ATOMIC CALCULATIONS FOR THE HIGHLY IONIZED IRON IONS PRODUCED IN SOLAR FLARES

H. E. Mason
Department of Applied Mathematics and Theoretical Physics
Silver Street
Cambridge CB3 9EW, GB

A. K. Bhatia
NASA/Goddard Space Flight Center
Laboratory for Astronomy and Solar Physics
Greenbelt, Maryland, 20771, USA

The XUV (90-150 Å) and X-ray (10-25 Å) spectra of solar flares are rich in lines from the highly ionized iron ions. Atomic data have been calculated for Fe XVIII (Bhatia, unpublished), Fe XIX (Loulergue et al., 1984, Bhatia and Mason, 1984), Fe XX (Mason and Bhatia, 1980, 1983), Fe XXI (Mason et al., 1979), Fe XXII (Mason and Storey, 1980), Fe XXIII (Bhatia and Mason, 1981), Fe XXIV (Hayes, 1979). The University College London computer package was used. This consists of an atomic structure code (SUPERSTRUCTURE, Eissner et al., 1974); a 'distorted wave' electron scattering program (COLLDW, Eissner and Seaton, 1972); a 'Bethe' approximation electron scattering program (Burgess and Shoerey, unpublished); a program for obtaining electron collision strength in pair coupling from R matrices in LS coupling (JAJOM, Saraph, 1972); a proton scattering program (Bely and Faucher, 1970) and a program for obtaining level populations and intensity ratios.

The transitions $2s^2 2p^n - 2s2p^{n+1}$ fall into the wavelength region 90-150 Å. There are few solar lines in this wavelength region in the absence of flare activity. The only solar flare spectra covering this wavelength region were obtained by the Goddard Space Flight Center's grating spectrometer on OSO-5 (Kastner et al., 1974). An analysis of one of these spectra using recent atomic data has been published by Mason et al. (1984). A steep, positive slope in the emission measure between $10^{6.5}$ and $10^{7.3}$ K was found. An electron density of $\simeq 4 \times 10^{11}$ cm^{-3} at 10^7K was deduced from the line intensity ratios of FE XXI. Theoretical intensity ratios for the Fe XIX lines (Loulergue et al., 1984) agree well with the solar flare spectra and also with recent tokamak spectra published by Stratton et al., 1984. Consistent values are obtained between the theoretical and tokamak intensity ratio I(91.02Å/I(108.37Å) as a function of electron density. The variation in this intensity ratio is due to the enhancement of the $2s^2 2p^4\ ^1D_2$ population relative to that of $2s^2 2p^4\ ^3P_2$ with increasing electron density.

The $2s^2 2p^n - 2s^2 2p^{n-1} 3d$ transitions fall into the wavelength region 10-25 Å. The highest resolution solar flare spectra have been obtained with the X-ray polychromator-flat crystal spectrometer (XRP-FCS) on the Solar Maximum Mission (SMM) (Phillips et al., 1982). The Fe XIX lines fall around 13.5 Å and are partially blended with the lines from Ne VIII and Ne IX. Atomic structure and electron scattering calculations have been carried out for the configurations $2s^2 2p^4 > 2s^2 2p^3 3s$ and $2s^2 2p^3 3d$ of Fe XIX

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(Bhatia and Mason, 1984). To obtain accurate energy level separations for the excited configurations, it was necessary to consider configuration interaction with $2s2p^4 3p$, $2p^5 3s$, $2p^5 3d$. The wavelength identifications have been re-examined by Fawcett and Mason (1984). There is good agreement between the theoretical and solar flare intensity ratios for Fe XIX.

REFERENCES

Bhatia, A.K., and Mason, H.E. 1981, Astron. Astrophys., 103, 324.
Bhatia, A.K., and Mason, H.E. 1984, Preprint
Bely, O., and Faucher, P. 1970, Astron. Astrophys., 6, 88.
Eissner, W., Jones, M., and Nussbaumer, H. 1974, Comp. Phys. Commun. 8, 270.
Eissner, W., and Seaton, M.J. 1972, J. Phys. B., 5, 2187.
Fawcett, B.C. and Mason, H.E. 1984, Preprint.
Hayes, M.A. 1979, Mon. Not. R. Astr. Soc., 189, 55p.
Kastner, S.O., Neupert, W.M., and Swartz, M. 1974, Astrophysics J, 191, 261
Loulergue, M., Mason, H.E., Nussbaumer, H., and Storey, P.J. 1984, Preprint.
Mason, H.E., and Bhatia, A.K. 1980, Astron. Astrophys., 83, 380.
Mason, H.E., and Bhatia, A.K. 1983, Astron. Astrophys. Suppl. Ser., 52, 181.
Mason, H.E., and Bhatia, A.K., Kastner, S.O., Neupert, W.M., and Swartz, M. 1984, Solar Phys., 92, 199.
Mason, H.E., Doschek, G.A., Feldman, U., and Bhatia, A.K. 1979, Astron. Astrophys., 73, 74.
Mason, H.E. and Storey, P.J. 1980, Mon. Nat. R. Astr. Soc., 191, 631.
Phillips, K.J.H., Leibacher, J.W., Wolfson, C.J., Parkinson, J.H., Fawcett, B.C., Kent, B.J., Mason, H.E., Acton, L.W., Culhane, J.L., and Gabriel, A.H. 1982, Astrophys. J., 256, 774.
Saraph, H.E. 1972, Comp. Phys. Commun., 3, 256.
Stratton, B.C., Moos, H.W., and Finkerthal, M. 1984, Astrophys. J., 279, L31.

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