PHOTOSPHERIC AND CHROMOSPHERIC UMBRAL DOTS IN A DECAYING SUNSPOT*

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Abstract. Time-sequenced Hα filtergrams and narrow-band blue filtergrams (λ₀ = 4308 Å, ∆λ = 10 Å) of umbral dots in a decaying sunspot were studied. The results are: (a) Photospheric umbral dots have lifetimes of about 40 min. (b) Two types of proper motion were found for photospheric umbral dots. Umbral dots born in the umbra or in the light bridge show virtually no proper motion. On the other hand, umbral dots of penumbral origin move inward to the umbra with speeds of about 0.4 km s⁻¹. (c) Chromospheric umbral dots, which have dimensions of 0.6' x 1.2' in the mean, were more numerously found than photospheric umbral dots. (d) Photospheric umbral dots were observed to be associated with chromospheric umbral dots. Thus umbral dots are not phenomena confined to photospheric levels but also extend to chromospheric levels. (e) Some of the chromospheric umbral dots are unrelated to the photospheric umbral dots. They may be excited by the infalling matter from the umbral corona.

1. Introduction

Umbral dots have been studied intensively because they offer us clues to our understanding of the energy balance and the dynamic structure of sunspot atmospheres. Their characteristics were summarized by Moore (1981). However, basic data such as the direction and the magnitudes of their proper motions remain unknown. On the other hand, Zirin (1974) and Loughhead (1974) suggested the existence of chromospheric counterparts of photospheric umbral dots, but a systematic survey of chromospheric fine structure in umbrae has not been performed. The purpose of this work is to derive these basic characteristics of umbral dots from an observation with high-resolution filtergrams.

Hα line-center filtergrams and G-band filtergrams (λ₀ = 4308 Å) of an active region with two mature sunspots were taken in good seeing conditions at the Pic du Midi Observatory on June 4, 1980. Umbral dots were detected numerously in both filtergrams. Preliminary reduction of a long time series of filtergrams was performed and the following results were obtained on umbral dots. Firstly, two types of umbral dots were found. Dots of the first type are born in umbra regions or in light-bridge regions, and they show virtually no proper motion. On the other hand, dots of the second type originate in penumbral regions, and they move inward to umbra regions with speeds of about 0.4 km s⁻¹. Secondly, fine features (d ~ 1.5'') were identified more abundantly in chromospheric levels than in photospheric levels. Morphological characteristics of these chromospheric dots were derived, and it was confirmed that photospheric umbral dots have chromospheric umbral dots as their counterparts in the chromosphere. Also, an interesting correlation between lifetimes and proper motion speeds was found for

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chromospheric dots. The implications of these results will be discussed in the final section.

2. Observation

The observation was performed with the 50 cm refractor at Pic du Midi Observatory by G. Ceppatelli and R. Muller on June 4, 1980. An active region (HL No. 16873) with two mature sunspots was observed through a 0.5 Å bandpass Hα Lyot filter (tuned at line center) and through a 10 Å bandpass blue filter centered at 4308 Å (Figure 1). Features seen in 4308 Å filtergrams represent the structure in the upper photospheric levels (Kitai and Muller, 1984). Cine cameras were used to get filtergrams. Bursts of exposures were taken in good seeing conditions. By selecting the best images from each burst of exposures, we obtained time-sequenced filtergram images of the region, with a time-resolution of about 5 min. The total time span of the series was about 2 hr, from 7h08m UT to 9h06m UT. During a period of superb seeing conditions, from 7h47m to 7h59m, the time resolution attained 30 s.

As can be seen in Figure 1, the two spots have roundish shapes, surrounded by penumbrae and have regular superpenumbral structures. During the day of the observation, no conspicuous active phenomena were detected in this region. Also bright

Fig. 1(a-b). (a) 4308 Å filtergram taken at 07:57:10 UT. (b) Hα line-center filtergram taken at 07:50:30 UT. Umbral dots seen in the smaller sunspot were studied in this work.