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On the magnetic field strength in the solar corona

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Abstract. On the base of the interferometric observations during the total solar eclipse on 11 August 1999 magnetic field strength in a coronal volume at the height of 10^5 km above the solar limb has been evaluated using an indirect method. A cold coronal emission (CCE), seen in the lines of H_α and K CaII, existed there. The conclusion is made that the magnetic field strength in this bulk, before the investigated CCE-region formed, was about 100-200 G.

1. Introduction

Magnetic fields play a great role in the solar corona. The structure of the solar corona is shaped by magnetic fields. Magnetic field measurements are possible only by radio methods, but there are some uncertainties in interpretation of the polarization observations how it is discussed for example in Ryabov *et al.* (2003). That is why the indirect method of the estimation of the magnetic field strength in the solar corona seems to be valuable. The solar corona is known to be a hot plasma radiating strongly in the ultraviolet and X-ray ranges. It is observed in lines of high ionized elements. However since 1868 a faint H_α-emission in the corona, having T$\sim$ $(10^4 - 10^5)$ K, was observed more than once during and out of the solar eclipses from the Earth (see Dermendjiev, Mouradian & Leroy (1994)). Investigating the CCE-region, observed in August 1999, and supposing some similarity of the K Ca II emission in the CCE-region and calcium flocculi on the Sun we can evaluate the magnetic strength in the coronal volume at the hight of 10^5 km above the solar limb before cooling occured there.

2. Data and analysis

During the solar eclipse on 11 August 1999 a horizontal solar instrument consisting of two coelostat mirrows, feeding two parallel tubes with identical optical and signal registration systems, was used to photograph the solar corona simultaneously in the lines of H_α 6563 Å and K CaII 3933 Å. The Fabry-Perot interferometers for the H_α and K CaII lines together with the corresponding narrow interference filters were employed. The interference filters with the full widths of 15 Å for the H_α line and 40 Å for the K CaII line were used as the premonochromators. The observations, instrument and the method of the treatment are described in more details in Delone et al. (2002).

A cold coronal emission region, located at the height of 100000 km above the solar limb, was found not associated with H_α-prominences. Simultaneous observations of the line profiles of the light (hydrogen) and heavy (calcium) elements gave us a possibility to determine the turbulent velocities of the CCE region and temperature in it. The temperature was found to change between 5×10^4 K in separate points and $(1-1.3) \times 10^5$ K for the most part of the CCE region (see Yakunina et al. (2002)).

As it is known from observations a Ca II flocculi area and magnetic field pattern have usually the same general shape and calcium emission plages are outlined nearly by a 10 G contour line (see Howard (1959)). Still Piddington (1956) has shown that an upward-travelling MHD waves can provide a heating of the solar material in the chromosphere and inner corona. A plausible mechanism, within these conditions, responsible for the excitation of the ionized calcium and fitting observations, is briefly described in Leighton (1959). We can believe that this mechanism is the same in the CCE-region and calcium flocculi. The lower limit of the magnetic field strength in quiet prominences seems to be of the same order as in Ca II flocculi. We can suppouse that magnetic field (not less than 10 - 20 G), typical for plasma volumes, emitting the lines of H_α and K Ca II, existed in the CCE-region or beneath it in the photosphere. The MHD waves, responsible for the energy transfer and plasma heating, dissipate very slowly in a low density plasma and consequently can reach considerable heights in the corona. In Priest et al. (2000) the dissipation height of Alfven waves in coronal holes has been evaluated to be about 1.7 $R_\odot$. In the corona with a greater plasma density this limit might be at lower heights. According to data from SGD during the 7 - 15 August 1999 there was no photospheric magnetic field of such strength (10-20 G) in position angles around the CCE-region. Consequently this magnetic field existed in own cool coronal region.

So we have determined the temperature in CCE-region about 10^5 K and supposed the magnetic field strength to be not less than 10-20 G in it. According to Marshall (1957) mechanism of cooling of the coronal plasma is associated with decreasing of the magnetic field strength. Marshall (1957) has shown that the temperature decrease is proportional to the decrease of the magnetic field strength. If we assume the temperature in the quiet corona about 2×10^6 K, i.e. an order greater than in the CCE-region, we can belive that cooling in the investigated CCE-region occured when the magnetic field strength became an order less in this volume.

3. Summary

So knowing the ratio of the temperatures in the quiet corona and CCE-region (more than an order of value) and the lower limit of the flocculi magnetic field strength (10-20 G) we can conclude that the magnetic field strength in the coronal volume, before the investigated CCE-region formed in it, was not less than 100-200 G.

References

Delone, A., Divlekeev, M., Gorshkov, A., Porfir'eva, G., Smirnova, O. & Yakunina, G. 2002, *Proc.Inter.Conf. "First results of 1999 Total Eclipse Observations" Varna, 2000, (Ed. D. N . Mishev and K. J. H. Phillips)*, 63–68.

Dermendjiev, V. N., Mouradian, Z. & Leroy, J.-L. 1994, *C. R. Acad. Bulg. Sci.*, **47**, No 7, 5–7.

Howard, R. 1959, *Ap. J.*, **130**, 193–201.

Leighton, R.B. 1959, *Ap. J.*, **130**, 366–380.

Marshall, L. 1957, *Ap. J.*, **126**, 177–184.

Piddington, J. N. 1956, *Mon. Not. RAS* **116**, 314–323.

Priest, E. R., Foley, C. R., Heyvaerts, J., Arber, T. D., Mackay, D., Culhane, J. L., & Acton, L. W. 2000, *Ap. J.*, **539**, 1002–1022.

Ryabov, B. I., Korzhavin, A. H., Kaltman, T. I., Peterova, H. G., Agalakov, B. V., & Borisevich, T. P. 2003, In *Nizhniy Novgorod Conf. 2-7 June 2003 The actual problems of physics of solar and stellar activity* (ed. V. V. Zaitsev). Sbornik dokladov, vol. 1, 54–57. Russian.

Yakunina, G., Smirnova, O., Delone, A., Gorshkov, A., & Porfir'eva, G. 2002, *Journal of Physical Studies*, (Ukraina), **6**, No 4, 429–431.