

FORMS AND DEVELOPMENT OF DARK SPOTS AFTER SL-9 JUPITER COLLISION OBSERVED AT BELGRADE

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1. INTRODUCTION

The row of about 20 fragments of Shoemaker - Levi (SL-9) comet collided with Jupiter in July 1994. The event was observed at the Belgrade Observatory from July 17 till August 8 - comprising the colliding period and two weeks after the collision was ended. The ZEISS 65/1055 cm refractor with the aperture reduced to 40 cm and an SBIG professional CCD imaging camera was used. In all 238 Jupiter's images were obtained - mostly in the V spectral region. Some results were reviewed elsewhere (e.g., Popović *et al.* 1995). Here the observed shapes and some impact spots developing tendencies are shown.

2. THE PROCEDURE

The images of good and fair qualities (in all 127) have been taken to be processed. Malkov (1995) created a special software, Analyst, for processing the Jupiter's image and to evaluate jovigraphic coordinates of arbitrary points of the planet's disk. The CCD images, usually of quite low contrast, were sharpened to some degree. The boundaries of impact spots were marked with great number of dots by an observer and controlled by another. So, the areas inside the dotted contours in Figure 1b,1c and 1c have to be taken as dark and where a darkest core in a spot was found it was marked in the same manner. This also means that a higher local density of dots does not present a grater darkness of an impact spot. The number of dots in a contour simply depends on the number of images overlapped in that particular case and on the number of points the observer had drawn around that spot.

Several difficulties were met in this process. The individual spot images highly depended on seeing conditions. A good example is the H spot in Figure 1b and some other images where double contours can be seen. Some uncertainties in repeated markings of spot boundaries by one or two observers also contributed to the scattering of spot contours. Besides, the images at distances from the planet's limb less than about 30° (sometimes even slightly more) are very much disturbed: their positions, sizes (they seem usually bigger) and their identities are uncertain. Such disturbances can be seen: in Figure 1b in the W spot at longitude 170° , in Figure 1c in K spot at

longitude 225° , in Q spot at longitude 355° and in Figure 1d in L spot at longitude 255° , and in G+R spot at longitude 315° . They are also present in Figure 1e near longitudes 55 and 175° .

In order to point out some characteristics of the impact spot development from July 17 till August 8, in Figures 1b, 1c, and 1d we present a specific sample of our observations. The whole observing interval has been divided in three phases (the mentioned figures respectively) each comprising several nights - sufficient to expose all longitudes and to present some more informative examples out of ten observed and identified impact spots. These are labeled with the corresponding letters between Figures 1a and 1b. The impact spot Q is divided into Qa and Qb because of plotting reasons. Figure 1b corresponds to the interval July 17 - July 25. It contains the early images: spots H, E, A and C were observed on the first night. The G spot was seen on July 18, but its typical double image, G+R was observed on July 23. The last one is shown in the Figure. The same is valid for the L and Q spots. Similarly the spots W+K are shown as observed on July 25. Figure 1c corresponds to July 26 till July 30. It shows the intermediate stages of the impact spots: H as observed on July 26, E, C and W+K on July 29, and L, G+R and Q on July 30. The last Figure 1d contains observations from July 31 till August 8. Images of the spots H, E, Q and R (part of the common image above longitude 315 degrees) have been taken from the observation on July 31. Spots L and G (up to $l = 315^\circ$) are taken from August 6. The spots W+K as well as an additional trace belonging to L (up to about $l = 250^\circ$) are shown as seen on August 8. A strip chart of all impact spots in late July based on some Hubble Space Telescope data and published by Mac Robert (1994) rearranged to start from longitude $l = 0$ degrees, is shown here in Figure 1a. It can be used for tentative comparison with our data in Figures 1b, 1c and 1d.

Comparing the impact spot longitudes in Figure 1a and 1b one can find our longitudes on the average about 10° smaller. We can only state that they were calculated with respect to the central meridian in System II Jovigraphic longitudes corrected for the effect of planet's phase (taken from *Astronomicheskij Ezhegodnik*, 1994, p.231). The discrepancy probably arises from different ephemeris sources. The mutual distances between neighboring spots are in a better agreement in the mentioned figures - with two exceptions. The spots W and K are in our case more distant $\Delta l_{K-W} = 20^\circ$ which is about 4 times their distance in Figure 1a. A similar $\Delta l_{K-W} = 19^\circ$ cites O'Meara (1994). One may argue whether we observed the spot U instead of W. The fragment U actually fell on July 21 but it didn't leave a residual dark spot (Beatty and Levy, 1995). The effect might be explained by relative motions of these spots. Actually, some of our observations (not shown here) indicate a 10° eastward displacement of the K spot's core from July 20 till July 25. We have no data on W spot motion until July 25. The K-W distance in Figure 1a corresponds to the planet's rotation increment having occurred between the two impact instants. In our observations the R spot is somewhat nearer to spot G ($\Delta l_R - G = 12^\circ$). A possibility that it might be another spot, D or S, has been considered. However, we searched for D on July 18 when the vicinity of the G spot was still clear. It could not be identified. It would be more difficult to resolve, a similar in size, spot S within the complex G on July 23rd.

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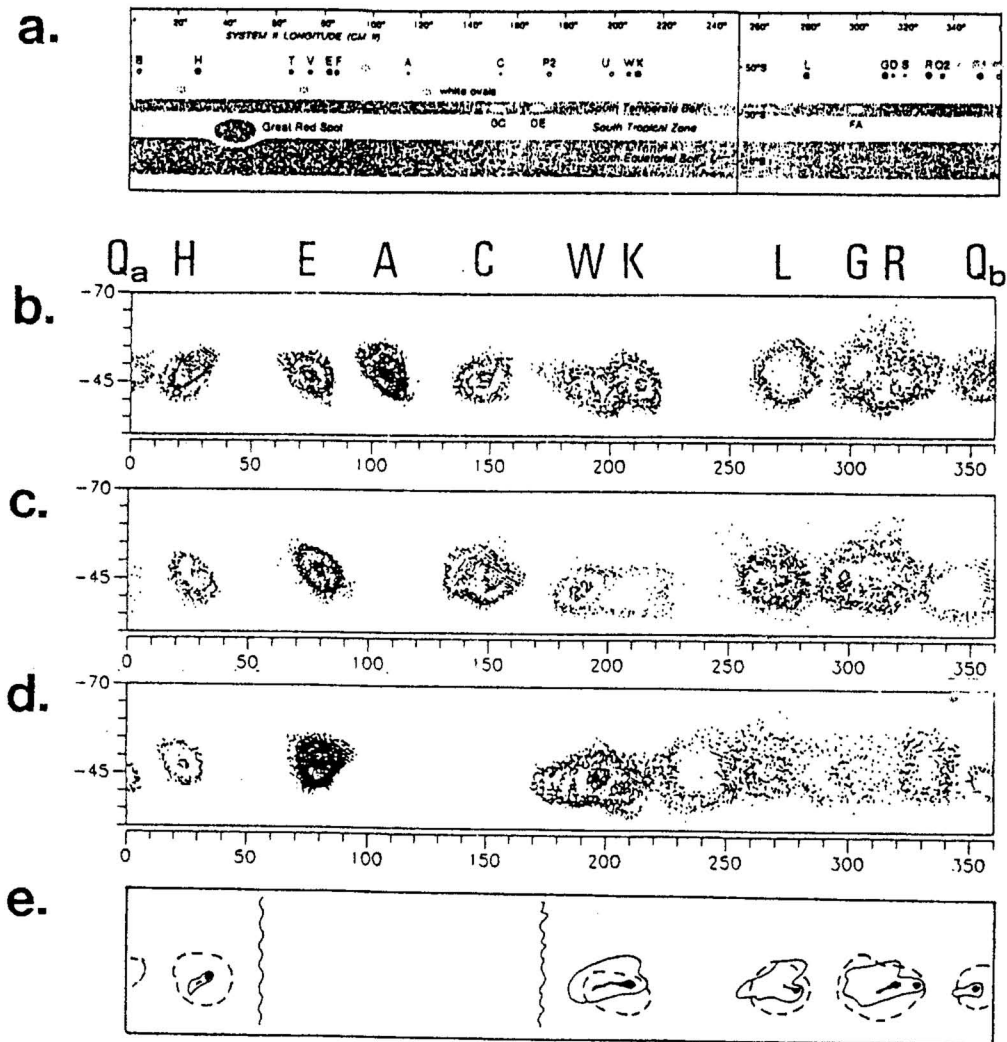


Fig. 1. Longitudinal distribution of SL-9 impact spots around Jupiter, **1a**. Three samples of our impact spots observations (jovigraphic south latitude, **b**, versus longitude, **l**, in [°]): **1b** = 17. VII till 25.VII, **1c** = 26.VII till 30.VII and **1d** = 31.VII till 8.VIII. Overlapped contours of H, K, L, G+R and Q impact spots observed at Belgrade (dashed lines) and as seen by HST (continuous lines and dark cores) on July 23, **1e**. No data exist between the two vertical wavy lines.

3. SHAPES AND CHANGES OF THE IMPACT SPOTS

Our observing conditions and the applied image processing procedure did not favour high resolution images. To get an impression about the present results, a comparison of our mean spot contours for the evening of July 23 with the corresponding Hubble Space Telescope images provided by H.B Hammel and P. Nicholson (Beatty and Levy, 1995) is given in Figure 1e. Looking at small impact spots H and Q one finds fine and well resolved HST images (thin lines and dark cores) with resolution much better than 1" and our larger and rounded contours (dashed lines) indicating an overall resolution of about 2" (taking 1" equal to about 4°.5 in jovigraphic latitude). In the case of K, L and G+R spots the same effect is present but its influence increases the spot sizes only slightly. Hence, the fidelity of shapes and sizes of impact spots obtained at Belgrade is somewhat better in large and more evolved ones.

As far as the short term evolution (up to 22 days) of the impact spots is concerned, we can notice the following behaviour. Some spots weakened and disappeared: A in about 8 days and C in about 14 or 15 days. Hence the former is not shown after the Figure 1b, and the last one in Figure 1d. We can take the spots H, E and Q as not very large but quite stable. Especially the spot E weakens very slowly. These impact spots also do not show any elongation in E-W direction. On the other hand, large or complex spots W+K, L and G+R did not vanish or weaken. They exhibit a tendency to extend some "wings" in latitude, mostly southward, and to create some "extensions" and "additions" in longitudinal direction. Namely, G+R complex has a southward scattered contour in Figure 1b, L spot has such features in SW, W and NE directions, and G+R complex in south direction in Figure 1c. WK spots have already been elongated in E-W direction but in Figure 1d they are almost touched by a westward, weakly bound, addition of the spot L (between longitudes 220° and 250°). However, the main body of L is connected with the extended G+R complex. So, we have here, from longitudes approximately 170° to 340°, an almost continuous band as a complex impact trace of the great SL-9 fragments K, L and G correspondingly contributed by W and R.

4. CONCLUSION

Some kind of lower size of the observed small impact spots at about 10° in latitude suggests that the resulting resolution in Belgrade SL-9 impact spots observation has been about 2". This made the smallest spots (e.g., D) undetectable and another small ones as being of approximately circular shape. The big and complex impact spots are somewhat larger than they would be under the ideal observing conditions (space observations).

Observed through a 22-day interval, three kinds of evolution of impact spots in Jupiter's atmosphere were noticed. Two out of ten identified spots (A and C) weakened and disappeared in 8 to 15 days. The other three (H, E and Q) seemed to be stationary or weakening very slowly. Three largest and complex spots (W+K, L and G+R) exhibited a clear tendency of further developing: increasing sizes and elongating shapes - eventually merging one with another. This behaviour is probably depending on increasingly stronger colliding interactions (involving more and more mass and energy) in the three respective cases.

Acknowledgements

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