OBSERVATIONAL EVIDENCES FOR CORONAL TEMPERATURE DEPRESSION ABOVE SUNSPOT UMBRA

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ABSTRACT. Three large spots observed by the X-ray Polychromator on Solar Maximum Mission satelite are analysed. The X-ray spectroheliograms were used to derive the two-dimensional electron temperature distribution. For each of the spots, a significant depression in temperature obove the spot umbra is present. For one of these spots, observed simultaneously by Westerbork Synthesis Radioteleskope at 6 cm, this temperature minimum correspond to the centre of a microwave ring structure. This confirms the existence of the temperature depression above the spot umbra.

НАБЛЮДАТЕЛЬНЫЕ ПОДТВЕРЖДЕНИЯ СУЩЕСТВОВАНИЯ ДЕПРЕССИИ ЭЛЕКТРОННОЙ ТЕМПЕРАТУРЫ НАД ТЕНЬЮ ПЯТНА: В работе проведен анализ рентгеновских наблюдений трех больших пятен, полученных с помощью спектрометра с плоским кристаллом помещенного на спутнике СММ. По спектрогелиграммам в мягком рентгене рассчитано двухмерное распределение электронной температуры. Для всех трех пятен получена значительная депресия температуры над тенью пятна. Для одного из этих пятен наблюдаемого в Вестерборке на волне 6 см минимум температуры соответствует центру микроволновой кольцеобразной структуры. Это тоже подтверждает существование депрессии над тенью пятна.

POZOROVACIE DÔKAZY O POKLESE KORONÁLNEJ TEPLOTY NAD UMBROU SLNEČNÝCH ŠKVŔN: V práci je uvedená analýza rontgenových pozorovaní troch veľkých slnečných škvŕn, napozorovaných pomocou spektrometra s rovinným kryštálom (X-ray polychromator), umiestneného na družici Solar Maximum Mission. Spektroheliogramy mäkkého rontgenového žiarenia boli použité na výpočet dvojrozmerného rozdelenia elektrónovej teploty. Pre každú zo skúmaných škvŕn bol zistený významný pokles teploty nad umbrou škvrny. Pre jednu z týchto skúmaných škvŕn,

ktorá bola simultánne pozorované Westerborským syntézovým rádioteleskopom na vlne 6 cm bolo zistené, že toto teplotné minimum koinciduje s centrom mikrovlnnej prstencovej štruktúry. Toto potvrdzuje existenciu teplotného poklesu nad umbrou škvrny.

The Flat Crystal Spectrometer observations consist of 2' x 2' spectroheliograms with 15" pixel spacing, made simultaneously in six soft X-ray lines, from O VIII to Fe XXV. Here the spectroheliograms of three large spots are investigated. These spots are: main spot in HL 16864 active region (May 25, 1980), preceding and following spots in HL 17255 active region (November 9, 1980). Because of low count statistics, all possessed images (obtained during several orbits) were summed. It was possible to do because time variations of the observed regions were small. Only three softest channels showed significant emission above the spots, and as the temperature diagnostics the Ne IX to Mg XI line intensity ratio was used.

The results of calculated temperature distribution are presented in Figures 1 and 3, for HL 16864 and HL 17255 following spot. In Figure 2 the brightness temperature distribution at 6 cm as obtained by Westerbork Synthesis Radio Telescope for HL 16864 on May 25, 1980 is presented for comparison. The center of the observed ring structure in radio map correspond to the minimum temperature obtained from X-ray images. Because of low X-ray intensities, for the preceding HL 17255 spot only averaged temperature for umbra and penumbra were calculated. Zhe results for the latter spot are as follows:

$$\text{for umbra} \qquad T_e = 1.8 \, {}^{+0.3}_{-0.1} \times 10^6 \text{ K}$$

$$\text{for penumbra} \qquad T_e = 2.3 \, {}^{+0.3}_{-0.1} \times 10^6 \text{ K}$$

For each of analysed spots a significant depression in the coronal electron temperature above the spot umbra is present. This result is important for modelling of the sunspot-associated microwave emission. The microwave brightness temperature ring structures above sunspot are well kown from both theory (Zlotnik, 1968a,b; Gelfreikh and Lubyshev, 1979) and observations (Alissandrakis and Kundu, 1982; Strong et al., 1984; McConnel and Kundu, 1984). This is mainly due to an effect connected with strong rise of cyclotron absorption with the increase of the angle between magnetic field and the line of sight direction. Nevertheless a comparison of individual observations with model calculations (e.g. Strong et al., 1984) indicates that the coronal electron temperature above the umbra is lower than in the undisturbed corona. Our results are independent and direct evidence for depression of the coronal electron temperature above sunspot umbrae.

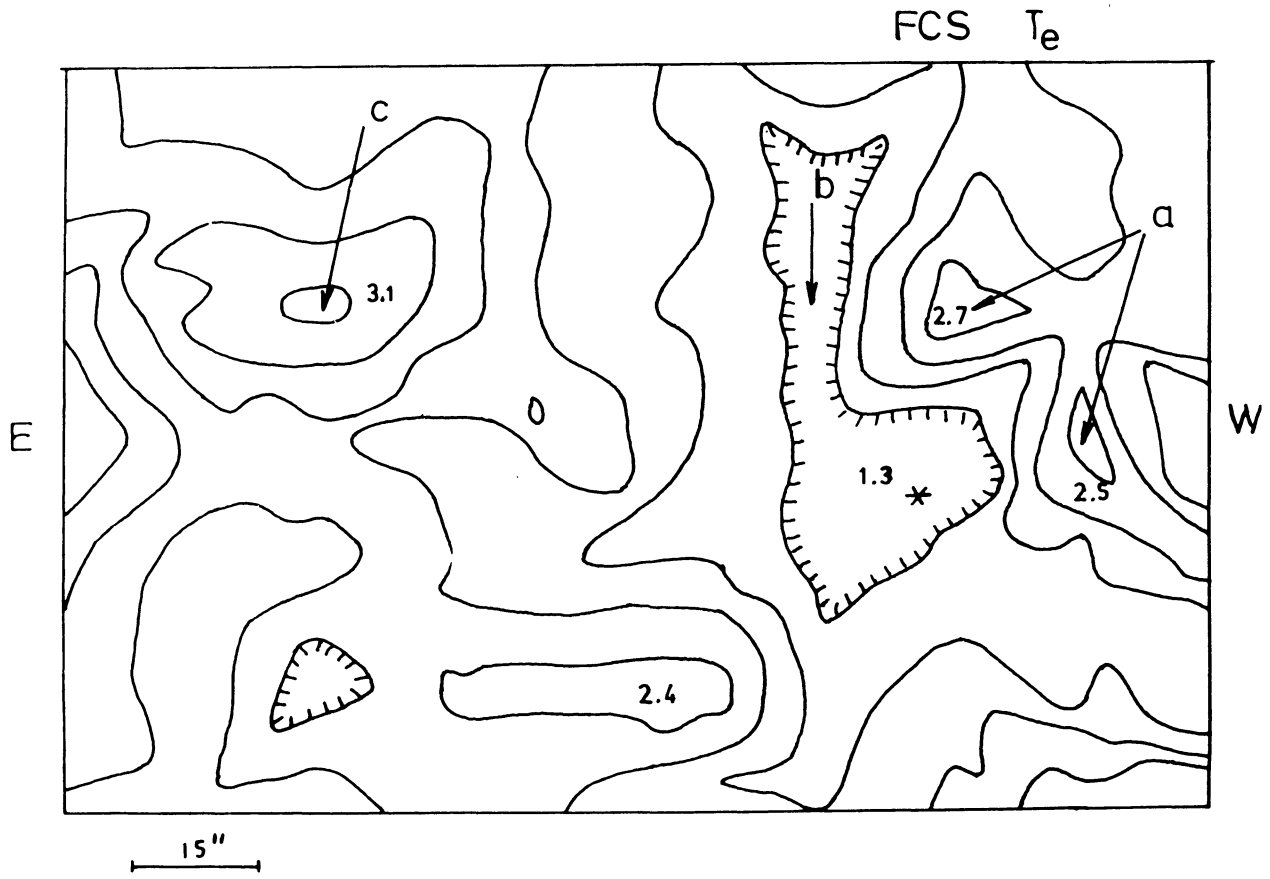

Fig. 1: Electron temperature distribution in HL 16864 (May 25, 1980) obtained from Ne IX to Mg XI line ratio. The center of the spot umbra is denoted by asterisk.

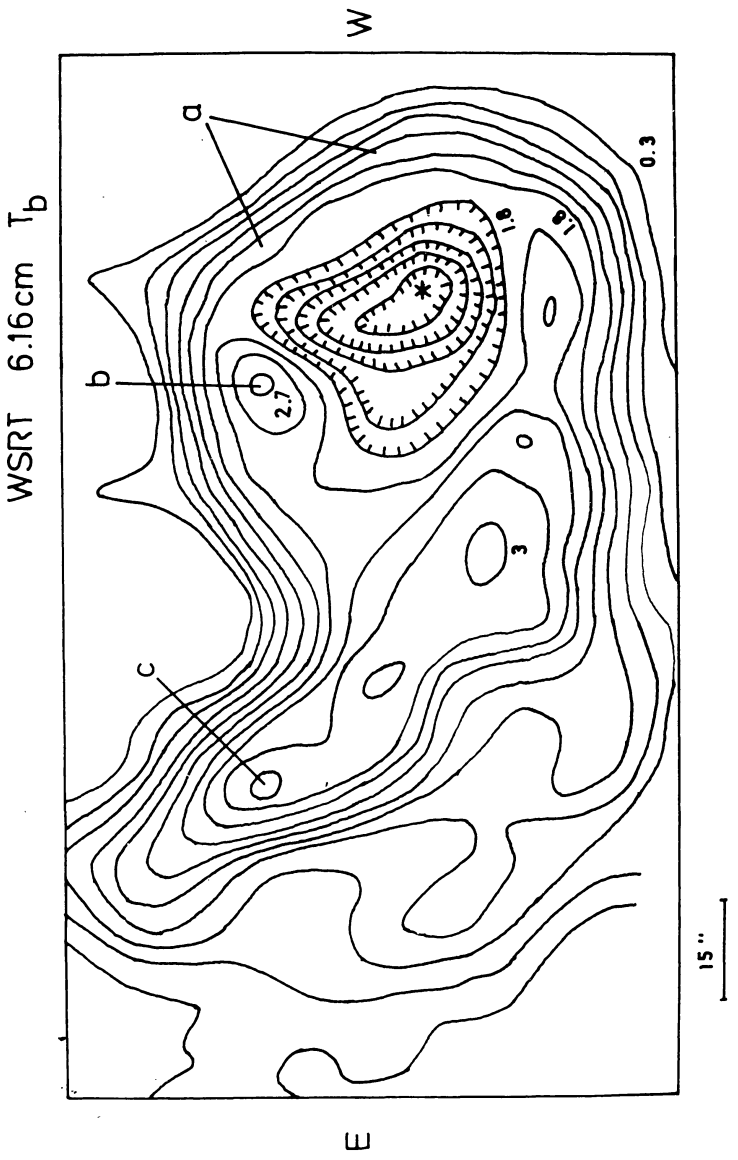

Fig. 2: 6 cm brightness temperature distribution in HL 16864 (May 25, 1980) according to Kundu and Alissandrakis (1984).

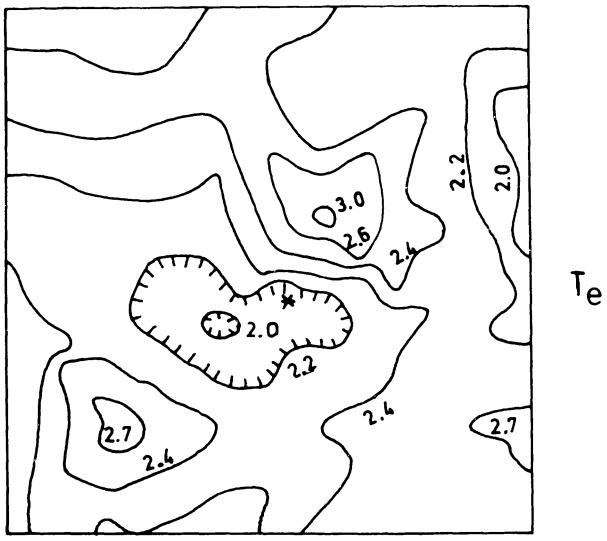

Fig. 3: Electron temperature distribution above the following spot of HL 17255 (November 9, 1980). The center of the spot umbra is denoted by asterisk.

REFERENCES

Alissandrakis, C.E., Kundu, M.R.: 1982, Astrophys. J. Letters 253, L49.
Gelfreikh, G.B., Lubyshev, B.I.: 1979, Astron. Zh. 56, 562.
McConnel, D., Kundu, M.R.: 1984, Astrophys. J. 279, 421.
Kundu, M.R., Alissandrakis, C.E.: 1984, Solar Phys. 94, 249.
Strong, K.T., Alissandrakis, C.E., Kundu, M.R.: 1984, Astrophys. J. 278, 865.
Zlotnik, E.Ya.: 1968a, Astron. Zh. 45, 310.
Zlotnik, E. Ya.: 1968b, Astron. Zh. 45, 585.