INFRARED OBSERVATIONS OF QUIESCENT PROMINENCES

P. Heinzel, P. Kotrč, M. Sobotka, F. Zloch
Astronomical Institute of the Czechoslovak Academy of Sciences,
251 65 Ondřejov, Czechoslovakia

Z. A. Scherbakova
Crimean Astrophysical Observatory, Nauchnyj, Crimea, USSR

ABSTRACT. We have developed a sophisticated numerical technique to reduce infrared photographic spectra of quiescent prominences, taking into account the influence of instrumental profiles, scattered light and the noise. The reduced profiles were subsequently compared with theoretical ones. It is demonstrated that in order to reproduce the wings of the optically thin HeI 1083 nm triplet line, it is necessary to consider a temperature rise towards the prominence-corona interface, in contrast to commonly used isothermal models.

ИНФРАКРАСНЫЕ НАБЛЮДЕНИЯ СПОКОЙНЫХ ПРОТУБЕРАНЦЕВ. В предлагаемой статье демонстрируется метод обработки инфракрасных фотографических спектров спокойных протуберанцев. Учитывается влияние инструментальных профилей спектрографа, микрофотометра, фотоматериала и влияние рассеяного света. Далее, исправленные профили наблюденных протуберанцев были сравнены с теоретическими. Показано, что оптически тонкие крылья триплета HeI 1083 nm нельзя объяснить в рамках простой изотермической модели протуберанца и нужно учитывать возрастание температуры в переходном слое между протуберанцем и короной.

INFRAČERVENÁ POZOROVÁNÍ KLIDNÝCH PROTUBERANCÍ. V práci je popsána numerická metoda redukce infračervených spekter klidných protuberancí. V úvahu je brán vliv instrumentálních profilů spektrografu, mikrofotometru, fotografické emulze a vliv rozptýleného světla. Redukované profily pozorovaných protuberancí byly následně porovnány s teoretickými. Je ukázáno, že opticky tenká křídla tripletu HeI 1083 nm nelze vysvětlit v rámci jednoduchého izotermálního modelu protuberance a že je nutné vzít v úvahu růst teploty v přechodové oblasti mezi samou protuberancí a okolní koronou.

We report on the further progress in our project of the infrared photographic observations of quiescent prominences in the HeI 1083 nm triplet. Our reduction of high-resolution spectra takes into account the influence of the instrumental profiles of the Ondřejov horizontal spectrograph HSFA 2 and that of the Soviet infrared emulsion I-1060-V, scattered light and noise. This technique is used to verify the interesting results of Landman et al. (1977). In measuring the emission lines HI H-α , H-β , HeI D_3 and 1083 nm, CaII and others, these authors found that it is not possible to use the constant source function derived for the line core for the wings of these lines. In other words, the wings of these lines cannot be explained within the frequently used approximation of an isothermal model which is sufficient in the line core emitted by the cool regions of the prominence / T_{kin} = 6 000 - 10 000 K/. Measuring these lines by sensitive photoelectric detectors, but with low spatial resolution, Landman and others found that the wings of these lines are more intensive than those predicted from an isothermal atmosphere at an average temperature of 8 000 K. Therefore, Landman and co-workers have introduced a two-component prominence model with a temperature structure to explain the differences in the wings. Such a temperature rise in the prominence-corona transition zone is also indicated by space ultraviolet measurements. The emission profiles calculated for the prominence model with cool central parts and hot periphery fit the observations well. The difference between the cool isothermal and two-component profiles is most pronounced for the H-α line, but on the other hand, it only reaches 5 % of the maximum intensity value. So small a difference in the singlet emission lines is detectable only by photoelectric detectors. However, as follows from Landman's data, neutral helium 1083 nm triplet seems to be suitable for photographic detection of these faint wings. Some calculations of the line profiles and fitting to the spectra observed at the Crimean Astrophysical Observatory were performed two years ago by Heinzel et al. (1984). In the previous spectra reduction, we did not take into account the influence of the instrumental profile, which can be substantial for the wing analysis and, therefore, we decided to solve this problem thoroughly.

There was no suitable laser to measure the instrumental profile in the infrared region. We only had low-pressure helium discharge lamp, the lines of which are strongly thermally broadened. To determine the lamp temperature we used the HeI D_3 587.6 nm line. The instrumental profile of the spectrograph in the D_3 region was considered to be close to the theoretical one according to Sobotka's (1985) former measurements and, therefore, we calculated this profile as the convolution of the spectrograph slit and difraction profiles, together with the microphotometer slit profile. The temperature of the helium lamp (550 K) served to calculate the thermal profile of the weaker 2^3P_0 - 2^3S_1 component of the 1083 nm triplet. We then performed the convolution of the thermal profile of this component with the slit profiles of the spectrograph and that of the microphotometer. We made two exposures of the 1083 nm line, first for the line center, the second for the wings. These measured profiles are the convolution of the thermal profile, slit profiles, instrumental profile of the spectrograph and the emulsion profile. We then obtained the instrumental profile (Fig. 1) corresponding to zero-width slits by means of deconvolving the thermal

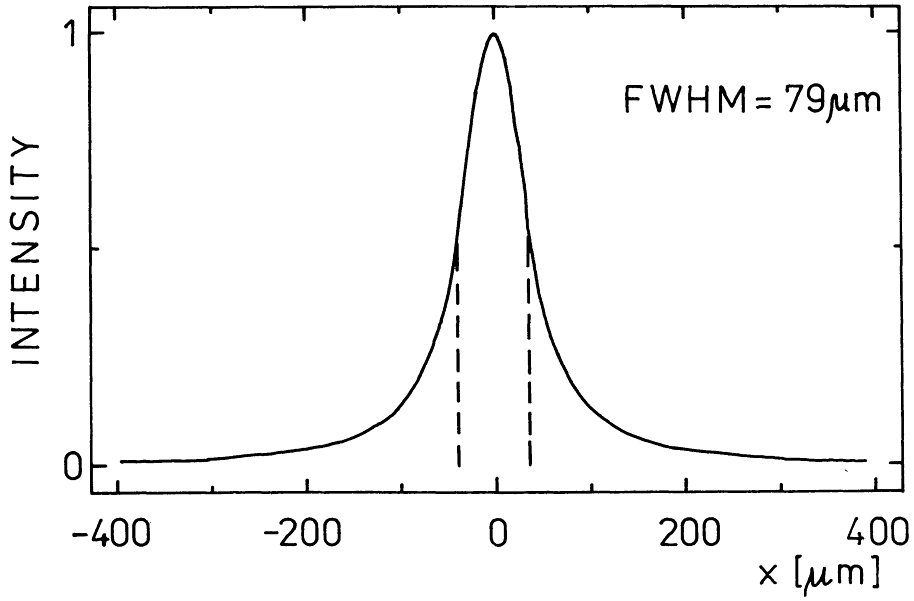

Fig. 1 The instrumental profile of the spectrograph and of the emulsion (see discussion in the text).

and slit-profiles from the measured one. There are two components in this profile: the intrinsic instrumental profile of the spectrograph and the emulsion profile. Since two exposures were used (for the line center and wings), our resulting profile is composed of two parts joined to each other at the point 0.5 I_{max}. The core of the profile is approximated by a Gaussian curve, and the wings are well fitted by the Lorentzian dispersion function. The FWHM of the resulting profile is 48 pm, i.e. 79 μm in the focal plane of the spectrograph camera (see Fig. 1).

On 15th September 1983 we obtained a series of high spatial /about 3''/ and spectral resolution data on HeI 1083 nm triplet in a quiescent prominence with the Ondřejov HSFA-2 horizontal telescope with spectrograph (Fig. 2). The observed profiles have been reduced using the method described above and subsequently compared with the theoretical calculations based on an isothermal constant source function model. An example of this comparison is displayed in Fig. 3. As compared to our previous results, we achieved much more pronounced differences between the observed profiles and those following from the isother-

Fig. 2 An example of the ifrared HeI 1083 nm emission spectrum of a quiescent prominence as observed by HSFA-2 instrument in Ondřejov.

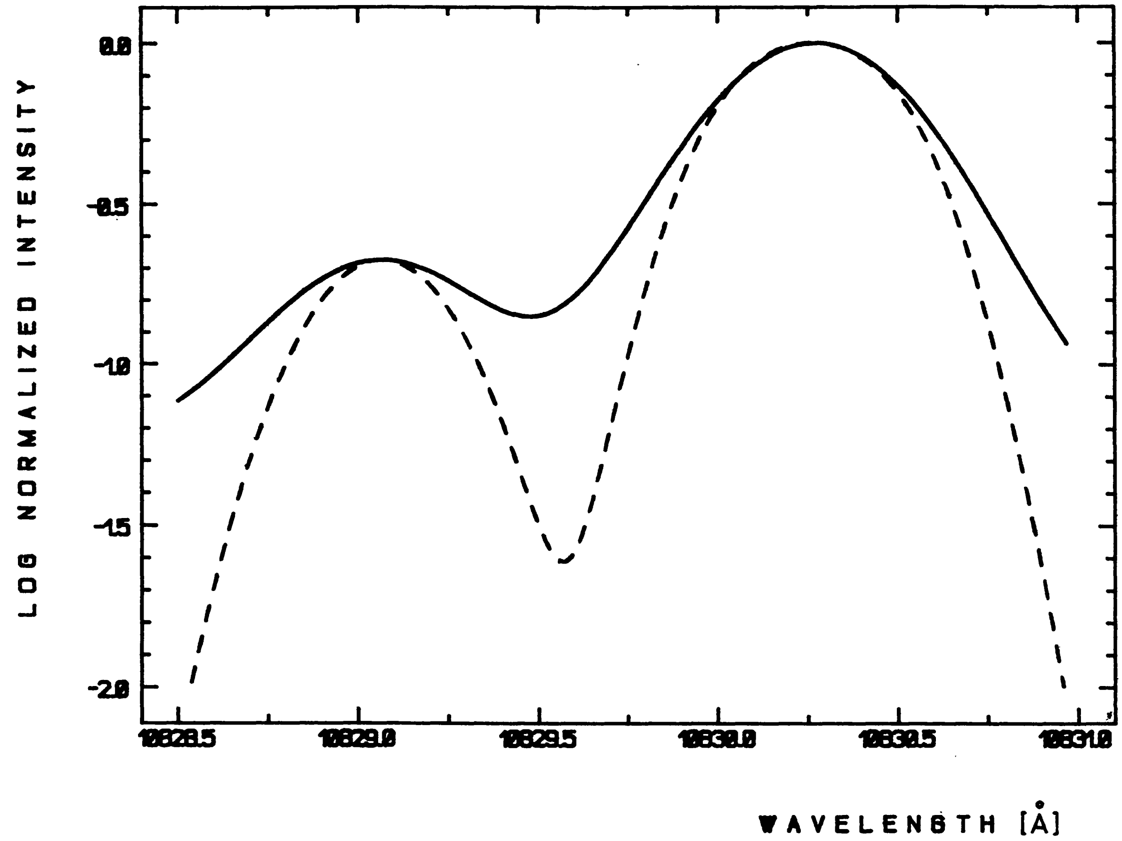

Fig. 3 A comparison of the observed HeI 1083 nm triplet profile (full line) with the theoretical one derived from an isothermal prominence model with a constant source function (dashed line). Optical thickness of the main component $2^3P_2 - 2^3S_1$ amounts 0.825 and was obtained by fitting the peak intensity of the component $2^3P_0 - 2^3S_1$.Doppler width 0.0305nm is obtained from the requirement that the theoretical intensities should fit the emission profile around the central peak.

mal one-component model. This strongly supports the Landman´s original hypothesis according to which the enhanced emission of the HeI 1083 nm line wings can be explained in terms of the multicomponent temperature model. However, this conclusion is still rather qualitative. In future, we plan to investigate quantitatively the dependence of this higher-temperature emission on the prominence optical depth as derived from the cool component. This procedure could answer the question concerning the temperature structure of the prominence-corona interface and that of the interfillar medium.

REFERENCES

Heinzel, P., Kotrč, P., Sobotka, M., Zloch, F. and Scherbakova, Z. A: 1984, in Proc. 7th Czechosl. Solar Meeting, ed. SUAA Hurbanovo, p. 163 (in czech)
Landman, D. A., Edberg, S. J. and Laney, C. D.: 1977, Astrophys. J. 218, 888
Sobotka, M.: 1985, Bull. Astron. Inst. Czechosl. 36, 230

(see page 182)

DISCUSSION

To the paper Heinzel, Kotrč et al. from page 171

J. Staude

Did you already obtain some preliminary information on the extent of the transition region between the cold component and the surrounding corona ?

P. Heinzel

I can comment this question. For one prominence, we obtained several spatially -resolved HeI 10830 line profiles which indicate the spatial variations of the prominence emission. From these measurements, we intend to deduce the optical thickness of the hotter component and its spatial relation to that of the cold component. Such an analysis should lead to a determination of the temperature structure of the prominence - corona transition region and that of the interfillar medium. However, the geometrical extent of the transition region strongly depends on the gas pressure accepted in the models.