BRIGHT RIMS OF SOLAR PROMINENCES

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Abstract

Bright rims were first noticed by Royds (1920) and later observed and discussed by d’Azambuja and d’Azambuja (1948). There is as yet no generally accepted theory for the origin or the existence of this phenomenon. The aim of the present study, of which this article is a progress report, is to establish the physical relation and of bright rims to various types of prominences and/or to particular phases in their development. It is also of interest and importance to determine whether and how bright rims differ from plages and other bright solar features.

1 Introduction

Bright rims were first noticed by Royds (1920) and later observed and discussed by d’Azambuja and d’Azambuja (1948). These authors described this phenomenon as a more or less continuous emission rim penetrating diffusively into the prominence from below, on the side of the prominence closest to disk center. There is as yet no generally accepted theory for the origin or the existence of this phenomenon, although several theories have been presented. Kostik and Orlova (1975) proposed that a bright rim is a result of photospheric radiation reflected by the filament back onto the chromosphere, while Heinzel et al. (1995) explain bright rims as an effect of Hα line radiation diffusion in a 1-D slab, situated parallel to the solar surface, and irradiated from below. According to this explanation the bright rim is an integral part of the filament. This theory has been contested by Paletou (1997) who showed with 2-D modeling that the observed intensity of the bright rim can not be explained by the suggested mechanism. Another possible cause for the existence of bright rims could be that they are a result of local heating due to magnetic reconnection (Engvold (1988)). This could take place in the chromosphere immediately below the filament, or at the lower boundary of a filament where its magnetic field may interact with new emerging flux. This idea is currently being investigated by the lead author (I.H).

The aim of the present study, of which this article is a progress report, is to establish the physical relation of bright rims to various types of prominences and/or to particular phases in their development. It is also of interest and importance to determine whether and how bright rims differ from plages and other bright solar features.

2 Central questions

A first step towards obtaining a comprehensive physical understanding of the phenomenon of bright rims, would be to establish relevant criteria and definitions of bright rims. One of the central questions is where the bright rims is located: Is it a part of the filament itself, or is it a brightening of the chromo-
sphere below? A physical explanation of bright rims will strongly depend on the answer to this question.

In their historical works Royds (1920) and d'Azambuja and d'Azambuja (1948) claim that bright rims exist for all filaments and that bright rims are continuous and rather homogenous. Observations with high resolution instruments seem to show, however, that this is not the case. One does in fact observe filaments without bright rims and filaments with bright rims can be discontinuous as well as continuous. It is therefore of great interest to determine if the existence of bright rims is linked to any particular kind of filament and furthermore what determines the size and shape of bright rims.

3 Data and observations

In order to study the physical relation of bright rims to various types of filaments and to derive a meaningful and clear definition of bright rims we have found it desirable to study a large number of filaments and their possible bright rims. Full disk Hα images of the Sun from Big Bear Solar Observatory (BBSO) are used for a statistical investigation into the relationship between bright rims and the dark filament body. A survey has been made for filaments both with and without bright rims from data obtained in the period January to June 1998.

Figure 2: Filament with a well-developed bright rim observed at the SVST on September 10, 1998, at 09:27 UT.

Although the above mentioned data will give a general overview of the characteristics of bright rims, we have found it necessary to study high resolution data of a filament with a well-developed bright rim. These data were obtained during an international observation campaign at the Canary Islands on the 9th and

Figure 1: Filament with a well-developed bright rim observed at the SVST on September 10, 1998, at 09:02 UT.
10th of September, 1998. Coordinated observations were obtained from the Swedish Vacuum Solar Telescope (SVST) on La Palma and the MSDP spectrograph at the VTT on Tenerife. One common target on both days was a filament, situated close to the south-west limb, which exhibited a bright rim.

The SVST data consists of time-series of the Hα line center, ± 250 mÅ, ± 450 mÅ, 700 mÅ. For the 9th of September the time-series was obtained between 10:38 UT and 11:32 UT and for the 10th the series stretches between 08:34 UT and 09:55 UT. For both series the cadence is about 66 seconds for each wavelength position. These data are used to study the time evolution and dynamic behavior of the bright rim.

In addition, using the MSDP spectrograph at the VTT on Tenerife, we obtained simultaneous, monochromatic observations of 9 points in the Hα line profile, in a 2-D field-of-view. Several such FOV were required to cover the whole filament. Line profiles were reconstructed and subsequently velocity maps could be derived for each field-of-view.

4 Preliminary findings

We submit that a useful, although not sufficient, criterion for bright rims of AR filaments, is that they follow the lower contour of the filament. In addition, a bright rim appears on the "center-near" side of a filament. Also, it is generally accepted that bright rims penetrate diffusively from below into the filament. Figures 3 and 4 show two filaments observed on March 20 and March 5, 1998, at the BBSO where the bright rims can be seen to follow the contours of the filaments.

The present data have been used to check if and how bright rims can be distinguished from plages. For the cases of high latitude filaments bright rims are less frequently observed. Also, the areas around such filaments show very few and weak plages. For AR filaments and filaments close to AR, on the other
Figure 5: Velocity maps of a segment of the filament observed on September 10, 1998, obtained from MSDP spectroheliograms. The location of this segment can be deduced from Figure 2.
hand, bright rims are much more common, as are also plages. The fact that bright rims can be seen to follow the contours of the filaments they are associated with, suggest that they are different from plages.

The statistical survey revealed that bright rims exist for all types of filaments (quiescent, active region), although bright rims occur more frequently in plage and AR filaments than in quiescent filaments. This also suggests a height dependency for bright rims. In addition, the intensity and shape of bright rims are linked to the particular type of filament, i.e: quiescent filaments have weak and relatively broad, rather diffusive bright rims, while AR filaments in general have more sharply defined narrow bright rims.

Figures 1 and 2 show a filament observed at the SVST on 10 Sep 1998. As can be seen the two images, the visibility of the bright rim appears closely linked to the “feet” of the filament. Also, the intensity of the bright rim varies spatially (the central parts being brighter). When viewed as a movie, one notices relative motion between the bright rim and the associated filament barbs.

Figure 5 shows a velocity map of a segment of the filament observed on September 10, 1998. The black outline marks the location of the filament, the white the location of the bright rim. A tentative interpretation from this velocity map is that there is a noticeable variation in the line-of-sight velocity along the bright rim structure.
The line profiles shown in Figures 7 and 8 were computed from MSDP observations. Figure 6 shows the locations of the pixels for which the profiles have been computed. Figure 7 shows bright rim profiles, while Figure 8 shows plage profiles. The dashed profile is the corresponding quiet chromosphere reference profile. The line profiles of plages (1-4) are broad and systematically red-shifted. Line profiles A and B belong truly to a bright rim. Profile B is symmetric and narrow and differ from profiles 1-4 from the neighboring plage. One notices also that the bright rim profiles A, C and D have a “bump” in the central parts, indicating that multiple profiles make up the line profile.

More spectral data will be studied in order to establish whether or not bright rim are systematically different from plages.

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References


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