Recurrent sunspot groups and the visibility function

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Received: October 5, 1990

Abstract. The definition is given of recurrent and potentially recurrent sunspot groups, and the principle of constructing OC-diagrams (diagrams of observational conditions of sunspot groups) for potentially recurrent group is described. The conditions are derived under which sunspot groups can be observed as recurrent groups. The frequency distribution of sunspot groups with an actual lifetime of 20 to 40 days is determined by means of OC-diatrams in terms of their observed lifetimes.

The non-existence of recurrent sunspot groups with lifetimes of 15 to 25 days, found earlier, is explained as apparent using OC-diagrams. These groups are not observed as a result of the existence of the visibility function.

Key words: sunspots

1. Introduction

In the series of papers on the visibility function, published in the Bull. Astron. Inst. Czechosl., we considered only sunspot groups with relatively short lifetimes, which are observed only during a single solar rotation, i.e. non-recurrent groups. And even if the group could have been recurrent, we only considered to exist during that single rotation. For example, sunspot groups with actual lifetime T = 20 days, appearing for the first time in the vicinity of the western limb of the solar disk, could be observed at the eastern limb at the end of their lifetime, i.e. they could be recurrent groups. However, in Papers 7 and 10 (Kopecký and Kopecká 1989, 1990b) we did not consider these groups with $T = 20$ days to be recurrent.

Consequently, in this paper we shall devote our attention to recurrent groups for which OC-diagrams have to be constructed in a slightly different and more complicated way than previously (see Paper 1, Kopecký et al., 1985). In the case of the recurrent groups the frequency distribtuion of sunspot groups $\tilde{F}(\tilde{T})$ in terms of their observed lifetimes $\tilde{T}$ then has a character quite different from

Contrib. Astron. Obs. Skalnaté Pleso **22**, (1992), 173– 186.

that obtained for the non-recurrent groups in Paper 7. Simultaneously, we shall be dealing, with regard to the effect of the visibility function $\phi(\lambda)$ and thus also of the OC-diagrams, with the conditions under which the groups could be observed as recurrent, and with some other related questions, namely the question of non-existence of recurrent groups with particular lifetimes.

In this paper it is also necessary to bear in mind that the graphical method of constructing OC-diagrams and their processing may also lead to certain inaccuracies in the numerical results.

2. Recurrent and potentially recurrent sunspot groups

By "recurrent sunspot group" one understands a group which is observed at least during two consecutive rotations of the Sun.

In this study we shall have to define the term "potentially recurrent group". By "potentially recurrent group" we shall understand a sunspot group which, given its actual lifetime T and curve of area development $S(T, S_M, \tau)$, S_M being the group's maximum area nad τ its age, may be observed during at least two consecutive rotations of the Sun, but need not be observed during at least two consecutive rotations of the Sun in all cases. Whether this potentially recurrent group is or is not observed during two consecutive rotations of the Sun, i.e. whether it is or is not a recurrent group, depends on the place of its actual origin, besides on T and $S(T, S_M, \tau)$, i.e. on the angular distance λ_1 from the CM (central meridian) of its actual place of origin.

3. OC-diagrams for potentially recurrent sunspot groups

The basic system of axes of OC-diagrams is retained in constructing OC-diagrams for potentially recurrent sunspot groups. This means that the angular distance λ_1 from the CM to the place of the actual group's origin is plotted on the horizontal axis, and the angular distance λ_3 from the CM to the place where the group can be observed for the first time, and the angular distance λ_4 from the CM to the place where the group can be observed last are plotted on the vertical axis. A more detailed description of the construction of OC-diagrams for non.recurrent groups and its use can be found in Papers 1 and 7.

We shall now, for the time being, restrict ourselves to the potentially recurrent groups which can be observed during two consecutive rotations of the Sun at the most.

With these groups we must consider a total of 3 consecutive rotations of the Sun, because some of these groups can first be observed during the first of the

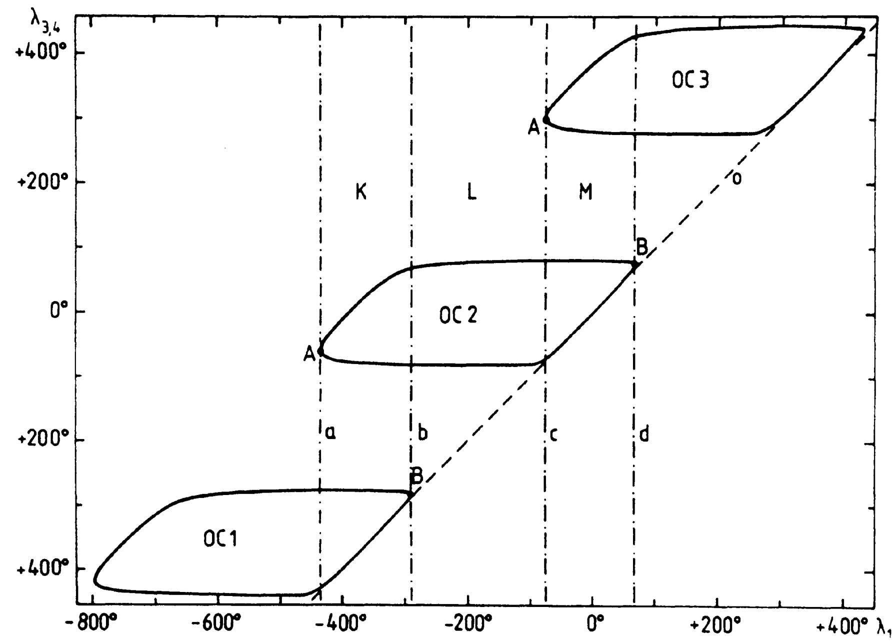

Figure 1. The principle of OC-diagrams for potentially recurrent sunspot groups. In regions K and M these groups are recurrent, in region L non-recurrent. Details in text

three rotations being considered, and last in the subsequent second rotation; other groups can first be observed only during the second rotation and last in the subsequent third rotation. Understandably, these groups will also include groups which can only be observed during a single solar rotation, regardless of whether during the first, second, or third.

Let us then consider the potentially recurrent groups which can be observed during two consecutive rotations of the Sun, which display the same shape of the development curve of their actual area $S(T, S_M, \tau)$, and there fore also the same actual lifetime T. We shall construct the basic shape of the OC-diagram for these groups using the method described in Paper 1.

In this particular case we must take into account the 3 consecutive solar rotations mentioned above, for each of which we shall get the appropriate OC-diagram. These OC-diagrams have the same shape and are mutually shifted by 360^o along the λ_1 - as well as the $\lambda_{3,4}$ - axis; we shall designate them OC1, OC2 and OC3. For type $A^T_{S_M}$ (see Paper 7) of area development $S(T, S_M, \tau)$, $T =$ 30 days and $S_M = 300$ MSH (millionth of the solar hemisphere area) the OC1, OC2 and OC3 diagrams are shown in Fig. 1, where line o, running at an angle of 45^o, connects the places of actual origin of the groups in our diagram.

Figure 1 shows that these OC-diagrams overlap along the λ_1-axis, i.e. within a certain interval of λ_1-values there are the OC1 as well as OC2, and OC2 as well as the OC3 diagrams. The vertical (dot-dashed) lines a, b, c and d, tangent at points A and B to the OC-diagrams, bound these overlapping regions, and divided our whole diagram and namely the OC2 diagram which we shall consider as fundamental, into three regions which we shall designate K, L and M. Regions K and M are regions in which the potentially recurrent groups we are considering are observed during two consecutive rotations, and they are thus referred to as recurrent. In region K we observe the groups which we have already observed during the preceding rotation, i.e. which have already passed through the OC1 diagram; in region M we observe the groups for the first time, however, these group can then also be observed in the subsequent rotation, i.e. they will also pass through the OC3 diagram. Groups which can only be observed during this rotation of the Sun are in region L of the OC2 diagram, and will therefore not be referred to as recurrent. With increasing actual lifetime T regions K and M increase to the detriment of region L.

The OC-diagrams constructed in this manner apply if the sunspot groups are being observed continually. However, if the groups are only being observed once every 24 hours, we have to construct the internal structure of these OC-diagrams which will enable us to determine the frequency distribution of the groups with respect to their observed lifetime, the number groups which have newly appeared at various distances from the CM, etc.

The method of constructing the internal structure of the OC-diagram if observations are being made once every 24 hours is described in Paper 1. However, it only applies to short-lived non-recurrent sunspot groups. The internal structure of the OC-diagrams will differ slightly for potentially non-recurrent groups.

We shall only consider the OC2 and OC3 diagrams and only regions L and M (Fig. 1). Region K in the OC2 diagram has a structure identical with region M in the OC3 diagram, and the groups in it have not been observed in the OC2 diagram for the first time, but already existed in the OC1 diagram.

The internal structure in region L of the OC2 diagram, where no recurrent groups occur, will be constructed in the manner described in Paper 1, i.e. we shall move the bottom boundary of the OC-diagram $\lambda_3(\lambda_1)$ by the angular velocity of the Sun's rotation ω upwards, and the top boundary $\lambda_4(\lambda_1)$ upwards by ω (Fig. 2). The interpretation of the areas thus created is the same as in the cases described in Papers 1 and 7, i.e. the area is proportional to the number of sunspot groups which exist (or have been observed) in them, and the numbers inscribed in them in Fig. 2 give the number of days for which the groups located in them can be observed in the course of their passage across the solar disk, in other words they give the observed lifetime $\tilde{T}$ of these groups.

In region M of the OC2 and OC3 diagrams the construction of their internal structure can be slightly simplified, provided we are only interested in determining how many groups in this region have a particular observed lifetime $\tilde{T}$. By the observed lifetime $\tilde{T}$ of these recurrent groups we understand the num-

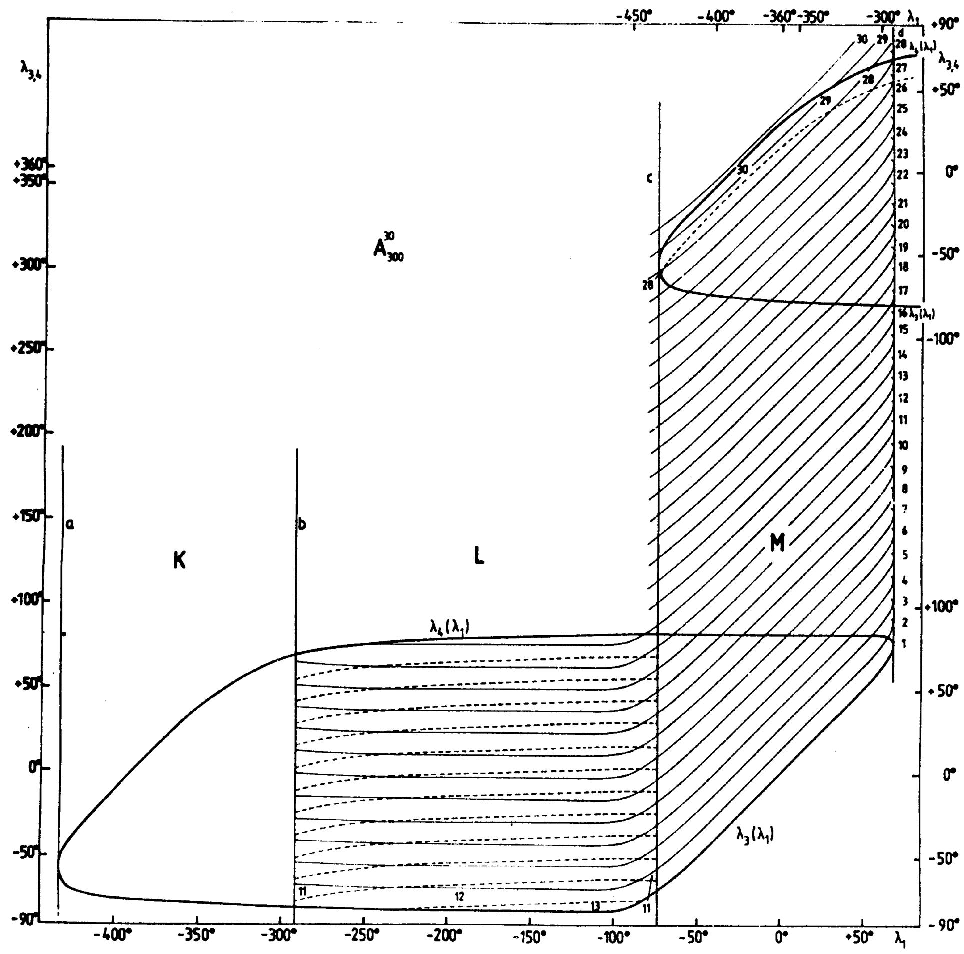

Figure 2. Construction of OC-diagrams for potentially recurrent groups with lifetime $T = 30$ days and maximum area $S_M = 300$ MSH if observed once every 24 hours. Details in text

ber of days since they were first observed in the OC2 diagram to the last time they were observed in the OC3 diagram. In this case we shall move the botom boundary $\lambda_3(\lambda_1)$ of the OC2 diagram in its region M upwards by ω into the whole M-region of the OC3 diagram. The shifted curves $\lambda_3(\lambda_1)$ thus form belts which determine the number of days we could have observed the group from the time it was observed first (number inscribed to the right of these belts in Fig. 2). At the same time, we shall move boundary $\lambda_4(\lambda_1)$ of the OC3 diagram downwards by one ω, which yields the belt bounding the region of the OC3 diagram in which we are able to observed the recurrent groups for the last time.

This belt is divided by curves $\lambda_3(\lambda_1)$ of the OC2 diagram into areas in which we are able to observed the recurrent groups with a particular observed lifetime $\tilde{T}$, inscribed in these areas in Fig. 2, for the last time. The areas are, of course, again proportional to the number of groups with this particular observed lifetime. Note that the question of proportionality of the areas in the OC-diagtrams and of the number of groups they contain is dealt with in Paper 8 of this series (Kopecký 1989).

4. Some relations which apply to potentially recurrent sunspot groups

We shall adopt the coordinate system of the OC2 diagram whose coordinate origin, $\lambda_1 = 0$ and $\lambda_{3,4} = 0$, lies on line o in the OC2 diagram (Fig. 1).

Lines a and d are tangents to the OC2 diagram at points A and B (Fig. 1). These points are defined and their coordinates determined in Paper 8. As in Paper 8 we shall designate their coordinates along the horizontal λ_1-axis $\lambda_{1,A}$ and $\lambda_{1,B}$.

The reader should bear in mind that all three OC-diagrams, OC1, OC2 and OC3, are identical in shape, and that they are shifted by angle 2π in the direction of the λ_1-axis and $\lambda_{3,4}$-axis with respect to one another. As indicated by Fig. 1, the quations of lines a, b, c and d then read, respectively

$$\lambda_1 = \lambda_{1,A} \tag{1}$$

$$\lambda_1 = \lambda_{1,B} - 2\pi \tag{2}$$

$$\lambda_1 = \lambda_{1,A} + 2\pi \tag{3}$$

$$\lambda_1 = \lambda_{1,B} \tag{4}$$

For the given type of sunspot group, i.e. a group with a given area development curve $S(T, S_M, \tau)$, to be potentially recurrent, line a must be to the left of line b, and line c to the left of line d (Fig. 1) in the OC1, OC2 and OC3 diagrams for this type of group. In other words, if the given group is to be potentially recurrent, the extreme points A and B of its OC-diagram must satisfy, in view of Eqs (1) - (4), the condition

$$\lambda_{1,B} - \lambda_{1,A} > 2\pi \tag{5}$$

and/or

$$\lambda_{1,A} < \lambda_{1,B} - 2\pi \tag{6}$$

As alredy mentioned, region L in the diagram in Fig. 1 narrows until it vanishes altogether when lines b and c merge as T increases. Then

$$\lambda_{1,B} - \lambda_{1,A} = 4\pi \quad (7)$$

In this case all groups appropriate to this OC-diagram are recurrent, and none of them can be observed during just one rotation.

If

$$\lambda_{1,B} - \lambda_{1,A} > 4\pi \quad (8)$$

line b is to the right of line c, and the region between them will be designated L'. Similarly, the region between lines a and c will be designted K', and that between lines b and d will be designted M'. In this case none of the groups appropriate to this OC-diagram can be observed in just one rotation either, and all these groups are recurrent. Moreover, groups which can be observed during two consecutive rotations are located in regions K' and M', and groups which can be observed in 3 consecutive rotations are located in region L'.

We can now also determine what part of the groups considered are observed during one, two or three consecutive rotations of the Sun.

Consider set $f(T)$ of potentially recurrent groups whose OC-diagram satisfies condition (5), but not condition (8). All groups belonging to set $f(T)$ will pass through the OC2-diagram. $f(T)_N$ of these $f(T)$ groups are then non-recurrent, and $f(T)_{2R}$ groups are recurrent and can be observed during 2 rotations; hence,

$$f(T) = f(T)_N + f(T)_{2R} \quad (9)$$

Assume that Δf sunspot groups originate per unit heliographic longitude λ_1 and unit time. Then

$$f(T) = \Delta f(\lambda_{1,B} - \lambda_{1,A}) \quad (10)$$

In view of Eqs (1) to (4) and Fig. 1, we then get

$$f(T)_N = \Delta f(\lambda_{1,A} - \lambda_{1,B} + 4\pi) \quad (11)$$

$$f(T)_{2R} = 2\Delta f(\lambda_{1,B} - \lambda_{1,A} - 2\pi) \quad (12)$$

If set $f(T)$ of sunspot groups creates the OC-diagram which satisfies condition (8),

$$f(T) = f(T)_{2R} + f(T)_{3R} \quad (13)$$

where $f(T)_{3R}$ is the number of groups which can be observed during 3 rotations. Hence,

$$f(T)_{2R} = 4\Delta f\pi \quad (14)$$

$$f(T)_{3R} = \Delta f(\lambda_{1,B} - \lambda_{1,A} - 4\pi) \tag{15}$$

Equations (14) and (15) imply that the number of groups $f(T)_{2R}$, observed during 2 rotations, does not change in set $f(T)$ of groups whose OC-diagrams satisfies condition (8), with increasing T, but remains constant. Only the number of groups $f(T)_{3R}$, observed during 3 rotations changes.

If

$$\lambda_{1,B} - \lambda_{1,A} > 6\pi \tag{16}$$

the sunspot groups whose OC-diagram satisfies condition (16), can also be observed during 4 consecutive rotations. The corresponding $f(T)_{4R}$ can be determined analogously to the preceding cases. And so on.

5. Frequency distribution $\tilde{F}(\tilde{T})$ of potentially recurrent groups with respect to observed lifetimes

In Paper 7 we dealt in detail with the frequency distribution $\tilde{F}(\tilde{T})$ of sunspot groups with respect to their observed lifetimes $\tilde{T}$, in particular with groups which display area development curve $S(T, S_M, \tau)$ of group types $A^T_{S_M}$ and $B^T_{S_M}$ (see Paper 7). Using OC-diagrams the frequency distribution $\tilde{F}(\tilde{T})$ was determined for all 16 combinations $T = 5$, 10, 15, 20 days, and $S_M = 50$, 100, 150 and 200 MSH. In constructing the appropriate OC-diagrams it was assumed that the visibility curve $S_o\phi(\lambda)(S_o$ is the minimum group area observed in the centre of the solar disk expressed in MSH, $\phi(\lambda)$ is the visibility function) has the form

$$S_o\phi(\lambda) = 5\sec^2\lambda \tag{17}$$

As already mentioned in the introduction, groups with $T = 20$ days were not considered to be potentially recurrent in Paper 7, and their $\tilde{F}(\tilde{T})$ was determined as if they could only be observed during a single rotation. It should also be pointed out that sunspot groups with $T = 15$ days would be potentially recurent if the visibility function did not exist, and the groups could thus be observed all the time until they reached the solar limb. However, in view of the existence of the visibility curve $S_o\phi(\lambda)$, defined by Eq. (17), sunspot groups with $T = 15$ days are not potentially recurrent, as indicated by their OC-diagram which does not satisfy condition (5) and as mentioned in Paper 9 (Kopecký and Kopecká 1990a).

In this study we have restricted ourselves to constructing OC-diagrams and to their interpretation only as regards sunspot groups whose area development $S(T, S_M, \tau)$ is of type $A^T_{S_M}$, actual lifetimes $T = 20$, 25, 30, 35 and 40 days, and whose maximum areas S_M are given, according to Gnevyshev (1938), by the relation

$$S_M = 10T. \tag{18}$$

We shall thus investigate sunspot groups with area development curves of the type

$$A^T_{S_M} = A^T_{10T} \tag{19}$$

assuming that the groups are being observed once every 24 hours. These sunspot groups with $T = 20$ to 40 days are potentially recurrent, and some of them can be observed as recurrent during two consecutive rotations.

The frequency distribution $\tilde{F}(\tilde{T})$ of these groups with respect to their observed lifetimes, expressed in terms of their percentage frequency, was determined using the method described in detail in Paper 7, however, with the following difference:

In Paper 7 we considered either non-recurrent groups or groups with $T =$ 20 days which could be potentially recurrent, as if they are non-recurrent. In this case we assumed all new groups on the solar disk to constitute 100 %, i.e. all groups which passed through the given OC-diagram. However, in the case of potentially recurrent groups, the 100 % will be made up of the groups who appeared as new for the first time during the given solar rotation, i.e. those which were not observed during the previous rotation. This means that, in determining $\tilde{F}(\tilde{T})$ for the potentially recurrent groups, we shall only be working with the OC2 and OC3 diagrams, and only with groups occurring in regions L and M of these OC-diagrams (Fig. 1). As already mentioned, $\tilde{F}(\tilde{T})$ in regions L and M will then be determined using the method described in Paper 7, based on the OC-diagrams constructed and analyzed as in Fig. 2.

The result of determining these frequency distributions $\tilde{F}(\tilde{T})$ of the potentially recurrent groups with respect to their observed lifetimes $\tilde{T}$ is shown in Fig. 3 in the form of a histogram (black areas). For comparison Fig. 3 also shows the frequency distribution $\tilde{F}(\tilde{T})$ of the same potentially recurrent groups in the form of histograms with hatched areas if their recurrence is disregarded, i.e. as if we assumed that all groups appropriate to a given OC-diagram existed only during a single solar rotation.

Figure 3 indicates that, with increasing actual lifetime T of the sunspot groups, also the absolute and relative number of recurrent groups with observed lifetimes $\tilde{T} \leq T$ increases. The number $N(R)_{\%}$ of recurrent groups expressed in percentage of the total number of potentially recurrent groups with the given actual lifetime T, is shown in the r.h. part of Fig. 3. One can see that $N(R)_{\%}$ increases with T approximately linearly.

However, what is more important is that these potentially recurrent groups are not observed simultaneously as apparent short-lived groups, i.e. as apparently one-day, apparently two-day to apparently several-day groups. For example,

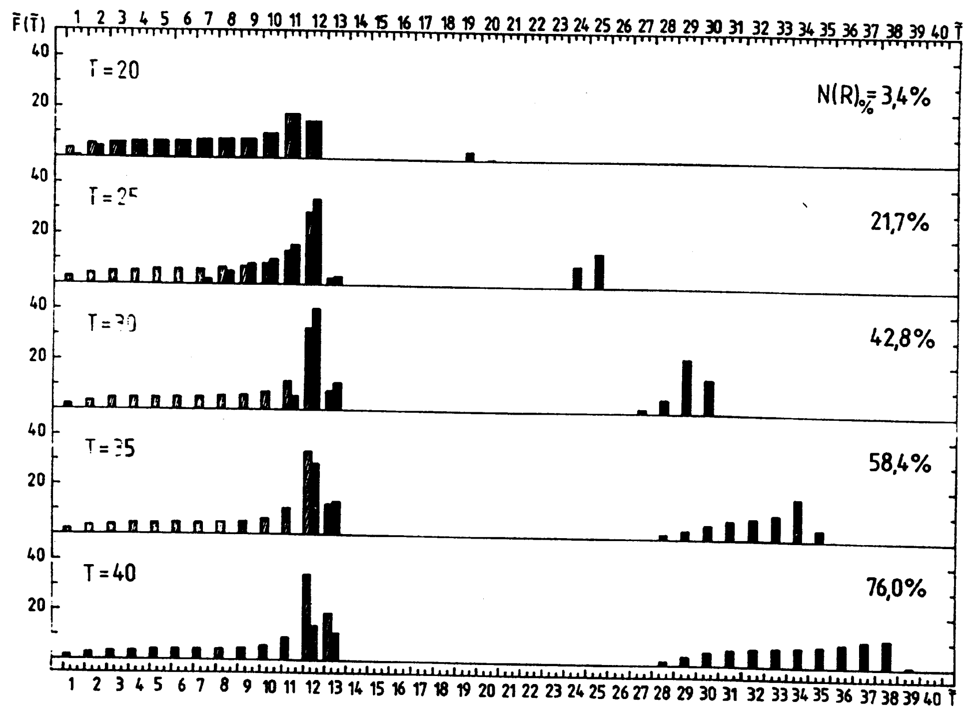

Figure 3. Frequency distribution $\tilde{F}(\tilde{T})$ of potentially recurrent groups in % with respect to their observed lifetime $\tilde{T}$: black areas if their recurrence is considered, hatched areas if the groups are considered as non-recurrent. The r.h. of the histograms gives the number $N(R)_{\%}$ of recurrent groups in % of the total number of potentially recurrent groups with the given actual lifetime T

with potential recurrent groups, $T = 35$ and 40 days, we do not observe groups with apparent lifetimes of $\tilde{T} = 1$ to 11 days. This is caused by these groups, which we would label as short-lived if recurrence were not considered, actually being recurrent; they are thus included in the set of groups with very long observed lifetimes $\tilde{T} > \pi/\omega$.

6. Non-existing recurrent sunspot groups

In a previous paper (Kopecký and Kuklin 1981) we pointed out that the sunspot group catalogues in "Greenwich Photoheliographic Results" of 1945-1951 practically recorded no recurrent sunspot groups with lifetime $T = 15$ - 25 days (nor with $T = 45$ - 55 days, etc.). This involves recurrent groups which would originate west of the CM and become extinct during the subsequent rotation of the

Sun east of the CM. Similar results were obtained in the referenced paper also from the Pulkovo sunspot catalogues. In this paper we also discussed some of the possible explanations of the non-existence of these recurrent sunspot groups, however, with but little success. We were unable to find the real cause of thé non-existence of recurrent sunspot groups with lifetimes T = 15 - 25 days and T = 45 - 55 days.

We earmarked the effect of the visibility function as the most probable cause of the non-existence of these groups. The deliberations and discussions of the problem non-existence of recurrent groups with particular lifetimes finally led us in this earlier study to the conclusion that "the effect of the visibility function had been underestimated" and that "the effect of the visibility function could be significant also for long-lived sunspot groups". These conclusions thus prompted this series of papers on the visibility function.

That is why we want to go back, at least briefly, to the problems of non-existence of recurrent groups with lifetimes T = 15 - 25 days in this paper with regard to the impact the visibility function can have on this problem, using the OC-diagrams we have constructed.

As shown in Section 4 of this paper, for a group with a given area development curve $S(T, S_M, \tau)$ to be potentially recurrent, its OC-diagrams must satisfy condition (5). That is why we constructed the graph in Fig. 4 which shows the dependence of difference $(\lambda_{1,B} - \lambda_{1,A})$ on the actual lifetime T. The dashed horizontal line represents the value $(\lambda_{1,B} - \lambda_{1,A}) = 2\pi$. Based on the OC-diagrams for the visibility function defined by Eq. (17), Fig. 4 shows $(\lambda_{1,B} - \lambda_{1,A})$ as a function of T for the following sequences of types of area development curves $S(T, S_M, \tau)$ of sunspot groups: black circles represent the dependence for type A^T_{10T}, white circles for type A^T_{50}, and crosses for type A^T_{200}. The dot-dashed line represents the dependence

$$\lambda_{1,B} - \lambda_{1,A} = \pi + \omega T \tag{20}$$

which applies to OC-diagrams of the O^T-type (see Paper 9), i.e. if the visibility function does not exist.

Figure 4 indicates that $(\lambda_{1,B} - \lambda_{1,A})$ as a function of T for area development curves of types A^T_{10T} and A^T_{200} intersect line $(\lambda_{1,B} - \lambda_{1,A}) = 2\pi$ roughly at $T \leq 19$ days. This then means that groups with area developments of the A^T_{10T} and A^T_{200} type may only become potentially recurrent if their actual lifetimes $T > 19$ days, and cannot be observed as recurrent if their actual lifetime $T \leq 19$ days.

Figure 4 also indicates that groups with area development curves of the A^T_{50}-type must in fact display actual lifetimes $T > 23$ days to become potentially recurrent, and if their $T \leq 23$ days, they cannot be observed in two consecutive rotations like recurrent groups.

Table 1 gives us an idea of the extent to which a group can be observed as recurrent depends on the shape of the area development curve $S(T, S_M, \tau)$. It

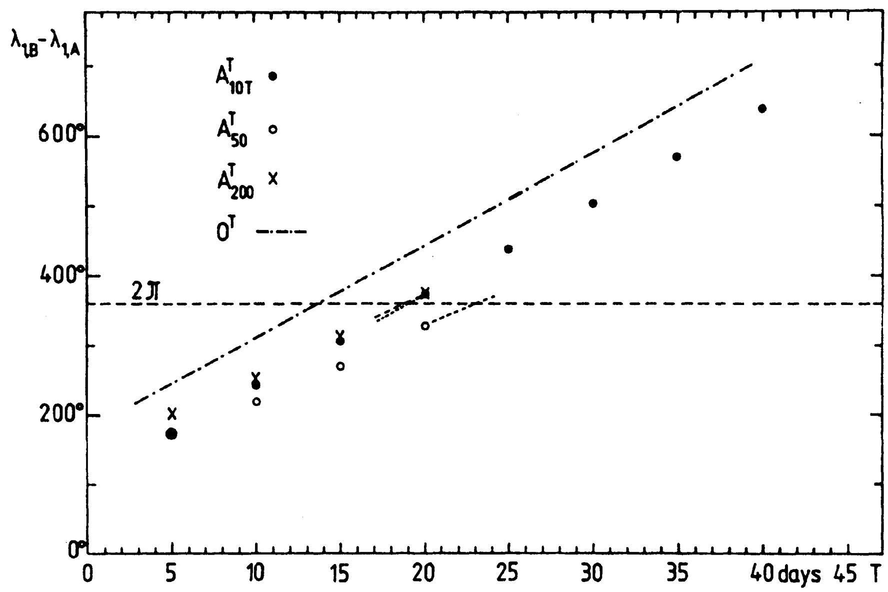

Figure 4. Width of the OC-diagram $(\lambda_{1,B}-\lambda_{1,A})$ along the λ_1-axis as a function of the actual lifetime T of the group for various types of area development curves $S(T, S_M, \tau)$ of sunspot groups. The point of interesection of this curve with line $(\lambda_{1,B}-\lambda_{1,A}) = 2\pi$ determeines the value of the actual lifetime T from which the given type of sunspot group can be observed as recurrent

gives the values of $(\lambda_{1,B} - \lambda_{1,A})$ as obtained from the OC-diagrams in Paper 7 for area development curves of the $A^T_{S_M}$ and $B^T_{S_M}$ types for $T = 20$ days. In view of Eq. (5), Tab. 1 implies that sunspot groups with actual lifetime $T = 20$ days cannot be observed as recurrent, if their area development curves are of the A^{20}_{50}, A^{20}_{100} and B^{20}_{50} type.

In other words, if a group is potentially recurrent or not depends on its actual lifetime T, as well as on its maximum area S_M and overall shape of its area development curve $S(T, S_M, \tau)$.

From what has been said above it follows that sunspot groups with actual lifetimes $T < 20$ days cannot be observed as recurrent, and that groups with actual lifetimes $T = 20$ to 25 days only in a relatively small number of cases.

Let us now consider a group with an area development curve of the A^T_{10T}-type, whose actual lifetime $T = 20$ days. As proved in Paper 10 and in the preceding section, and as indicated in Figs 3 and 4, this group is potentially recurrent. However, this group can only be observed as recurrent in 3.4 % of the cases (Fig. 3), moreover as a group with observed lifetime $\tilde{T} = 19$ days in 3.3 % and with $\tilde{T} = 20$ days in 0.1 % of the cases. Groups with $\tilde{T} = 19$ days are

$A^T_{S_M}$	$\lambda_{1,B} - \lambda_{1,A}$	$B^T_{S_M}$	$\lambda_{1,B} - \lambda_{1,A}$
A^{20}_{50}	327^o	B^{20}_{50}	345^o
A^{20}_{100}	354^o	B^{20}_{100}	370^o
A^{20}_{150}	365^o	B^{20}_{150}	380^o
A^{20}_{200}	374^o	B^{20}_{200}	388^o

Table 1. Width $(\lambda_{1,B} - \lambda_{1,A})$ of the OC-diagrams along the λ_1-axis for groups with type $A^T_{S_M}$ and $B^T_{S_M}$-type area development curves, with actual lifetime $T = 20$ days, and with various maximum areas S_M expressed in MSH.

observed in roughly 1/3 of the cases on two consecutive days at the western limb of the solar disk at angular distances λ from the CM of 58^o to 80^o (as can be determined from the appropriate OC-diagram), and once during the subsequent rotation at the eastern limb at $\lambda = -63^o$ to $\lambda = -54^o$; in approximately 2/3 of the cases these groups with $\tilde{T} = 19$ days are observed for the first time only once at the western limb between $\lambda = 66^o$ and $\lambda = 80^o$, and during the subsequent rotation on two consecutive days at the eastern limb between $\lambda = -69^o$ and $\lambda = -41^o$. Groups with $T = 20$ days can be observed a total of 5 times, on two consecutive days during the first rotation at the western limb, and on three consecutive days during the subsequent rotation at the eastern limb, roughly at the same angular distances λ from the CM as the groups with $T = 19$ days. One should also realize that these groups are observed at the western limb of the solar disk in an early stage of their development, and at the eastern limb of the solar disk before their extinction; in both cases as groups with a relatively small area.

Considering all that has been said above regarding the groups with $T = 20$ days and $\tilde{T} = 19$ and 20 days, we can draw the following conclusions:

It is not very probable that the observer or the person who has processed the photographs of the solar photosphere will identify the smaller groups, lifetimes 1 - 2 days, at the western solar disk limb with the small group of sunspots, lifetime 1 - 3 days, which will appear after 16 and 17 days at the eastern limb, and that he will consider these two minor, apparently short-lived groups to be identical, i.e. to be a recurrent group. An analogous conclusion can also be drawn with regard to the groups with lifetimes of 21 to 25 days.

However, that even these recurrent groups can be discovered if the observations are processed carefully, can be seen from the "Debrecen Photoheliographic Results for the year 1977" (Dezsö et al. 1987) in which the "catalogue of recurrent series of sunspots" gives 2 recurrent groups with lifetime of 23 days and 1 group with lifetimes of 21 and 25 days under Rec. Ser. No. 2, 5, 10 and 12. We have thus arrived at the final conclusion that sunspot groups with actual lifetimes of 15 to 25 days can either not be observed as recurrent at all, or only exceptionally when their identification as recurrent groups requires careful processing of the observation data. This also proves that the hypothesis presented in an earlier paper by Kopecký and Kuklin (1982) that the non-existence of recurrent groups with lifetimes of 15 to 25 days is apparent and is due to the effect of the visibility function, is correct.

Acknowledgements. The authors express their sincere gratitude to Mrs M. Štíplová, Mrs. M. Tesaříková and Mrs. H. Hejnová for their technical assistance in preparing the manuscript.

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