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Weak cyanogen lines in the solar spectrum in the 4139 Å–4215 Å region

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Abstract. Identification reliability of some cyanogen lines in the solar spectrum is discussed in connection with velocity field investigations by means of line profile analysis. The identification have been shown to be faulty and to cause erroneous inferences on turbulent velocities in the solar atmosphere.

Key words : sun—molecular lines—CN line—velocity fields

So far the problem of the solar turbulent velocity has not been definitively solved. molecular lines enable one to find the general velocity amplitude in the upper photosphere where molecular layers are situated. To investigate the turbulent velocity field Punetha & Joshi (1984) have analysed profiles of 21 lines in the $\Delta v = -1$ sequence of the $B^2\Sigma^+ - X^2\Sigma^+$ violet bands of CN in the spectral range $\lambda\lambda$ 4139–4215. They have found that the Doppler widths $\Delta\lambda_D$ increase linearly with the equivalent widths w up to ~ 20 mÅ. The results were of great interest but unfortunately the $\Delta\lambda_D$-w relation seems to be artificially obtained as a result of identification errors.

Punetha & Joshi (1984) believed the identification by Moore, Minnaert & Houtgast (1966 ≡ Paper I). Unfortunately these generally accepted tables of solar lines are not complete, many weak cyanogen lines particularly being absent. On the contrary many solar lines are believed to belong exclusively to CN but they are in reality close unresolved blends of CN and other elements.

Now we shall discuss the reliability of the identification of the lines selected by Punetha & Joshi (1984). The identification of the lines 4214.915, 4181.353, 4140.755, 4178.625, 4178.235, 4162.292, 4147.213 has been discussed earlier (Porfir'eva & Sitnik 1968; Porfir'eva 1983, 1984). The question is whether it is possible to identify the solar lines 4214.834, 4214.363, 4193.447, 4159.865, 4148.395, 4139.089 and others only with CN.

Many solar lines identified with CN in Paper I are too intense to be considered purely molecular ones. Several intervals of the solar spectrum (Delboille, Rolland & Neven 1973) are shown in figure 1. Wavelengths of solar lines and their identification according to Paper I are given. Laboratory wavelengths of CN (Weinard 1955) and of SiH (Sauval 1969) are also given at the bottom of figure 1.

The solar lines 4140.755 and 4139.089 cannot be identified simply with CN $R_1 39(1-2)$ and CN $R_2 40(1-2)$ because they are too strong in comparison with the 4140.831 and 4138.987 lines which are believed to correspond to the violet and red component of the cyanogen doublets R39(1–2) and R40(1–2) respectively. The solar lines 4141.652 and 4144.768 also cannot be considered as purely molecular ones.

High resolution solar spectra distinctly show many new weak details which are not seen at all or are barely noticeable in moderate resolution solar spectra (Porfir'eva 1982). Let us analyse the profile of the line 4159.865 identified in Paper I with CN R27(1–2). As it is evident from figure 1b the line in reality is a complex blend. The line $\lambda_\odot \sim 4159.80$ in its violet wing can be identified with CN $R_1 27(1-2)$ ($\lambda_{lab} = 4159.799$, Weinard 1955). The line $\lambda_\odot \sim 4159.93$ in its red wing has been identified with SiH (Sauval 1969). By its intensity the solar line 4159.865 is too strong to be considered a pure molecular one.

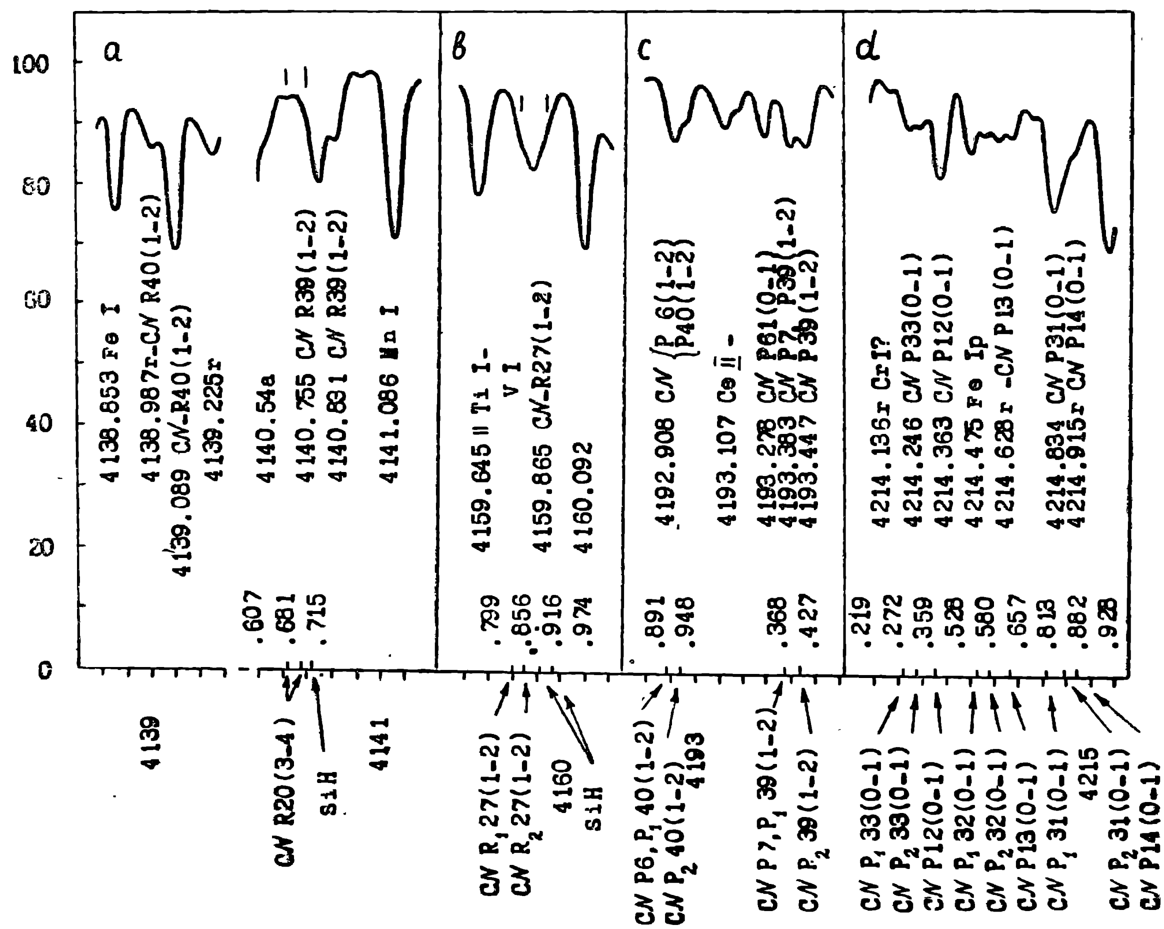

Figure 1. Molecular lines in the solar spectrum.

The 4192.908–.95 and 4193.383–.447 lines seem to be blends of CN lines with close rotational quantum numbers, namely P6, P40 (1–2); and P7, P39(1 2) respectively. But analysing their profiles (figure 1c) we can conclude that the solar line 4193.447) cannot be attributed exclusively to CN $P_2$39(1–2) otherwise the profiles of the blends 4192.908–.95 and 4193.383–.447 would be similar in form.

The $P_{1,2}$33 + P12, $P_{1,2}$32 + P13, and $P_{1,2}$31 + P14 cyanogen blends of (0–1) band are situated in row in the spectra (figure 1d). The 4214.834 and 4214.363 lines are too strong in comparison with the adjacent solar lines identified with CN (Profir'eva 1983), *i.e.* the lines 4214.834 and 4214.363 are likely to be blends of CN with other elements. All the inferences are confirmed by the comparison of the theoretical and observed cyanogen line equivalent widths in the solar spectrum.

Thus the identification of most of the lines selected by Punetha & Joshi (1984) is dubious. We see that the 4214.834, 4214.363, 4193.447, 4159.865, 4148.395, 4140.755, 4139.089 lines cannot be considered as pure cyanogen ones. Almost all these lines have relatively large values $\Delta\lambda_D$ and w (see table 1 of Punetha & Joshi 1984). The 4214.915, 4181.353, 4178.625, 4178.235, 4176.990 lines contain blends of cyanogen lines with different rotation quantum numbers but with coinciding wavelengths (Porfir'eva 1983). In such cases it is necessary to decompose the observed blend equivalent widths into components. Besides CN we must also take into account SiH in the identification of the solar lines 4178.235, 4162.292, 4159.815, 4148.395, 4147.213 (Porfir'eva 1984). Hence the relation $\Delta\lambda_D$-w for weak cyanogen lines obtained by Punetha & Joshi (1984) does not seem to be valid because of the questionable identification of the solar lines, and there are no grounds to conclude that there is a turbulent velocity change with optical depth.

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