capable by the MIXS detector on BepiColombo. We obtain expected fluorescence spectra expected during MPO's orbit, including spectra of different geochemical terranes. X-ray fluorescence is also possible on the night side of Mercury through particle induced X-ray events. Observations of these can also be made with MIXS, which due to their location on the planet's surface can provide information regarding surface-exosphere coupling dynamics.

Acknowledgements

The authors would like to thank Adrian Martindale and the members of the Leicester University space research center for access to the MIXS grasp data, and the author of the original model Bruce Swinyard. Additional thanks to Joseph Hutton for assistance with writing the code.

References

[1] Fraser, G. W. et al: The Mercury Imaging X-ray Spectrometer (MIXS) on BepiColumbo, Planetary and Space Science, Vol. 58, pp. 79-95, 2010

[2] Grande, M. et al: The D_CIXS X-ray mapping spectrometer on SMART-1, Planetary and Space Science, Vol. 51, pp. 427-433, 2003

[3] Clark, P. E. & Trombka, J. I.: Remote X-ray spectrometer for Near and future missions: Modeling and analyzing X-ray production from source to surface, Journal of Geophysical Research, Vol. 102, pp. 16,361-16,384, 1997