New Perspectives on Solar Prominences, IAU Colloquium 167
ASP Conference Series, Vol. 150, 1998
David Webb, David Rust, and Brigitte Schmieder (eds.)

Spectroscopic Study of a Quiescent Prominence

Y. D. Park
Korea Astronomy Observatory, San 36-1, Whaam-dong, Yuseong-gu, Taejeon 305-348, Korea

H. S. Yun
Department of Astronomy, Seoul National University, Seoul 151-742, Korea

K. Ichimoto
Solar Physics Division, National Astronomical Observatory of Japan, Mitaka, Tokyo 181, Japan

K. J. Sim and Y-J. Moon
Korea Astronomy Observatory, San 36-1, Whaam-dong, Yuseong-gu, Taejeon 305-348, Korea

Abstract. We have analyzed a set of spectra of Hα and CaII H & K lines taken from a quiescent prominence with the G1 CCD camera attached to a 25 cm coronagraph at the Norikura Coronal Station, the National Astronomical Observatory of Japan. From these lines we have determined temperature, turbulent velocity and electron density at various locations on the prominence. The final analysis shows that the averaged temperature of the prominence is about 8600K with mean turbulent velocity of 7.5 km/s and with a mean electron density of $< n_e > = 2.4 \times 10^{10}$ cm^{-3}.

1. Introduction

Spectroscopic studies of prominences have been made by numerous workers (e.g., Hirayama 1971, 1979; Engvold 1978, 1981; Heasley et al. 1974; Landmann 1981, 1985; Zhang et al. 1987). To understand their physical and morphological characteristics, it is desirable to know the detailed distribution of physical parameters of individual prominences.

In the present paper, we present two dimensional distributions of temperature, non-thermal velocity and electron density determined from a quiescent prominence.

https://doi.org/10.1017/S025292110004762X Published online by Cambridge University Press

2. Observation and Data Analysis

Observations were made with the G1 CCD camera attached to a 25 cm coronagraph/Littrow type spectrograph at the Norikura Coronal Station of the National Astronomical Observatory of Japan. The observed prominence was of the hedgerow type, which appeared on August 16, 1992 with a position angle of 110°. The prominence kept the same shape during the observation and its maximum projected height was more than 40,000 km. A set of spectra of Hα (6562.81Å), CaII H (3933.68Å) and K (3968.47Å) have been taken of the prominence with spectral resolution of 0.0115Å/pixel at the 2nd order of the Hα line and spatial resolution of 0.3 arc sec/pixel. In taking these spectra the slit was placed in parallel to the solar limb at 6 different heights on the prominence, each being separated by 10 arc sec. The individual spectra were taken 30 seconds apart for about half an hour, during which time the slit was kept fixed. In order to determine physical parameters of the prominence, the observed spectra were analyzed in detail.

We have measured the observed line widths of Hα, CaII H and K to estimate the temperature and have utilized the Goldberg-Unno method for determination of the Doppler width of the Ca II H and K lines (Gallegos and Machado 1973). In this way we derived non-thermal velocity, temperature and column density of neutral hydrogen and Ca II atoms at various locations in the prominence traced by the slit. For this analysis we excluded the spectra closest to the solar limb because these spectra were strongly affected by the photospheric light.

3. Results and Discussion

Table 1 shows mean values of physical parameters derived from the observed prominence. The non-thermal velocity ranges from 6 km/s to 10 km/s with a mean value of 7.5 km/s (Figure 1*a*). The temperature ranges from 4000K to 12,000K with a mean value of 8600 K (Figure 1*b*). Figure 1 (*c*) and (*d*) show the column density distributions of Ca II and hydrogen in the observed prominence. The mean electron density of the prominence is found to be $< n_e > = 2.4 \times 10^{10}$ cm^{-3} with a hydrogen ionization ratio of $n_{HII}/n_{HI} = 0.5$ and with an effective thickness of $l = 1000$ km, in good agreement with those of Gallegos and Machado (1973), Engvold (1976) and Hirayama (1990).

The mean temperature of our prominence turns out to be a little higher than generally favored 5000K $\sim$ 7500K. This could be accounted for by the following two considerations. First, our observed spectra of various lines had to be recorded at different times, because the CCD camera and spectrograph covered only a limited range in wavelength. Second, as Kubota (1980) reported, about 12.5% of prominences reveal a central reversal in the Ca II K line due to absorption of light coming from the surface layer of prominences. Hirayama (1990) demonstrated that the self-absorption effect should be taken into account in the determination of prominence temperatures when using Hα and/or Ca II K lines. In the present work, however, the self-absorption effect did not need to be taken into consideration since none of the spectral lines showed central reversal. We plan to continue our studies of quiescent prominences by two dimensional spectroscopy which will allow us to include also more optically thin lines.

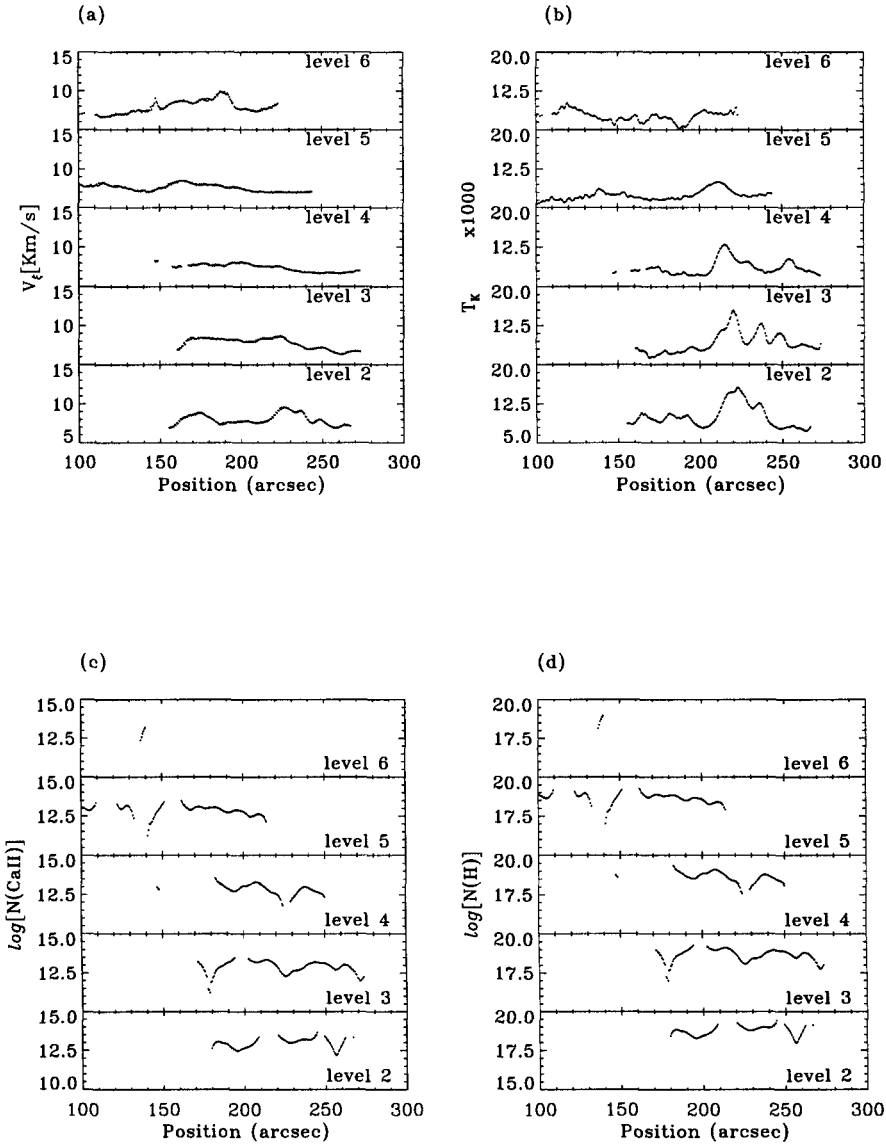

Figure 1. Distributions of (a) turbulent velocity, (b) kinetic temperature, (c) Ca II column density, and (d) hydrogen column density at different heights.

https://doi.org/10.1017/S025292110004762X Published online by Cambridge University Press

Table 1. Averaged values of physical parameters of our observed quiescent prominence deduced from Hα and Ca II H & K line widths and the intensity ratio of CaII H & K line center.

Physical parameters	Averaged values
T_k	8600 ±1200 K
V(Doppler)	3.5 km/s
V_ξ [a]	7.5 ±0.6 km/s
τ_K [b]	1.0
log [N(Ca II)]	12.88(±0.41) cm^{-2}
log [N(H)]	18.66(±0.41) cm^{-2}
n_e	2.4 x 10^{10} cm^{-3}

[a] Non-thermal velocity
[b] Optical depth of Ca II K

Acknowledgments. We (YDP and HSY) wish to thank staff members of Norikura Coronal Station for their hospitality during the visit. We also thank Dr. O. Engvold for his valuable comments on the present work. This work was supported in part by Korea Astronomy Observatory Research Fund and in part by Korea-China Cooperative Science Program under 966-0203-005-2.

References

Engvold, O. 1976, Solar Phys., 49, 283
Engvold, O. 1978, Solar Phys., 56, 87
Engvold, O. 1981, Solar Phys. 70, 315
Gallegos, H. G. and Machado, M. E. 1973, Solar Phys., 31, 427
Heasley, J. N., Mihalas, D. and Poland, A. I. 1974, ApJ, 192, 181
Hirayama, T. 1971, Solar Phys., 19, 384
Hirayama, T. 1979, Physics of Solar Prominences, E. Jensen et al. (eds.), Oslo, p. 4
Hirayama, T. 1990, in Dynamics of Quiescent Prominences, V. Ruzdjak and E. Tandberg-Hanssen (eds.), Springer-Verlag, New York, p. 187
Kubota. J. 1980, Publ. Astron. Soc. Japan, 32, 359
Landman, D. A. 1981, ApJ, 251, 768
Landman. D. A. 1985, ApJ, 290, 369
Zhang, Q. Z., Livingstone, W. C., Hu, J. and Fang, C. 1987, Solar Phys., 114, 245