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Observational conditions for the detection of X-ray fluorescence from sodium by the MIXS instrument on BepiColumbo

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Abstract

We model the expected fluorescence from the exosphere and surface of Mercury, as observed by the Mercury Imaging X-ray Spectrometer (MIXS) on the upcoming BepiColumbo mission, using code modified from that used for the SMART-1 D-CIXS instrument to the Moon. Modifications include detector parameters, solar proximity, surface elemental composition, and emission from the optically thin exosphere. From this, preferential observation parameters have been determined for MIXS during its orbit. Modelling of these observations is conducted, with particular emphasis on the sodium component.

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; however it is feasible that MIXS will be able to answer more of the major questions about Mercury than those covered by its primary aim.

In this work, we consider the potential for MIXS to observe fluorescence from Mercury's exosphere. From this elemental abundances of the exosphere can be determined, as well as improving knowledge of surface-exosphere interaction. The main target of this fluorescence detection is the sodium component. This is due to the fact that sodium is one of the more abundant, and volatile elements present in Mercury's exosphere. To evaluate the optimal configuration of these detectors for viewing the fluorescence, a model of the fluorescence from both the surface and exosphere of Mercury has been produced.

1.1 Fluorescence model

The model used for this work was originally designed for D-C1XS on the SMART-1 mission to the Moon [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. Figure one shows the expected observations from MIXS-C when viewing the surface fluorescence from Mercury. As expected, numerous fluorescence peaks are visible, with some of the most prominent being magnesium and silicon. Sodium is not easily observed, however it isn't highly abundant on Mercury's surface so this is to be expected.

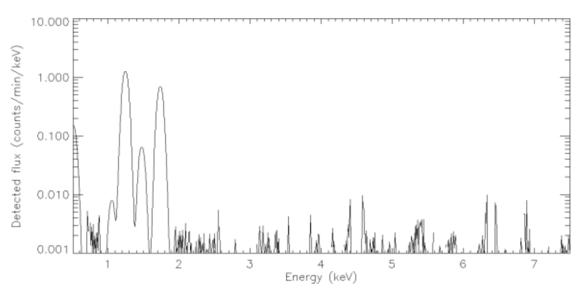

Figure 1: Model produced X-ray fluorescence spectrum for the surface of Mercury as observed by MIMXS-c for one minute during an X-class flare.

Additional model alterations are required to replicate exospheric conditions in the model. Inclusion of scale heights and an exospheric decay component produce this desired effect.

Figure two shows the fluorescence observed by MIXS when it is at a normal to the planet's surface. This therefore includes fluorescence from both the surface and exosphere combined. The sodium component is clearly visible compared to the peak in figure 1, with an expected detection rate of one photon a minute. However to obtain this result, certain conditions must be met. A high quantity of solar flux is used, along with a prolonged exposure time. Additionally, this observational configuration makes determining the exospheric fluorescence separately from the surface fluorescence impractical. This does however act as a proof of concept before more detailed observational parameters are determined.

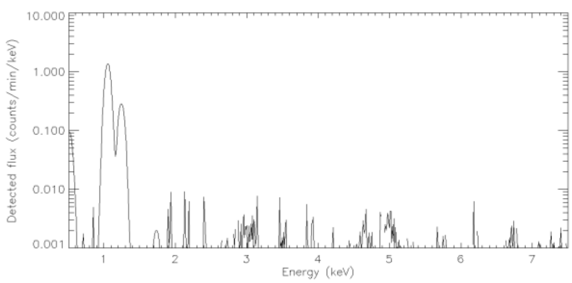

Figure 2: Model produced X-ray fluorescence if both the exosphere and surface of Mercury observed by MIXS-C for one minute during an X class solar flare.

2. Optimal observational conditions

Taking into account regions in which the detector cannot operate, it is possible to ascertain the most advantageous positions for observations. By waiting until the detector is positioned at a location shown in figure three, observations can be made through the polar region where the exospheric sodium concentration is at its most dense. This will also include the tail region of the sodium exosphere, which provides a high volume of observable sodium. It also allows for independent observation of the exospheric fluorescence, with the surface factor subtracted.

It is also necessary to consider the solar conditions required for the fluorescence to be detectable. The current launch date for BepiColumbo will place it at Mercury in a solar maximum, therefore greatly increasing the potential for such flares.

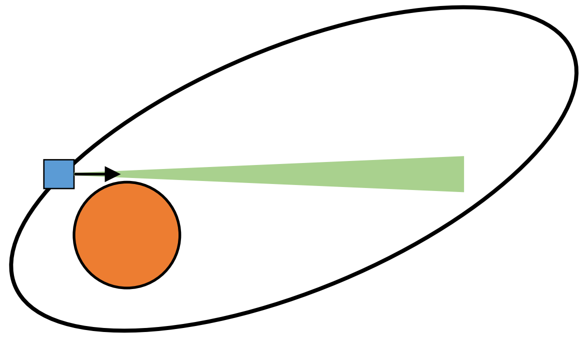

Figure 3: Optimal observational position for MIXS, modified from MPO orbital diagrams. Arrow indicates direction of observation, with additional observational cone.

3. Summary and Conclusions

The potential to observe X-ray fluorescence events at Mercury with MIXS should be capitalised on. At certain points in the proposed orbital paths around Mercury, MIXS will be in a position to observe this fluorescence, allowing for additional data for currently planned exospheric investigation. From these observations, predictions on MIXS' ability to explore the sodium tail of Mercury's exosphere will be possible, along with interactions between the exosphere and magnetosphere of the planet.

Acknowledgements

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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