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The 6.4 keV Fe Line and the SiO Emission in the GC

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Abstract. We present a map of the Galactic center in the J=1-0 line of SiO covering the region mapped with the ASCA satellite in the 6.4 keV Fe line. We find a correlation between the spatial distribution of the Fe 6.4 keV line and the SiO emission. The SiO abundance increases by more than a factor of 20 in the regions with strong Fe 6.4 keV line. This indicates that the Fe 6.4 keV line mainly arises from molecular clouds with large gas phase abundance of refractory elements. We discuss the implications of the correlation on the origin of the hard X-rays, and the heating and the chemistry of the molecular clouds in the GC.

1. Introduction

The Galactic center (GC) is a strong source of diffuse X-ray emission in the 2-10 keV energy range and from lines from several elements. One of the most interesting results is the spatial distribution and the intensity of the Fe Kα lines. In particular the Kα line from neutral or low ionized Fe atoms at 6.40 keV (hereafter Fe° line) shows a very different spatial distribution than those of the other Fe lines (Koyama et al. 96). The Fe° line is caused by fluorescence and appears when cold molecular clouds are exposed to a strong source of hard X-rays. In X-rays irradiated molecular clouds like those in the GC, it is expected that the X-rays will influence the heating, the ionization and the chemistry of these clouds. It is well known that the physical conditions and the chemistry of the molecular clouds in the GC differ substantially from those in the galactic disk. However, to what extend the heating and chemistry of the molecular clouds in the GC are influenced by the X-rays is unknown.

2. Results and discussion

Figures 1a, 1b and 1c show the spatial distribution of the SiO, the Fe° (Koyama et al. 96) and the CS integrated intensity (Bally et al. 1987) in the GC obtained with angular resolutions of $2'$, $3'$ and $3'$ respectively. The spatial distribution of the SiO emission is different from that of CS but similar to that of the Fe° line.

We find a correlation between the Fe° and the SiO emissions both on the large scale and within the Sgr A and Sgr B complexes. For the regions without or weak Fe° line emission, we do not detect the SiO line and derive an upper limit to the SiO/CS ratio of 4×10^{-2}. The SiO/CS ratio increases by more than a

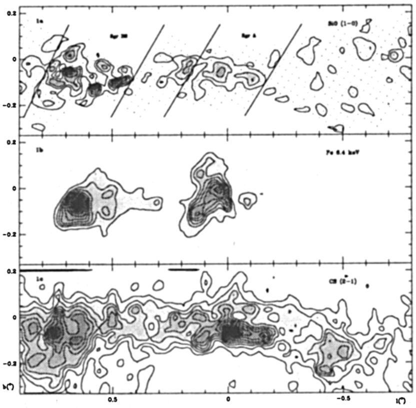

Figure 1. a-c Spatial distributions of the integrated intensity of the SiO J=1-0, Fe 6.4 keV and CS J=2-1 line emission towards the GC.

factor of 20 in the region with the strongest Fe° line emission (Martín-Pintado et al. 2000). The difference between the CS and the SiO emission is due to changes in the SiO abundance relative to that of CS (Martín-Pintado et al. 2000). The SiO abundance in the SiO clouds for the region with Fe° line emission is $\sim 10^{-9}$, and decreases to $\lesssim 5\times10^{-11}$ for the molecular clouds without Fe° line emission. Therefore, the Fe° line emission in the GC arises from the molecular clouds with large gas phase abundance of refractory elements like SiO.

A common origin for the X-rays and the large SiO abundance in gas phase and/or a peculiar chemistry induced by X-rays could both explain the correlation (see Martín-Pintado et al. 2000 for a detailed discussion). The relatively large abundance of SiO and its spatial distribution in the GC clouds can be explained by an increase of Si or SiO in gas phase due to grain processing by shocks (Martín-Pintado et al. 1997). It is possible that the sources driving the strong shocks responsible for the grain destruction also generate the hard X-ray emission which excite the Fe° line. Alternatively, molecular clouds irradiated by X-rays contain regions of high temperature where reactions with activation barriers could contribute to molecule formation. Then, the SiO abundance in the hot regions could be enhanced if Si is in gas phase. If silicate grains smaller than 10 Å are present, X-rays can evaporate these dust grains providing the small fraction of Si in gas phase (0.1%) required to explain the SiO abundance in the GC molecular clouds.

References

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