Measurements of coronal magnetic fields using magnetic-field induced transition in Fe X

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The interaction between the magnetic field and an atom/ion breaks the symmetry of an atomic system allowing atomic states with the same magnetic quantum number and parity to mix and gives rise to a magnetic-field-induced transition (MIT) to appear in spectra. The intensities of these lines have a strong, to first order quadratic dependence on the external field strength and therefore can be used for magnetic field diagnostics [1,2].

It was found that a pseudo-degeneracy of the $3p^43d\ ^4D_{7/2,5/2}$ occurred in Fe X, and an external magnetic field could induce a mixing of these two levels and cause a MIT at 257.26 Å from the metastable state $^4D_{7/2}$ to $^2P^o_{3/2}$ in addition to the M2 transition [3-5]. Both the laboratory measurement and analyses of solar spectra confirm that the energy difference between the $3p^43d\ ^4D_{7/2,5/2}$ levels is small enough for the MIT-intensity to be sensitive to the relatively weak magnetic fields expected in the solar corona [6,7]. Since the 257.26 Å line is one of the strongest lines in the Fe x spectrum in the solar corona, the properties of this metastable level can be directly used to measure the magnetic field strength in the solar corona.

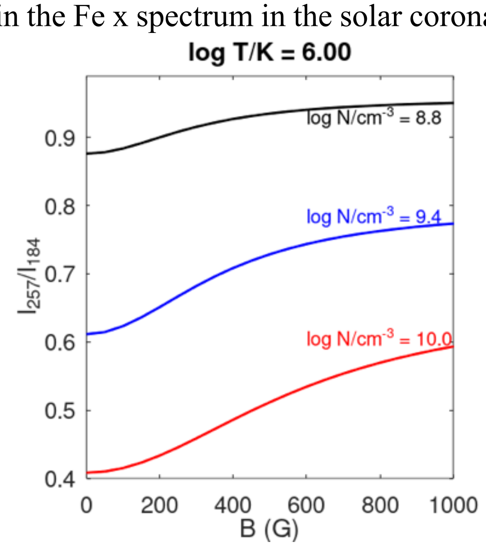

Figure 1. Intensity ratio of the Fe X 257 and 184 as a function of the magnetic field strength

The potential of utilizing the Fe X MIT for the coronal magnetic field strength measurements in the active region has been illustrated by applying the diagnostic technique to the vast data set accumulated by the Hinode/EIS mission [8-10]. The validation of the method has also been verified through a forward modeling with a 3D MHD model [11]. This new method can provide 2D maps of the magnetic field from the solar disk to the limb, complementing the DKIST and CoMP ground-based observatories.

References

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