THE LIFETIME AND EVOLUTION OF FIBRILS

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Abstract. A detailed study has been made of the lifetimes and evolution of fibrils in McMath 12417, using high resolution filtergrams in Hα and Ca II K made at Big Bear Solar Observatory. It was found that when viewed near disk centre, the lifetime of a fibril is a monotonically increasing function of its maximum apparent length. This relationship, together with the form of the variation of fibril lengths as a function of time, suggests that fibrils result from material being impulsively injected into magnetic field lines at approximately 30 km s⁻¹, and returning under gravity. The lifetimes and apparent lengths of fibrils are then a function of the inclination of the field lines only. A study of wavelength scans through the Hα line confirms that the apparent extension and retraction of fibrils represents true mass motion.

1. Introduction

One of the most prominent characteristics of an active region as viewed in a chromospheric spectral line such as Hα or Ca II K, is the appearance of numerous elongated features known as fibrils. These features are generally believed to follow magnetic field lines, and as a result, the fibril pattern is widely used to obtain information on magnetic field structure. However, despite the usefulness of the fibril pattern as a tool for the study of active regions, very little effort has been made to study the properties of the individual fibrils themselves. What little information exists is best summarized by Bray and Loughhead (1974). Briefly, it has been found that the lengths of fibrils depend on the longitudinal magnetic field strength (Smith, 1968), and their lifetimes vary with length, ranging from 1 min for the shortest, up to 20 mins for the longest (Foukal, 1971). Superpenumbral fibrils undergo gradual changes with time, an individual fibril being recognizable for typically 17 mins (Loughhead, 1968). Zirin (1974) showed that there exist both bright and dark fibrils, and both occur simultaneously, bright fibrils being more prominent in Ca II K, and dark fibrils being more prominent in Hα. The relationship between fibrils and other disk features has been discussed by Foukal (1971), who suggested that fibrils are simply the active-region analogues of spicules, the difference being merely one of field geometry.

The purpose of this paper is to present the results of a systematic study of the lifetimes, lengths, and evolution of fibrils in an active region, in the hope of obtaining a better understanding of their physical nature. Before beginning such a study, however, it is necessary to define what is meant by "lifetime". As an operating definition we will define the lifetime of a feature as the period during which its appearance (as characterized by shape and contrast) is recognizable by eye as belonging to the same entity. Such a definition is obviously subjective, but as will be seen later, this presents no great problem since most fibrils evolve in a
reasonably well defined way, such that during birth and death, their visibility changes markedly in a short time interval.

It is also necessary to consider what is meant by “length”, since the apparent length of a fibril depends critically on the contrast of the film and on the seeing conditions. For the purpose of defining apparent length, the “end” of the fibril was taken as the point beyond which it has insufficient contrast to be distinguishable (by eye) from its surroundings. It is natural to ask whether such a definition yields a physically meaningful length, since changes in overall intensity, for a tapered intensity distribution, would appear as changes in length when photographed on high contrast film such as the SO-392 film employed here. However, during the present study there did not seem to be any obvious correlation between variations in length and intensity for a given feature, and in fact it was not uncommon for a fibril to markedly fade without visibly changing length.

Although the seeing was variable (see Figure 2), this limitation was largely overcome by taking filtergrams closely spaced in time, and using the frames of best resolution (normally ~1 arcsec or better) for length measurements.

2. The Data

The data used in this study consists of a series of high resolution Hα and Ca II K filtergrams of the active region McMath 12417, made at 10 second intervals, using a pair of 10 inch refractors at Big Bear Solar Observatory during the period July 4-11, 1973. A Halle filter of 0.5 Å bandpass was used for on-band Hα, while a fully-tunable Zeiss filter of 0.25 Å bandpass was used off-band. A Halle filter of 0.3 Å bandpass was used for Ca II K (see Zirin, 1974).

The evolution of over 200 dark fibrils was followed individually in Hα line centre, and also 26 bright fibrils in Ca II K. Wavelength scans through the Hα line were used to derive velocity information. Figure 1 shows the region as it appeared in Hα on July 5, together with a definition of the various subregions used to group the fibrils for later discussion.

3. Results

3.1. Qualitative Description of Evolution

In order to put the quantitative results of this investigation into perspective, a brief qualitative description of the evolution of fibrils will first be given.

A. General Remarks

Fibrils evolve in a number of ways, for example extension and retraction, merging, and fading. Most dark fibrils in Hα co-evolve with a parallel bright strand, which often undergoes conspicuous increases in intensity. A typical example of fibril evolution is shown in Figure 2. Many fibrils are double, a fact noted by Tanaka (1972). In some cases a pair of fibrils (from the same plage)