ON THE NATURE OF PLASMA ARCS IN SOLAR ACTIVE REGIONS

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Abstract. A mechanism is proposed explaining the structures consisting of plasma arcs, as observed in X-ray photographs of solar active regions. It is suggested that the width of the arcs corresponds to the cut-off wavelength of a Rayleigh-Taylor instability which develops due to a difference in density between the plasma in the arcs and the plasma in the surrounding region. The transverse component of the magnetic field necessary to stabilize the instability at a wavelength corresponding to the width of the arcs is estimated to be of the order of 0.1 G.

1. Introduction

Recent X-ray photographs of the Sun taken by the American Science and Engineering team of Davis et al. (1974) reveal a strikingly regular feature characteristic of some of the active regions. These regions, as seen in the photograph (Figure 1), display a structure consisting of a sequence of adjacent arcs. Remarkably, these arcs have a characteristic 'width', common to all of them. In the schematic representation of Figure 2 this width is denoted by $\Delta$. The purpose of the present paper is to offer a possible explanation for this aspect of the magnetic field structure.

The fact that $\Delta$ is about the same in all arcs observed seems to indicate that there must exist a global, rather than local, mechanism responsible for that particular feature of the magnetic field structure. One obvious candidate for such mechanism is the field structure at the feet of the arcs. It is believed that the magnetic lines of force emerge from the photosphere in the form of bundles, the size and mutual separation of which are determined by the geometry of the supergranulation cells (see, e.g., Tandberg-Hanssen, 1967). We do not believe that blaming supergranulations for the structure of what is observed as essentially coronal features can be justified even qualitatively. Figure 3 taken from Tandberg-Hanssen (1967) illustrates the expected behavior of the magnetic field emerging from supergranulations. It is evident that at the coronal level it is hard to expect any structure reflecting supergranulations. This qualitative argument can be easily supported by quantitative estimates indicating that if the spacing between the field-producing elements of the supergranulation network is much smaller than the height at which the field is observed, the variations in the field intensity at that height, due to the discontinuous nature of the field sources, are negligible.

Looking for other mechanisms we observe that plasma instabilities usually exhibit the property of having a cut-off wavelength. What this means is that certain plasma configurations remain stable against perturbations with a characteristic length less
Fig. 1. X-ray photograph of the Sun taken by AS & E scientists on 8 March 1973, 1802 UT; exposure: 20.3 s; Nominal passband (1% level) 8-37, 44-60 Å (Davis et al., 1973). Active regions display arc structures.