ROLE OF PLASMA SPECTROSCOPY IN UNDERSTANDING PLASMA PROCESSES ON THE SUN

P.Meenakshi Raja Rao, P.Sarswathy, B.N.Raja Sekhar and G.Krishnamurty
Spectroscopy Division
Bhabha Atomic Research Centre
Trombay, Bombay- 400085
INDIA

Emission spectroscopic methods are very useful in determining the plasma parameters such as electron density, electron temperature, chemical abundances and energy levels of atoms and ions. A knowledge of the above mentioned parameters and collision cross sections provides an insight into various plasma processes on the Sun. As one passes from photosphere to chromosphere and corona the temperature as well as the electron density changes drastically (Te $\sim$4500 - 2X10^6 ^{0}K; $n_e \sim 10^8 - 10^{13}$ cm^{-3}) (1). Hence the solar spectrum, excited by different mechanisms and different equilibrium conditions, extends from vacuum ultraviolet to visible and infrared regions. For example the spectrum in the region between 3000-1300Å is produced by the upper photosphere and lower chromosphere. In this region the temperature is in the range of 6000-10000^{0}K. This region is characterised by several emission and absorption lines superimposed over continuum. Below 1600Å consists of emissions from highly ionised atomic species originating from chromosphere and corona (2). A correct interpretation of the spectral features is possible only after understanding the influence of various factors on spectral line shapes and intensities. They are 1) damping by collisions with neutral atoms; 2) collisions by charged particles leading to linear and quadratic Stark effects on atomic lines of hydrogen and helium; 3) thermal Doppler broadening 4) Doppler broadening or shift due to microturbulent velocity field.

In this context a detailed analyses of spectra (including line shapes and intensities) generated in laboratory plasmas under controlled conditions and evaluation of plasma parameters help a great deal in understanding astrophysical plasmas.

BARC has an ongoing programme in this field (3). The plasma sources used were Z-pinch devices such as vacuum spark and plasma focus developed in our research centre. The spectra from different zones of plasma were photographed in the visible region (4000-6000Å) on a indigenously built 1M Czerny-Turner spectrograph. In the case of vacuum spark the plasma was generated in helium atmosphere and plasma temperature was evaluated which was 1eV. From extensive work done on spectral emissions from 2KJ plasma focus device, where the plasma was generated in hydrogen atmosphere, the following important observations were made.

E. R. Priest and V. Krishan (eds.), Basic Plasma Processes on the Sun, 441–442.

https://doi.org/10.1017/S0074180900088392 Published online by Cambridge University Press

Observations

1. The instrumental width evaluated from hollow cathode spectra was 0.5Å
2. The spectral lines due to the hydrogen atom were very broad ($\Delta\lambda_{1/2}$ for H_β and H_γ lines = 20-40Å)
3. The spectral lines due to heavier elements like copper and zinc originating from electrode material also were broadened but to a lesser extent. ($\Delta\lambda_{12}$=1.0 - 5.5 Å)
4. No anomalies were observed in the intensity patterns.

These observations were made use of to evaluate the following plasma parameters.

1. Using copper as a thermometric species the plasma temperature was evaluated by the line intensity ratio method. ($T = 9800^0$ K in the focus region). At this temperature the Doppler width is 0.3Å for hydrogen lines0.05Å for Cu and Zn lines. Thus the contribution from instrumental and Doppler broadening to the observed line widths was not significant.

2. The atomic lines of hydrogen were subject to the linear Stark effect due to the high electron density environment. Hence from the observed half widths the electron density was evaluated. (n_e= $9.9X10^{16}$ cm^{-3} in the focus region.)

3. CuI and ZnI lines were influenced by quadratic Stark effect. From the observed half widths the Lorentzian component was evaluated and Stark coeffiecents (C_4) for the quadratic Stark effect were evaluated.

REFERENCES:

1. Engvold.O and Hange.O (1970) "Solar abundance determination"., Nuclear instruments and methods, 90, 351-362.

2. Heroux.L (1976) "Applications of beam-foil spectroscopy to solar ultraviolet emiision spectrum", Bashkin, S(Ed). "Beam-foil Spectroscopy", springer Verlag, 193-208.

3. Meenakshi Raja Rao P Saraswathy.P, Krishnamurty, G., Rout, R.K., Auluck, S.K.H., Shyam, A., Kulkarni, I.V., Oza, H.D., (1989) "Line broadening studies in low energy plasma Focus", Pramana-J.Phys.32, 627-639 and references therein.