STUDY OF THE FRAGMENTATION OF SOLAR ACTIVE REGIONS

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Abstract. Parameters of compactness and asymmetry are defined to study the differences in the dismemberment of the leading and following parts of sunspot groups. The asymmetry may have implications on the interactions of magnetic and velocity fields.

Key words: active regions – fragmentation

1. Introduction

As is widely accepted, sunspot groups usually have remarkable asymmetry properties which may contain information about the large-scale morphology of the emerged toroidal flux and, probably also about the causes of the flux emergence, on the other hand, they may reflect some features of the interaction between this flux and the ambient velocity fields. Most studies, observational and theoretical, analyze the differences of the magnetic field line tilts to the perpendicular direction in the leading vs. following parts of the groups as well as their observable consequences (e.g. Caligari et al., 1995; Moreno-Insertis et al., 1994; Petrovay et al., 1990; Schüssler and Wöhl, 1997; Van Driel-Gesztelyi and Petrovay, 1990). As a result it is commonly accepted that the field lines are steeper in the following part than in the leading one.

2. Sunspot fragmentation (F) and asymmetry (A) parameters

The target of the present report is a different feature of the active regions which may also have a certain asymmetry of similar significance. We consider the dispersion of both parts of the sunspot groups, in other words, we want to determine the extent to which the emerged flux is either concentrated into big spots close together or it is spread into a cluster of remote small spots. We describe this feature through a suitably chosen parameter which shows whether the cluster of field ropes is compact or diffuse. This fragmentation parameter F is defined for both (leading and following) parts separately and looks as follows:

$$F = \sum_{i=1}^{n} \frac{|\boldsymbol{r}_i - \boldsymbol{r}_o|}{a_i} \tag{1}$$

Where, n is the total number of spots within the considered part of the region, $\boldsymbol{r}_i$ -s and a_i -s are the positions and areas of the spots respectively and $\boldsymbol{r}_o$ is the point of weight of the spots in the given part of the group:

$$\boldsymbol{r}_o = \frac{\sum_{i=1}^{n} \boldsymbol{r}_i a_i}{\sum_{i=1}^{n} a_i} \tag{2}$$

The value of the parameter F is large if the members of the active region are numerous, dispersed and small. F is small if the relevant part is large and compact. By computing the F_l and F_f values for the leading a following parts the asymmetry of the active region can be described by using the formula:

$$A = \frac{F_f - F_l}{F_f + F_l} \tag{3}$$

The above formulas can obviously be used only for $n \geq 1$ cases. At the present state we can only provide some preliminary data, more detailed results will be published elsewhere. The observational data are taken from the catalogue "Debrecen Photoheliographic Data for the year 1987" and a historical Hungarian solar observational material made in the year 1906 at the Kalocsa Observatory. We select sunspot groups in which the bipolar character is unambiguous and the leading and following parts are separable even without magnetograms. Figure 1 shows examples from both materials along with their data and asymmetry parameters.

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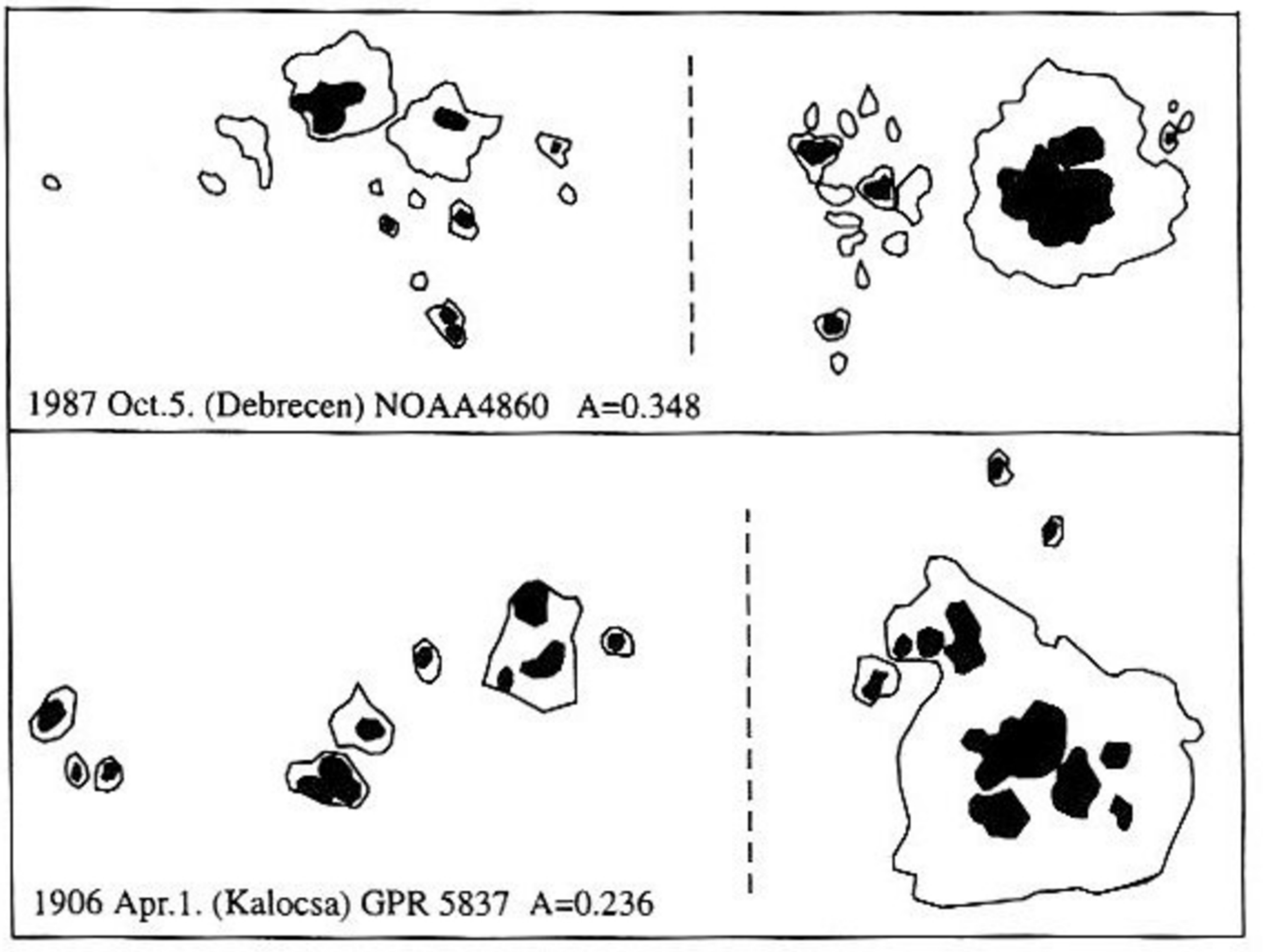

Figure 1. Contours of two sunspot groups along with their dates and sites of observation, sunspot group numbers and asymmetry parameters (A). The dashed lines are arbitrary marks of separation, they do not indicate the locations of the neutral lines.

3. Results

• The preliminary results show that the leading parts tend to be more compact than the following ones. This is actually no surprise, it is widely accepted as a qualitative statement (Fan et al., 1997), but in the present and subsequent works we want to formulate it more quantitatively. It appears that the A asymmetry parameter may have significant fluctuations in the process of development and decay but the most developed state of a regular bipolar group has a definitely positive value, somewhere about $A = 0.2 - 0.5$.
• This specific definition of the dispersion is tailored to the properties of the photoheliographic catalogue containing sunspot positions and areas, but obviously it can also be defined for different phenomena, such as flux density distribution in magnetograms, etc..
• A preliminary and qualitative interpretation of this feature can be given by considering the roles of magnetic and velocity fields. Two possible alternative approaches might assume that this asymmetry would be either the cause or the result of the flux emergence. We think that the former version appears to be more likely, i.e. the cause of the emergence might be the compactness of the flux rope cluster because the buoyancy may be more effective on a concentrated body than on a diffuse cluster.

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