Intriguing NOAA 0756

Introduction - Late April – early May 2005, NOAA 0756 put up a fine display. Being a big, complex and compact sunspot group, it was a great sight through telescopes and it was even an easy naked-eye object for much of its transit. This article covers some topics that were point of discussion for many solar observers:

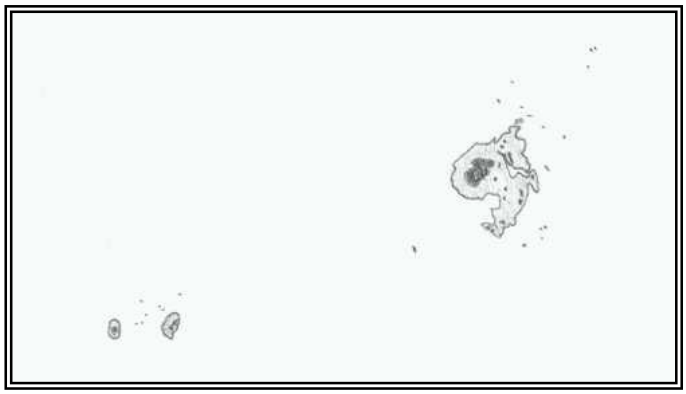
1. What was the correct classification of this sunspot group?
2. Was there or wasn't there a light bridge visible above the main umbra?
3. How unusual is the appearance of such a big sunspot so many years after solar cycle maximum at such low latitude?

Classification of NOAA 0756 - The classification of sunspot groups is based on visual observations. Be it McIntosh or Waldmeier, the guidelines for the classification are well described (see pages 8 and 9 of NOAA's User Guide at http://www.sec.noaa.gov/weekly/Usr_guide.pdf). However, a comparison of observatories reveals substantial deviations in the classification of NOAA 0756.

Observatory	25-Apr	26-Apr	27-Apr	28-Apr	29-Apr	30-Apr	1-May	2-May	3-May	4-May	5-May	6-May	7-May
NOAA	Cko	Dkc	Ekc	Ekc	Ekc	Ekc	Ekc	Dkc	Dkc	Dkc	Ekc	Dac	
STAR	Dkc	Dkc	Dkc	Dkc	Dkc	Dkc	Dkc	Dkc	Dkc	Dkc	Dkc	Dkc	
Kanzelhöhe	H	C	C	C		D	D	D	D	D		D	D
Specola/Locarno	G	H	H	H	H	D	D	D	D	D	H	H	H
Catania	D	H	H	E	E	E	E	E	D	D	D		D
Jan Janssens*	*Hax*	*Hkx*	*Hkx*	*Hkx*	*Hkx*	Hkx	Hkx	*Hkx*	*Hkx*	*Hkx*	Hkx	*Hkx*	*Hkx*

** : Classifications based on SOHO-images in italics*

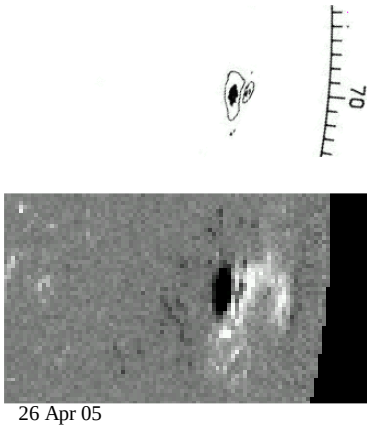
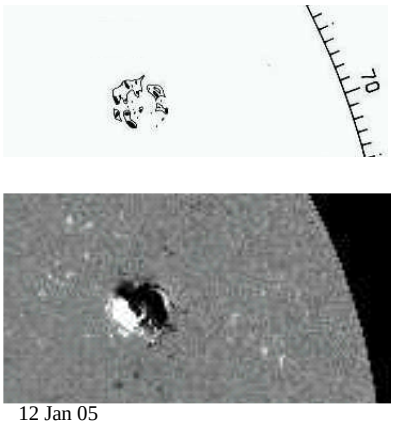
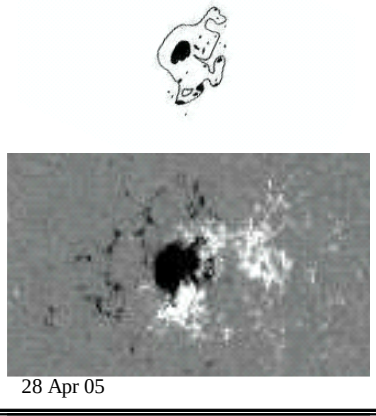
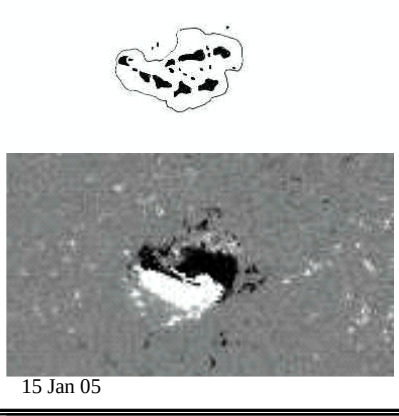
As can be readily seen in the table, there is no doubt that the main spot of this group was a complex sunspot with a diameter > 2,5° (". k ."). That is not the problem. The question is whether NOAA 0756 should be considered as an E-, D- or H-group. In other words, was this group a bipolar (E/D) or unipolar (H) spot? I can't find any good reason for assigning this group a type E. These bipolar groups need to have a length > 10°, regardless their complexity and area. This was clearly not the case for NOAA 0756; its length (and diameter) was around 5°. So where did some observatories get those large lengths? One explanation could be offered by the 01 May-drawing underneath by Catania, showing numerous small spots preceding and trailing NOAA 0756.



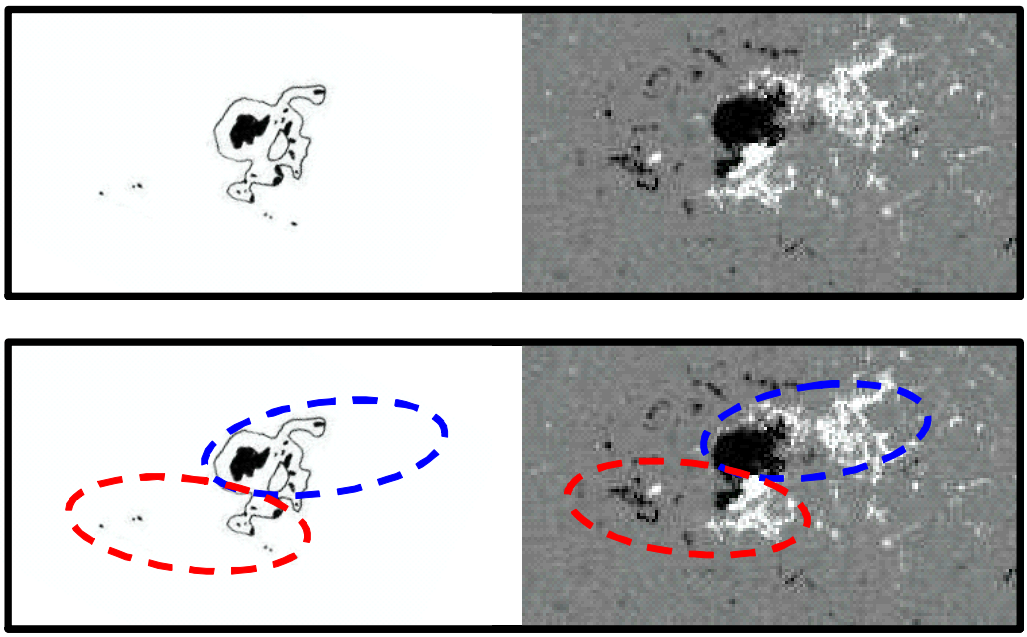
Together, these spots do increase the length to over 10°. Unfortunately, these spots do not show any penumbra, which is a condition for a bipolar E-group. Hence, if these tiny spots were taken into account, then the group should have been classified as a C-type (length >

10°!), which was not the case. Besides, the spots in front of NOAA 0756 were considered as a separate group (mostly B or A) by most observers (except NOAA), and the ones trailing were missed because they were simply too small to observe.
So, was this group a Dkc or an Hkx type? Based solely on visual observations, this is a tough one. The distinction can be made:

1. Based on the evolution of the group. Normally, a group is labelled compact as soon as there is a spot with a mature penumbra between the two main spots of the group. Now, an initially small bipolar group can grow in such a way that the main spots of the bipolar group become so big and so close to each other, that their penumbra becomes as one. An initially unipolar group would stay unipolar. The difference though is very important, as the Dkc-group has bipolar magnetic field embedded, whereas the Hkx-group would have a simple unipolar magnetic structure. So, a Dkc group has a much higher potential for producing flares than an Hkx-group (visible in CV-values).
2. Based on the appearance / complexity of the group. An Hkx-group has mostly one (irregular) umbra surrounded by one irregular penumbra. Smaller spots may be present in the penumbra, but mostly any significant spots are actually cut out by light bridges. In a Dkc-group, due to the opposite polarities, a lot of the umbrae are asymmetrical and they are separate from each other by penumbrae (not by light bridges, though they may be present).
3. Based on how fast the group is changing. An Hkx-group is usually the remainder of an old, bipolar sunspot group, and usually doesn't change much in appearance. A Dkc-group is constantly changing, with umbrae appearing, disappearing and coalescing all the time.

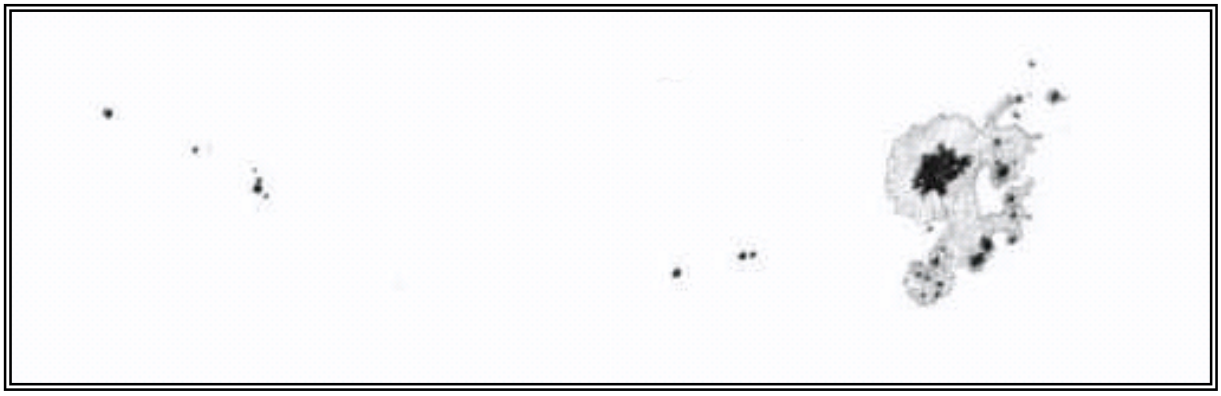
NOAA 0756	**NOAA 0720**
 26 Apr 05	 12 Jan 05
 28 Apr 05	 15 Jan 05

As a comparison, let's have a look at NOAA 0720 that appeared in January 2005 and that suffered of the same classification-problems.
From the visual Kanzelhöhe observations, NOAA 0720 clearly was a bipolar group before it quickly grew into a compact Dkc. In 3 days, it became very complex and increased its size 30-fold (50 MH on 11 Jan 05, 1540 MH on 14 Jan 05). The SOHO-magnetograms clearly show how the bipolar magnetic regions existed prior to this fast growing, and how they coexisted once the bipolar spots were embedded into one penumbra.
NOAA 0756 also developed quickly: a 3-fold increase from 330 MH on 25 Apr 05 to its maximum area of 1030 MH (28 Jan 05). This group shows complex and big, but except for the main spot, no other big spots are visible and they are not asymmetric. Based on the 25-26 Jan 05 drawings, one *could* say that this group was bipolar (Dko, not Dkc). Nonetheless, examining the 26 Jan 05 drawing closely, the main spot is not completely symmetric, and it actually mimics the form of the near spot. This suggests that the two may be separated by a light bridge and that it concerns one spot (Hkx). In fact, light bridges continued to dominate the appearance of NOAA 0756 throughout its entire transit. So the interpretation of the images during the first two days determines the further classification of the group. The issue gets solved quickly once the SOHO-magnetograms are involved. The spots that are seen visually, seem to be the leading part of a much bigger group which clearly shows a white (positive) polarity field in the trailing part. No mature spots developed in this part. Moreover, the two main spots that one could interpret as a D-group, have the same negative polarity. All this is very suggestive of an Hkx-group. Note this interpretation is not possible for NOAA 0720.
What about the positive polarity field south of the main spot? This may simply be an extra feature of the complexity of this group, something that happens regularly with entangled magnetic fields. There is however another possible, albeit exotic, explanation. It may be that the leading (negative, black) part of NOAA 0756 is interacting with the trailing (positive, white) part of the unnumbered NOAA-region a few degrees ahead of NOAA 0756.



As a conclusion, NOAA 0756 seems to be an Hkx-group, however with Dkc a close second based on visual observations solely. An Ekc-classification is ruled out.

Light bridge above NOAA 0756 main umbra – I usually observe the sun with my 8 inch (20 cm) Celestron, Thousand Oaks objective filter, blue ocular filter at a 68x magnification. The morning of 30 Apr 05 at 09:05 UT and under moderate seeing (Q=3), I observed 3 umbral dots in the main umbra of NOAA 0756. The drawing made by Locarno Solar Observatory on the same day at 07:45 UT, gives an excellent view of what I actually was observing. There were clearly 2 dots in the north of the umbra, and one in the south.



The Solar Astronomy Handbook (Beck, Hilbrecht et al., 1995) also mentions these dots could be "bright points", but the observed dots were not as bright as the surrounding photosphere (granulation). However, bright points are linked to the development of light bridges. The next morning I observed the sun again (07:10 UT) under slightly more favourable conditions (Q=3,5). I was not surprised to find 2 light bridges extending from the umbra's inner edge toward the place where I had previously seen the white blurs. The umbra was not completely separated, and the bridges were very fine, but the phenomenon was clearly visible. The southern dot had disappeared.

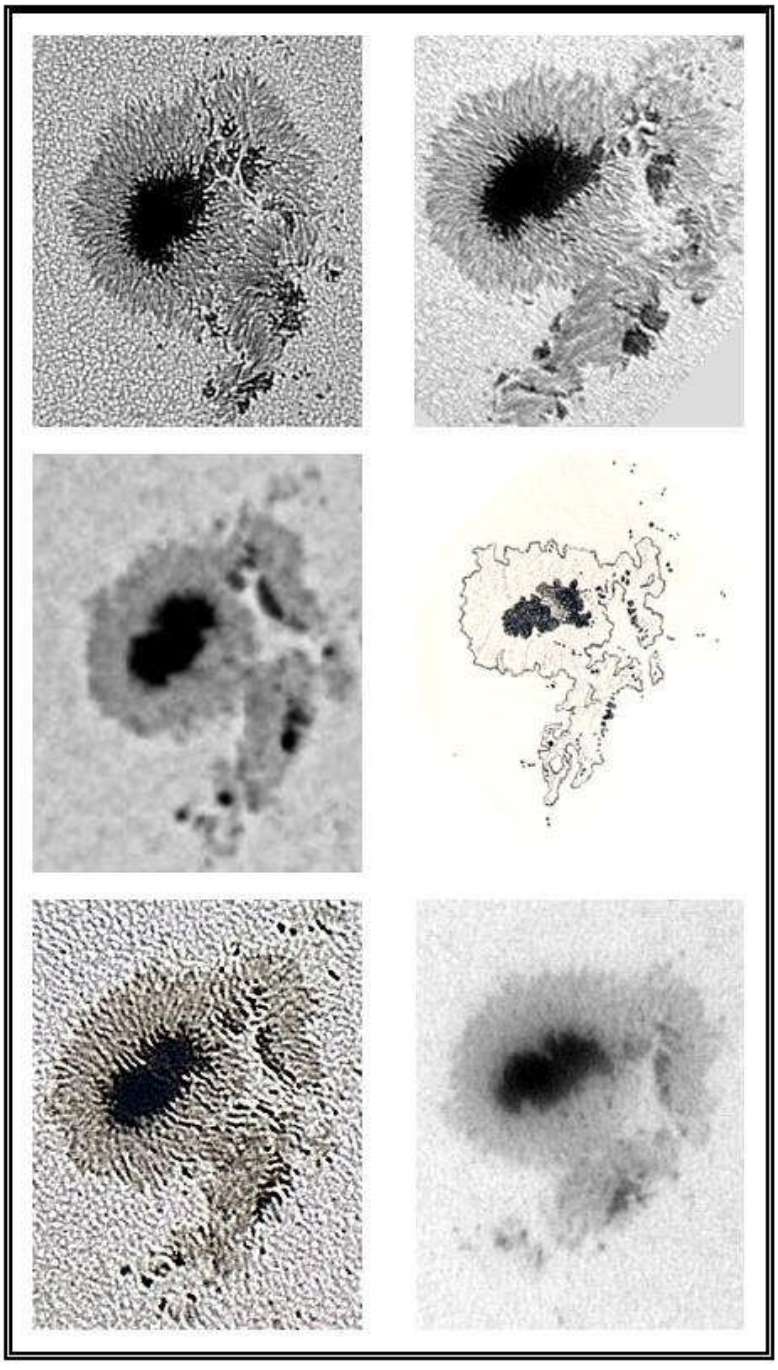
As hours went by, I failed to find any pictures of this light bridge on the internet. SOHO-images showed a dark umbra without any inner detail. At 17:00 UT (Q=2,5), I double-checked my observation. The eastern bridge had diminished in size, but the western (left on the drawing) had retained its length. It was much less pronounced though, and seemed somewhat smeared out with two brighter points along its length.

I brought my observations to the attention of the Yahoo solar observers group, and also kept an eye on images published at NASA's Spaceweather website. In the course of the week, enough pictures and especially drawings were gathered to confirm the existence of the light bridges and to show their evolution.

This evolution can be seen in the following set of images:

Upper left	29 Apr 05	11:03 UT	C. Viladrich
Upper right	30 Apr 05	10:14 UT	E. Perissinotto
Middle left	01 May 05	08:50 UT	J. Bavais
Middle right	01 May 05	14:18 UT	G. Elena
Lower left	01 May 05	17:26 UT	P. Maxon
Lower right	02 May 05	09:06 UT	G. Araujo

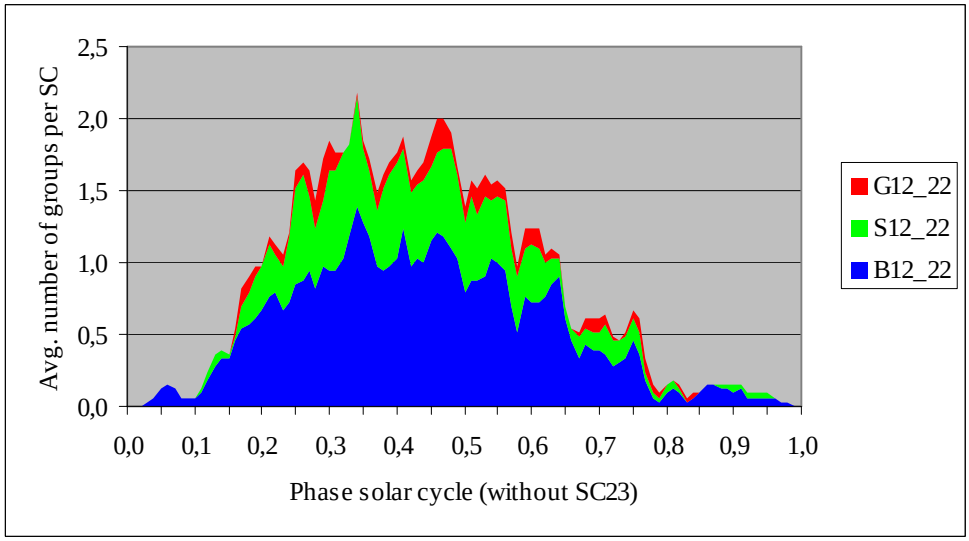
All images were rotated, mirrored, contrast enhanced and/or resized in order to bring out the finest details and ease comparison.



As can be seen, umbral dot activity was already present on 29 Apr 05. Enrico Perissinotto's image of 30 Apr 05 is a very good confirmation of Locarno's and my own observation, showing the 2 northern umbral dots almost in exactly the same location as the visual drawing. Joël Bavais' image clearly shows the 2 light bridges, though my own observation showed the left (western) light bridge reaching the middle of the umbra. After that, it seems like the light

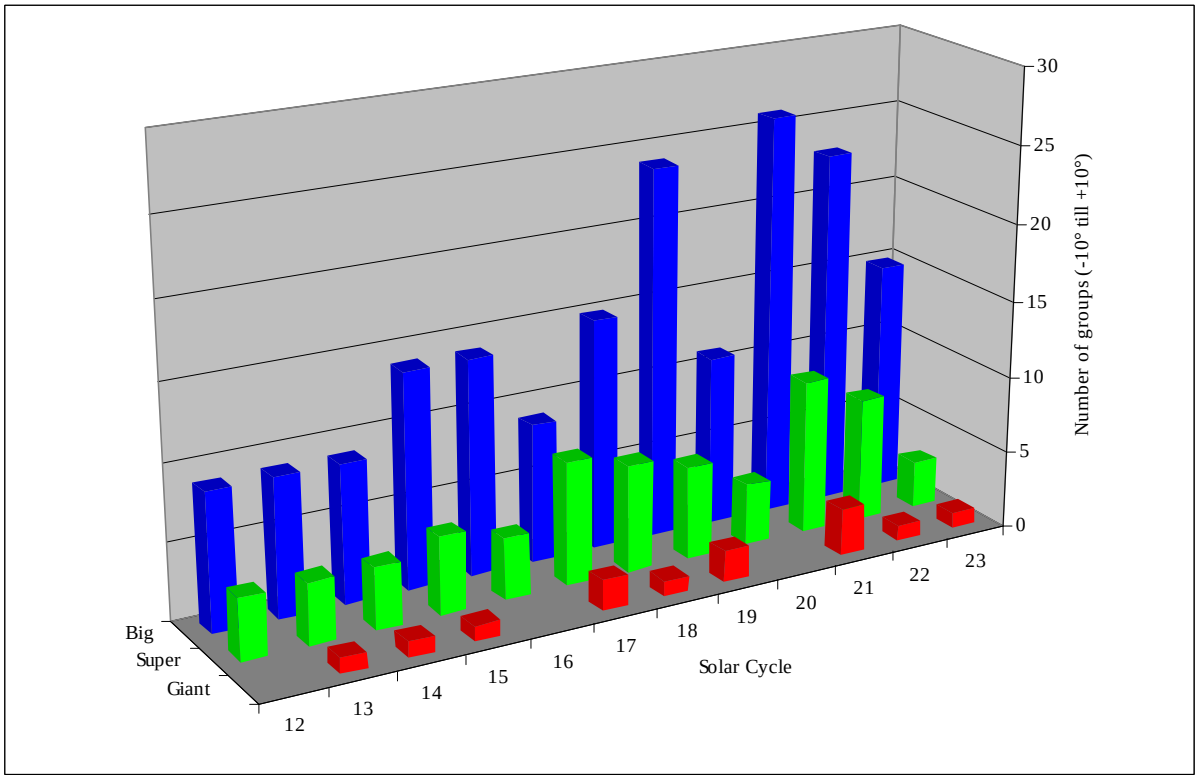
bridge disintegrates, as shown by the next 2 images. The brightness of the light bridge in the drawing is probably a bit too much, but it shows the light bridge was getting smeared out, as observed by myself a few hours later and photographed by Paul Maxon. The 02 May 05 picture by Gema Araujo shows most of the light bridge has vanished, with only the brightest part of the western light bridge remaining.
As described in chapter B.5.3. "The development of light bridges" in the Solar Astronomy Handbook, it appears that for some reason the light bridge failed to fully mature. In stead, it remained in stages 2 (inner penumbra filament projection into the umbra) and 3 (granules breaking of from the filaments) throughout these days. No joining up of the outer penumbra was observed. These faint, contrast-poor phenomena pose a significant challenge to the photographic skills of an observer.

Time of occurrence and latitude distribution of big sunspot groups – On some websites and in some articles, the appearance of big group NOAA 0756 so many years after the latest solar cycle (SC) maximum was suggested to be unusual. Also its low latitude (-6°), at least for such a big spot, seemed remarkable.
With its 1030 MH maximum area, NOAA 0756 was a big group (area between 720 & 1080 MH). It fell short of a super group though (area between 1080 and 1790 MH), and it ranks only as number 29th of biggest groups in the current solar cycle (SC23).
When one takes the solar cycle length as 1, the phase can be calculated. E.g. if the maximum of a solar cycle occurred after 44 months, and the solar cycle lasted 132 months (11 years), then the SC-maximum occurred at phase 0,33 (= 44/132). The appearance of a big spot can thus be linked to its phase in a solar cycle. Then the total number of big groups that occurred at a certain phase can be summed over all solar cycles, and averaged. For each phase, one thus obtains the average number of big, super and giant spots per phase that can occur during a solar cycle.

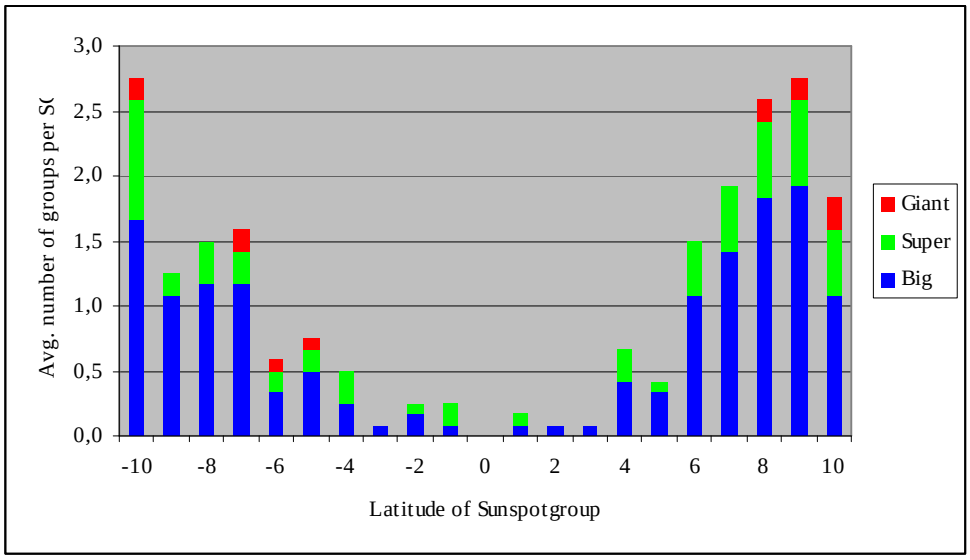


As can be seen (data from SC 12 thru 22), during most of the SC-maximum years there appears on the average one big and one super group per month. Giant groups tend to occur a few months prior to, but especially after SC-maximum. As the SC progresses, fewer big groups occur, but it does not become zero until phase 0,96! This is only 4 to 6 months prior to the solar cycle minimum. From the number of spotless days occurred so far, it has been deduced that the upcoming SC-minimum can occur around October 2006, this is still 18 months away (phase +/- 0,86 = 107 months since SC-minimum / 125 months SC23-duration).

All active cycles have produced big groups later than this (so even closer to SC-minimum), meaning that the appearance of big groups at this stage of the solar cycle is absolutely not extraordinary. In fact, we may still be greeted by a few big sunspot groups over the next year.

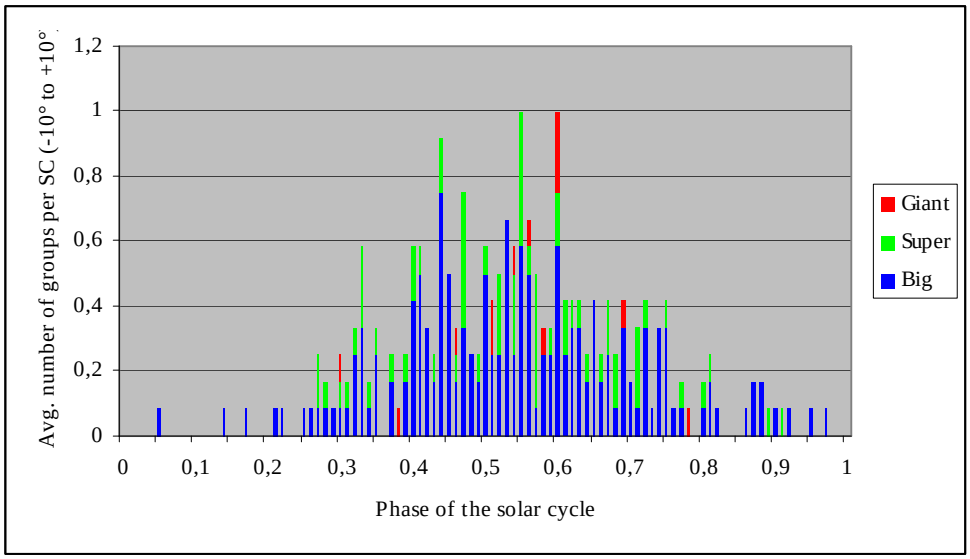


The graph above shows for each solar cycle all big, super and giant sunspot groups that occurred between solar latitudes -10° and +10°. It is clear that the appearance of big sunspot groups at low latitudes is absolutely nothing unusual. At latitude -6° there appears about 1 big spot every 2 solar cycles.



But how unusual is the appearance of a big spot at a low latitude at this stage of the solar cycle (phase = +/- 0,86)? Graph underneath seems to indicate this might be unusual, as only 1 SC has produced a big group between latitudes -10° and +10° at this phase since 1874. However, 11 big and super groups have occurred after phase 0,85. 6 out of the last 8 solar cycles have produced at least one such group, SC 19 and 22 being the exceptions. SC 15 and

17 even produced 3 such groups. Thus, NOAA 0756 only seems to confirm the statistics, and it shouldn't be a surprise if SC23 produces one more such group before the next solar minimum.



Conclusions – The results of the investigation on NOAA 0756 have lead to the following conclusions:

1. NOAA 0756 was most likely a Hkx-group, with Dkc a close second based on visual observations only.
2. Light bridges were visible over NOAA 0756's main umbra, but they never separated it completely.
3. The occurrence of a big group like NOAA 0756 at the low solar latitude of -6° at this stage of the solar cycle is not unusual and only confirms the statistics since 1874.

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08 May 2005