Chapter VI
Conclusions

In this work, we considered the magnetic loop structures above an active region (AR7912) as observed on a Fe^{+9} image during the total solar eclipse on October 24th, 1995. This picture shows a discontinuity in the Fe^{+9} emission, which to our knowledge has never been previously recorded and published. In this work, we model the magnetic field to verify the underlying loop structures. We used a generalization of Alissandrakis's method to solve the constant-α force-free magnetic field in terms of a Fourier transform (Alissandrakis, 1981). We modified his boundary condition for a general line-of-sight angle, φ, as shown in eq. (2.38). Thus, three components of the magnetic field are provided by numerical computations by fast Fourier transforms (FFTs) for our simulation of the magnetic field lines to explain the morphology of the loop structures.

The force-free magnetic field model gave us good agreement with loop features observed in X-rays and Fe^{+9} emission on the solar disk and limb. For the results in Chapter V, we used October 18th, 1995 magnetogram data as the boundary condition for all of our simulations. From our simulations, we found that the magnetic field vector plot for $\alpha = 0.1$ arc second^{-1} and the projection of the loops in x-z plane (Figure 5.4) confirmed that the discontinuity in the Fe^{+9} image did not occur from small magnetic loops near the footpoints, and the magnetic loop structure indeed comprises large ($\sim 10^5$ km) arches with one footpoint at each major sunspot. Comparison of our simulations on the solar disk rotated from 18^{th} to 17^{th} October and the magnetic field vector plots for various α values with a Yohkoh image for 17^{th} October, 1995 indicate a good value for the constant α as 0.1 arc second^{-1}. This yields the same S-shapes as observed in X-rays above active region AR7912. The simulations for 24^{th} October, 1995 at $\alpha = 0.1$ arc second^{-1} indicated a subset of the loops coinciding with the Fe^{+9} image, which are apparently filled with relatively cool plasma (*a priori* it is not possible to know which magnetic loops will be filled with cool plasma), and confirming a sharp discontinuity in the Fe^{+9} emission with height above the photosphere.

If the loops are in thermodynamic equilibrium, there should be a continuous and gradually varying intensity and width of observed Fe X features. From our overview of previous journal articles, we found that all of the Fe^{+9} photographs showed such gradually varying features (Hanaoka, Kurokawa and Saito, 1986; Kurokawa, Kitai and Ishiura, 1995). Therefore, to explain this discontinuity we invoke a transient heating model.

From previously published models of nonequilibrium thermodynamics in coronal loops, there were two possible ways to explain our observation. First, a heating front could occur after a solar flare, since the heating rapidly extends from the origin of the flare at the loop top to the feet of the loops (Krall, 1977; Machado and Emslie, 1979). One could not observe Fe^{+9} in the hotter plasma since loop Fe^{+9} can only be found at cool temperatures of about 10^6 K. A heating front should appear just for a few seconds after the solar flare (Emslie and Nagai, 1985 and Rust, Simnett, and Smith, 1987). Therefore, the chance that a solar flare had occurred within a few seconds before the solar eclipse observation is very low.

A more likely explanation is that the sharp gradient in Fe^{+9} emission and height is a phenomenon which occurs on a longer time scale after solar activity. After the heating front reaches the photosphere, the plasma in inner loops will have a high temperature and then will gradually release heat due to radiation and conduction (Krall, 1977; Machado and Emslie, 1979). In this stage, the loops are not in thermal equilibrium and can have a strong temperature gradient with height. This phase can last for a time scale of days after solar activity. It is quite plausible that there was magnetic reconnection and accompanying solar activity within a few days preceding the solar eclipse. In fact, AR7912 was very active during its transit of the solar disk over the preceding 2 weeks, including a huge X-ray flare on October 20^{th}. Therefore, this model can provide a good explanation for the discontinuity in our observation.