Model treatment of the magnetic field measurements in the solar corona above sunspots

A.N. Korzhavin[1], T.I. Kaltman[1], V.M. Bogod[2], V.I. Garaimov[2]

[1] St.Petersburg Branch of the Special Astrophysical Observatory, St.Petersburg, Russia
[2] Special Astrophysical Observatory, Karachaevo- Cherkessia, Russia

It is generally accepted that gyroresonance emission of thermal electrons of the corona is responsible for the radio emission of the sunspots. The brightness temperature is determined by the kinetic temperature of the gyroresonance layer. The layer effectively emitting an extraordinary mode (s=3) is generally higher than that of s=2 responsible for the emission of an ordinary mode. On the basis of spectral and polarization observations of RATAN-600 the method of the magnetic field measurement at the level of the chromosphere-corona transition region (CCTR) was developed (Akhmedov et al, 1982). Such measurements of a magnetic field on third harmonic of gyrofrequency for each radio source are treated regularly since May, 1999 with RATAN-600 in the frame of ground based support for the SOHO mission (Bogod et al.1997, Bogod et al, 1999).

This method of magnetic field measurements with multifrequency observations with RATAN-600 is analyzed and modeled for gaining a high quality and accuracy of the method and a refinement of the physical sense. The frequency spectra of sunspot radio sources radiation are modeled as the thermal gyroresonance emission on the first 4 harmonics of the gyrofrequency. The simple models for CCTR (two-step model and the model with thin transition region) and a dipole approximation of the magnetic field were used. The model calculations were made as for the different locations of spot on the solar disk, as for the different magnetic field strengths. On the Fig.1 the model sunspot emission of the e-mode (F_e), the o-mode (F_o) and the resulting ($F_e - F_o$) polarized flux spectra are presented. The interpolation of F_e emission flux (or F_o) to zero gives us a critical wavelength λ_{c3} (or λ_{c2}) and we can find a value of the magnetic field as (Akhmedov et al, 1982): $B[Gs] = \frac{3570}{\lambda_{c3}[cm]}$ or $B[Gs] = \frac{5355}{\lambda_{c2}[cm]}$. The model calculations confirm that with the modeled method the maximum magnetic field of the sunspots at the height of CCTR is measured. Accordingly to modeling the value of the magnetic field measured with RATAN-600 observations on the 3-th harmonic is about 7% less then the real value with an accuracy about 3%; for the measurements of the same value of magnetic field with the ordinary wave on the 2-nd harmonic the accuracy is better than 3%. It was found that after recent upgrade of RATAN-600 it became possible to measure the value of sunspot magnetic field on 2-nd harmonic. We have treated for example the observations of 3 sunspots: AR8716 (10.10.99), AR8668 (19.08.99) and AR8699 (13.09.99). The difference between the same values of the magnetic field measured on the 3-rd and on the 2-nd harmonics is about 20% that is greater then the accuracy found from modeling.

We have plotted optical magnetic fields measured at the photospheric level using the data published in the SGD versus coronal magnetic fields measured with RATAN-600 for August, 1999 (Fig.2, left). The regression line of this plot (53 points of

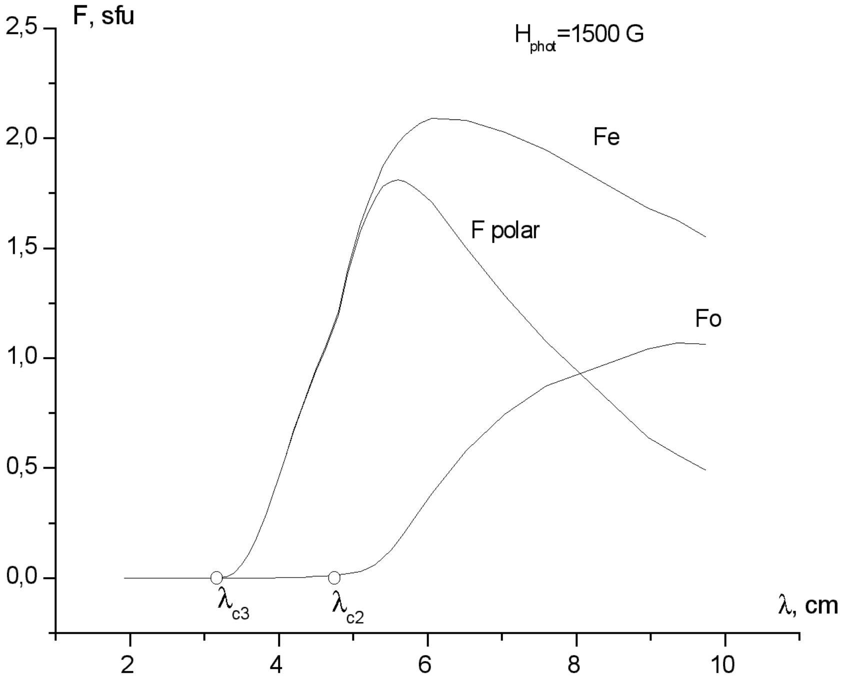

Fig.1. The model sunspot emission of the e-mode, o-mode and $F_e - F_o$ polarized flux

measurements) is: $H_{opt} = 1850 + 0.285H_{rad}$. The correlation coefficient is R=0.488. We have also plotted the same picture for magnetic fields measured with Ondrejov magnetograph versus magnetic fields measured with RATAN-600 for June-September, 1999 (Fig.2, right). The regression line (86 points of measurements) is: $H_{opt} = 600 + 0.953H_{rad}$, R=0.602.

The work was supported by grants of FRBR 00-02-18017 and INTAS-RFBR IR-97-1088. TIK feels thankful to the staff of the Ondrejov Observatory (Czech republic) for possibility to work with the magnetograph observations.

References

Sh.B. Akhmedov, G.B. Gelfreikh, V.M. Bogod, A.N. Korzhavin, 1982, Solar Phys., 79, 41

V.M. Bogod, V.I. Garaimov, N.P. Komar, V.A. Shatilov,1997, XXVII Radio Astronomy Conf., St.Petersburg: IPA Ross.Akad.Nauk, 3, 132

V.M. Bogod, V.I. Garaimov, N.P. Komar, A.N. Korzhavin,1999, Proc. 9-th European Meeting on Solar Physics, Florence, Italy, 1253

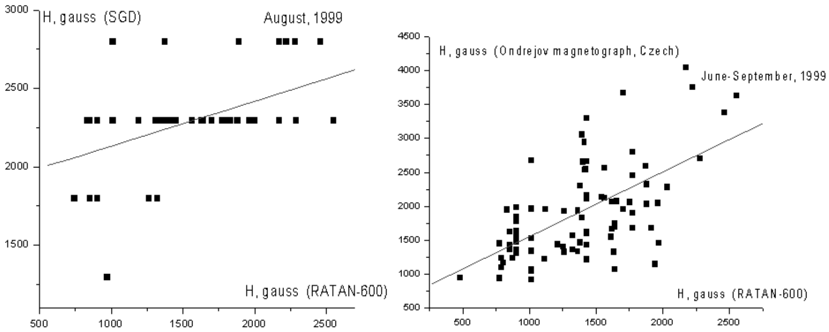

Fig.2. Comparison of radio and optical measurements of the sunspot magnetic fields