Structural changes in solar corona during total solar eclipses

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Total solar eclipses observed on the long baseline allow obtain the pictures of white-light solar corona with the long temporal distance. New mathematical methods of coronal picture processing allow visualization of very faint coronal structures and enable to compare their position in corona with very high accuracy. We can detect the moving of these faint structures by comparing of pictures obtained on the different places during the same total solar eclipse. Some techniques and results, as well as the MMV project, are described in this paper.

Introduction

Total solar eclipse is one of the most fascinating but very rare astronomical phenomena which they offers very good chance to observe some events hidden for most of both the terrestrial and cosmic equipment. There exist some unsolved problems of physics of solar corona, which could be discovered thanks to the total solar eclipse observations.

Especially the analysis of faint and dynamic phenomena occurred in the inner corona has a fundamental importance to the understanding of such processes as heating of solar corona, coronal mass loss, origin of solar wind, triggering of CMS and many others.

Modern types of analog films or electronic detectors (CCD/CMOS) in connection with modern objectives and over and above with possibility of precise preparation and tuning of experiment can afford highly quality observing material.

Observing of total solar eclipse carried out along the totality path allows us to obtain amount of pictures covering long temporal distance. Comparison of such pictures can provide information about the dynamic of solar corona.

The first considerable results were obtained by our team in 1999 eclipse, when we had a chance to process the pictures obtained along very long part of totality belt. We analyzed decrease of brightness the structure of long helmet streamers We found certain structural changes, which could be considered to represent either moving of coronal plasma or any types of coronal plasma waves. The typical speeds were found to be from 70 to 200 km/s.

Unfortunately, the corona eclipse pictures processing procedures were not possible to show as faint as needed structures and consequently changes in their position in corona. It means the obtained results are not fully credible.

Therefore we developed new procedures allowed very precise align of individual pictures to the final picture, as well as the procedures removing brightness decrease and enhancing structures of needed properties.

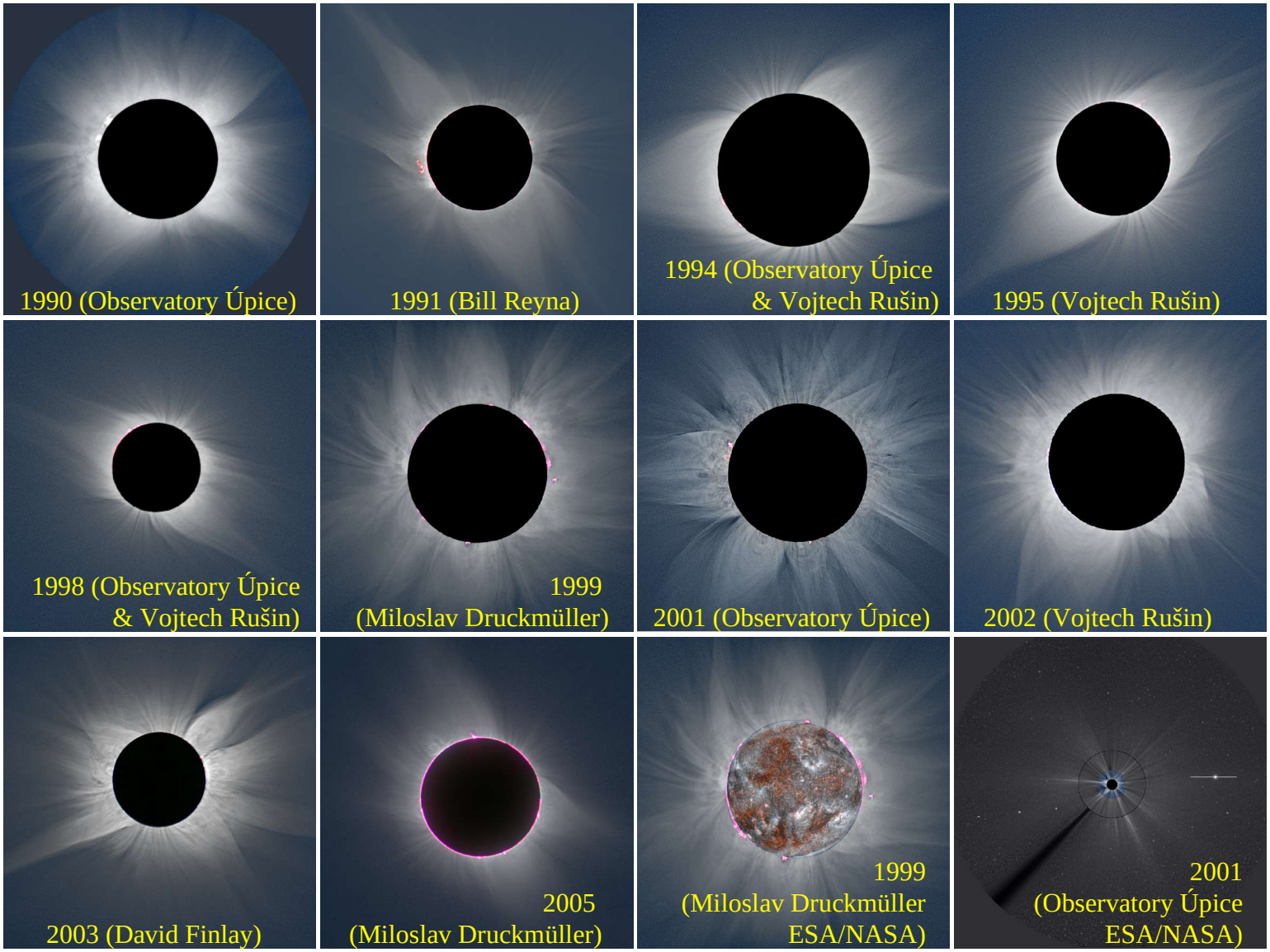
Based on the new mathematical processing procedures the MMV (Mathematical methods of Visualization of Solar Corona) project was established.

The pictures presented in this poster show examples of some structural changes (both physical and formed by projection of coronal structures) in solar corona during several minutes or hours. All pictures were processed within MMV project.

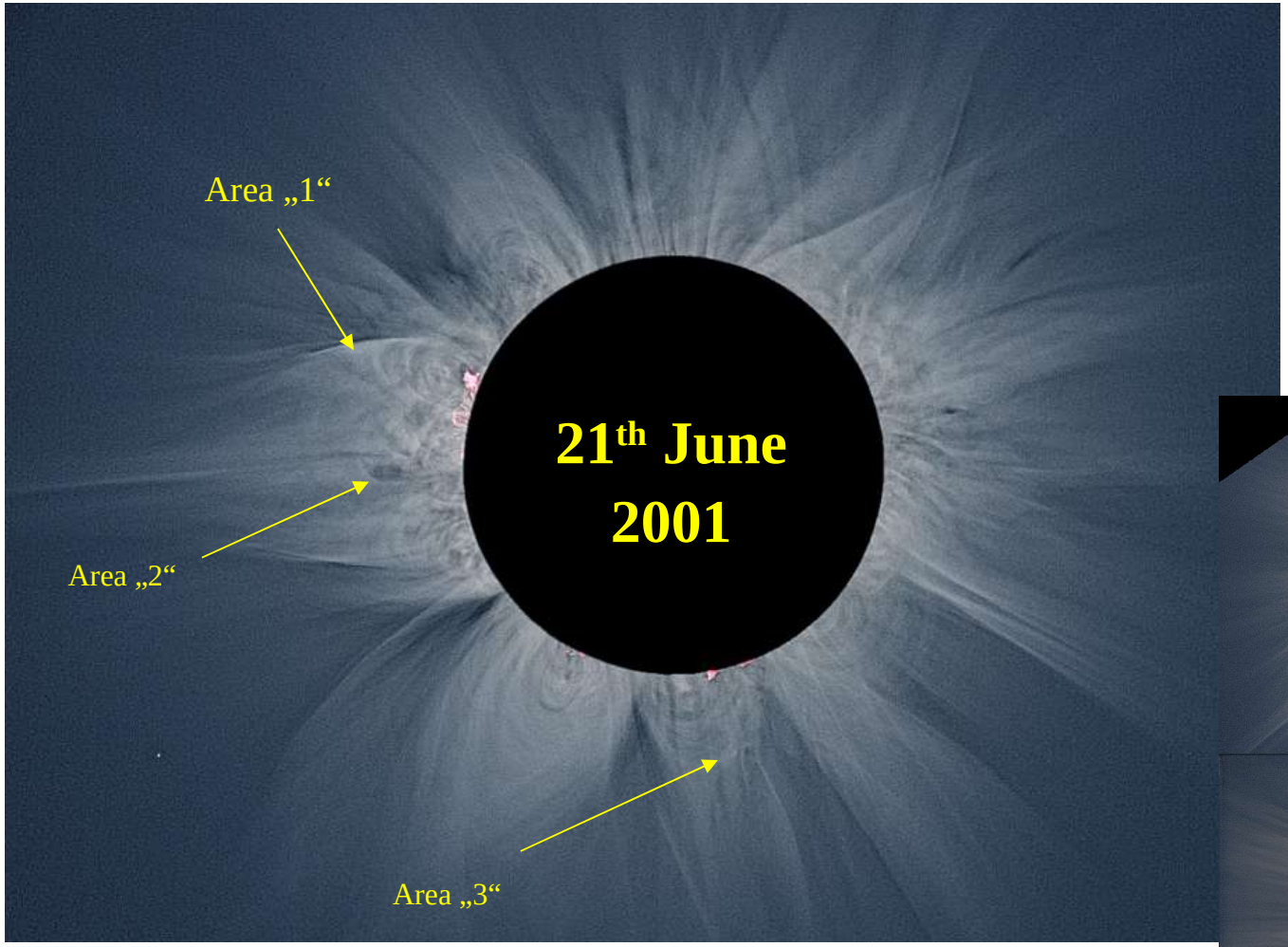
Mathematical methods of Visualization of Solar Corona

The large amount of observing material was obtained with great afford during the century of using photography for recording of total solar eclipses. This material contains much valuable information about solar corona, which has not been fully used yet. Fast computer processors, gigabyte sized memories and high resolution scanners together with newly developed mathematical methods make possible to use archival films and plates for creation of corona images in the quality which was not possible to be reached years ago when these images were taken. In 2002 we started the project MMV the aim of which is to develop new mathematical methods, which make the processing of corona images more effective, especially the highly precise registration, and to visualize coronal structures by means of adaptive filters inspired by human vision. The project is opened to any professionals or amateurs who have eclipse images of good quality and would like to participate on this project. More information and many processed eclipse images may be found on project Web page: www.zam.fme.vutbr.cz/~druck/Eclipse/Index.htm.

Some total solar eclipse pictures processed within M2V project



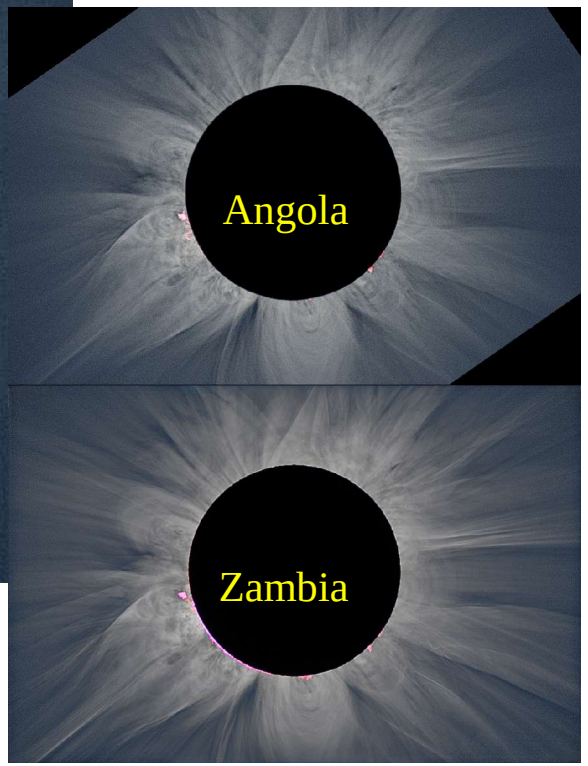
2001 total solar eclipse



Angola (Observatory Úpice)
T_{max}: 12:39 UT

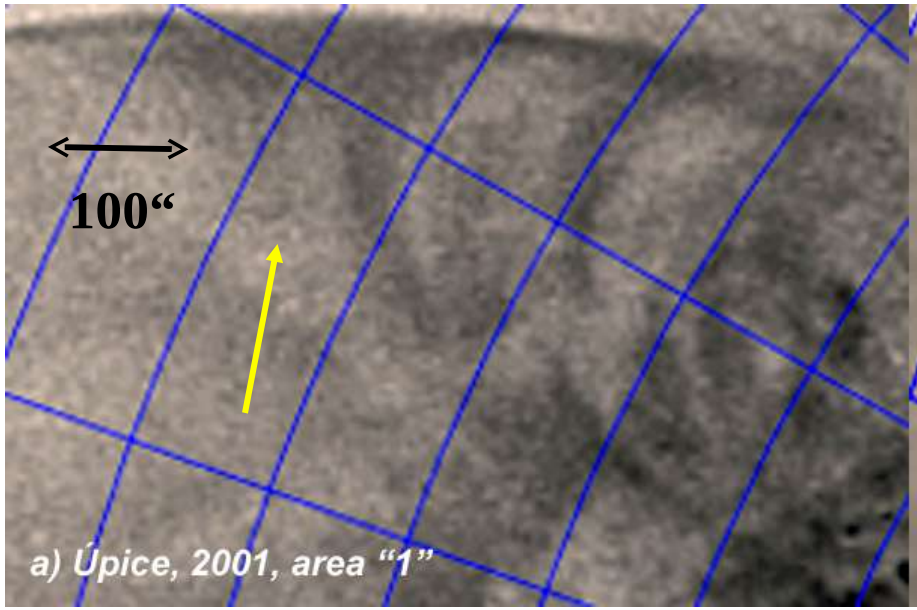
Zambia (Fridhelm Dorst)
T_{max}: 13:11 UT

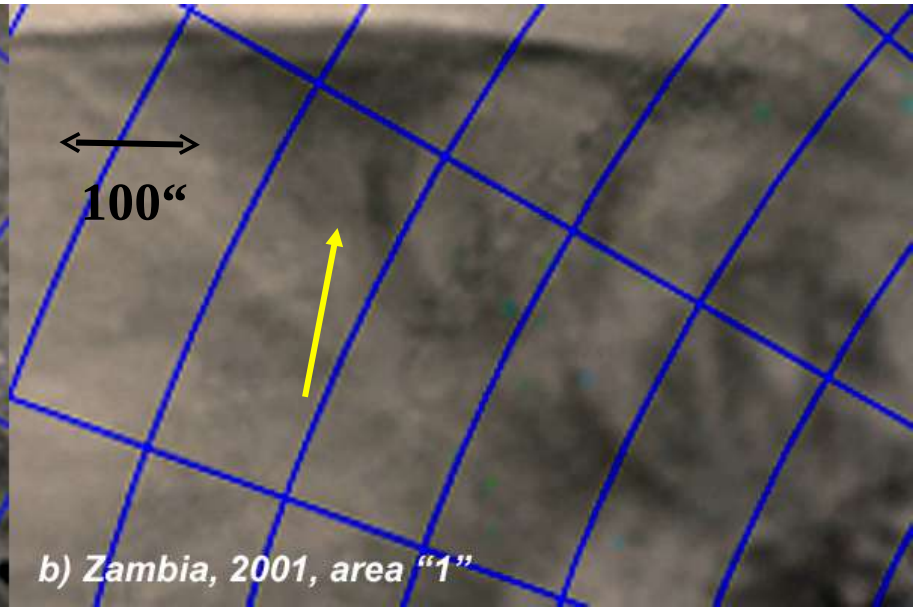
ΔT: 1920 s (32 min)



The areas mentioned in this paper are signed by arrows.

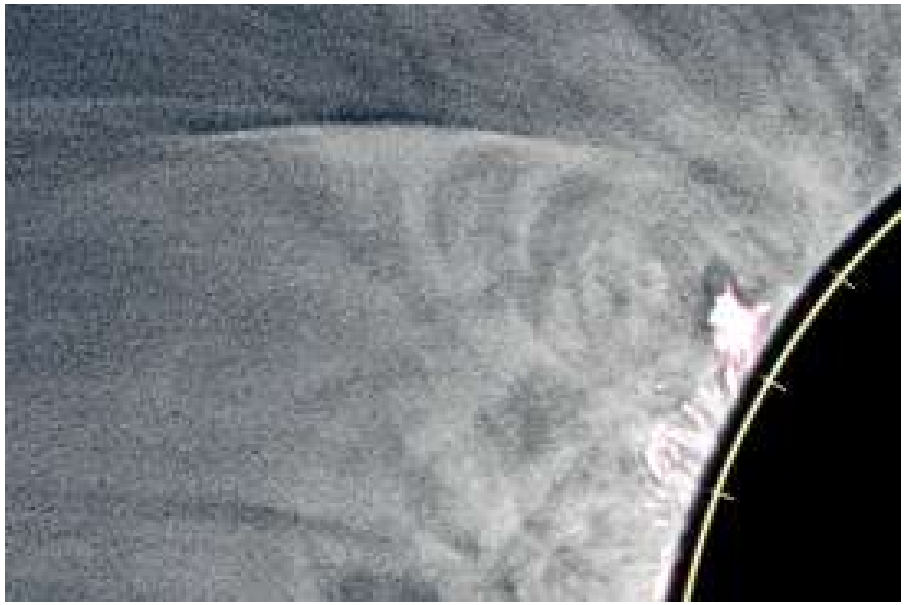
2001 total solar eclipse – area „1“



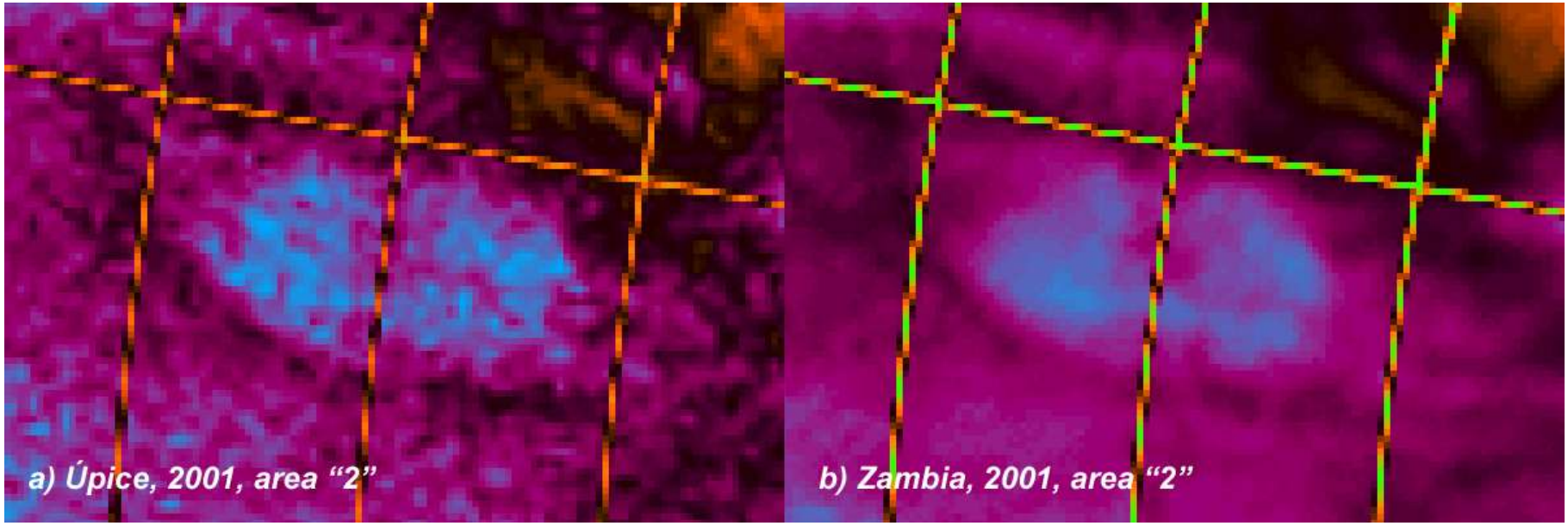


Very faint structure located in interesting and dynamic part of solar corona above east limb.

The dynamic of this event (part of loop system) is more evident on the movie. Nevertheless, it is visible, that this structure (designed by arrows on this negative pictures) move downwards with speed about 12 km/s.

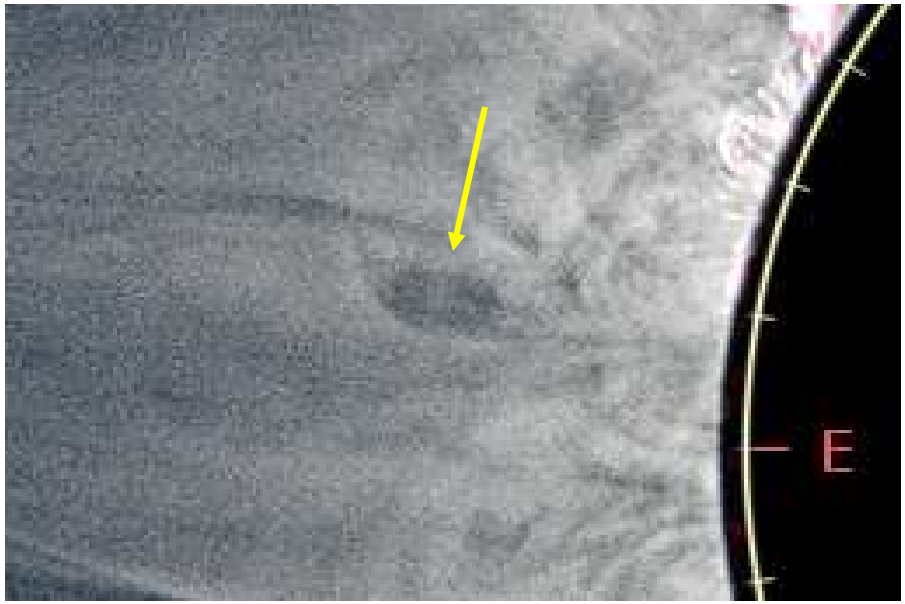


2001 total solar eclipse – area „2“

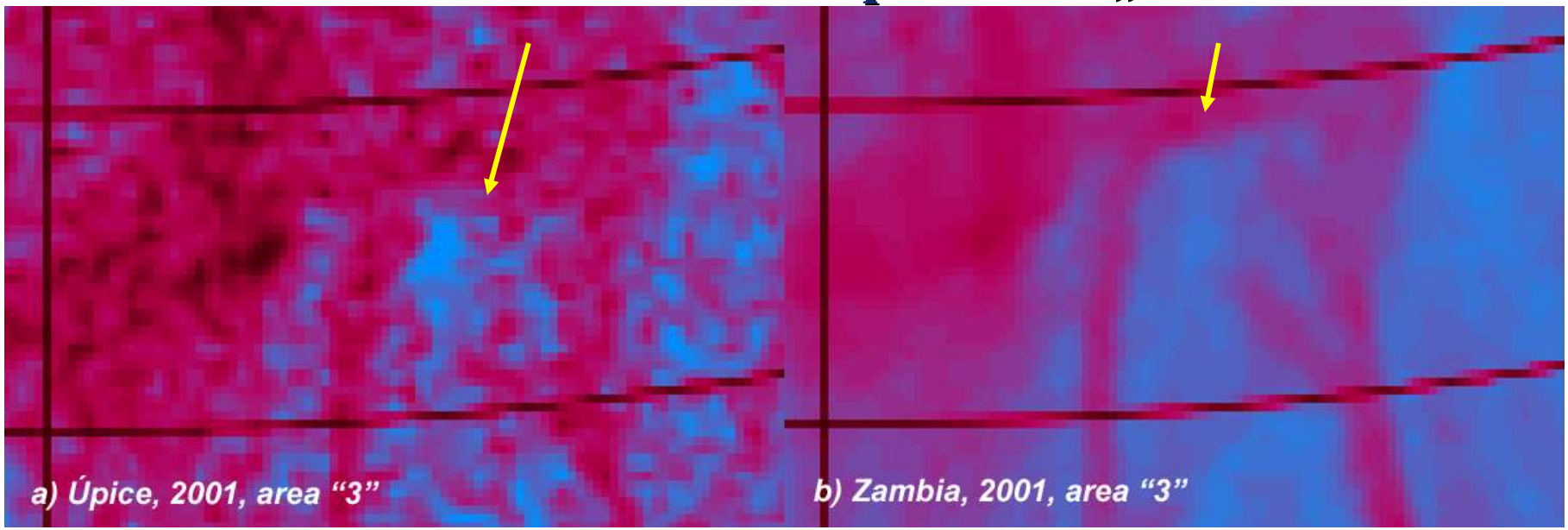


Large oval darkening closed to the large loop system extracted and enhanced from the original pictures.

The top edge (eastern side in fact) of this structure move downward with the speed about 3 km/s. The bottom one (western side) move outwards with speed about 6 km/s. That means this darkening shows the tendency to vanish.

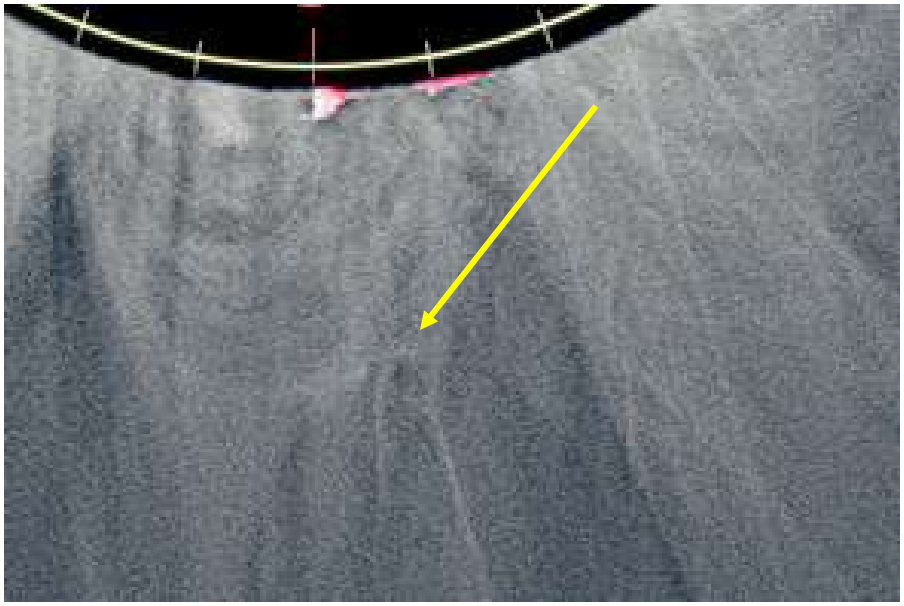


2001 total solar eclipse – area „3“

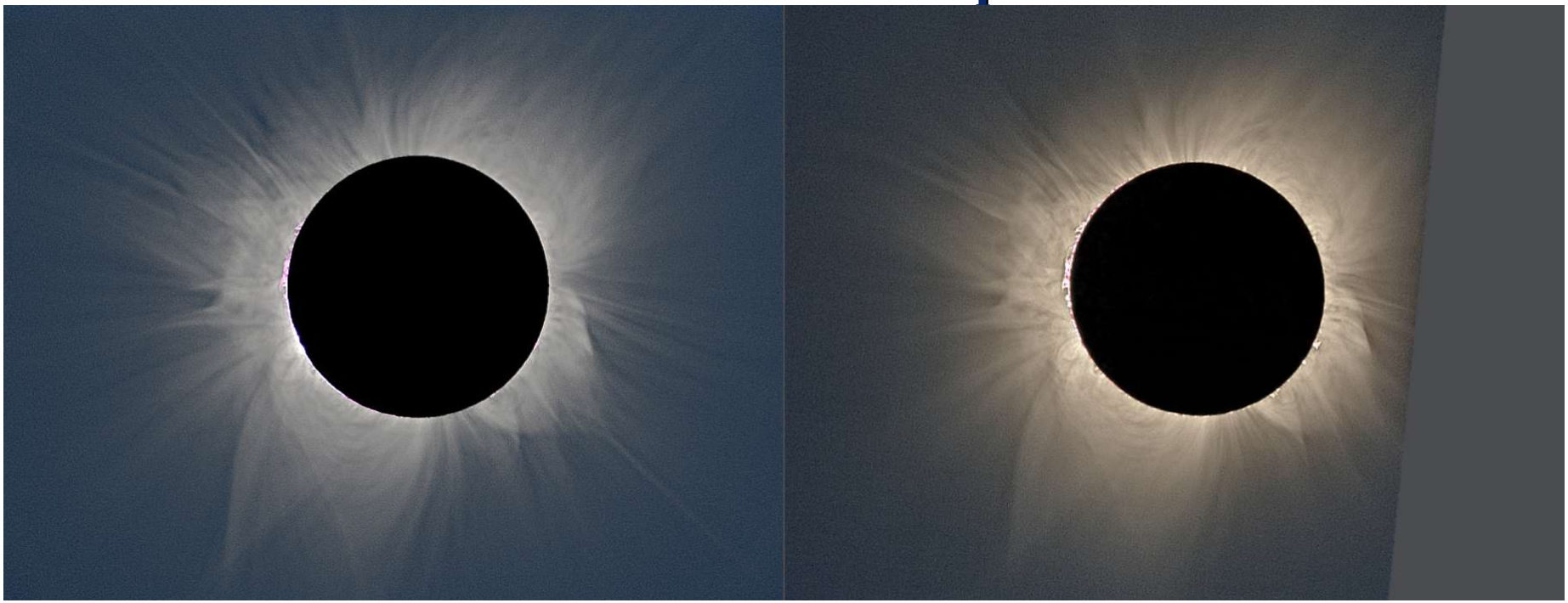


Next interesting area extracted and enhanced from the original pictures.

Sharp edge designed by narrow move with speed about 4 km/s for from the Sun.



2002 total solar eclipse

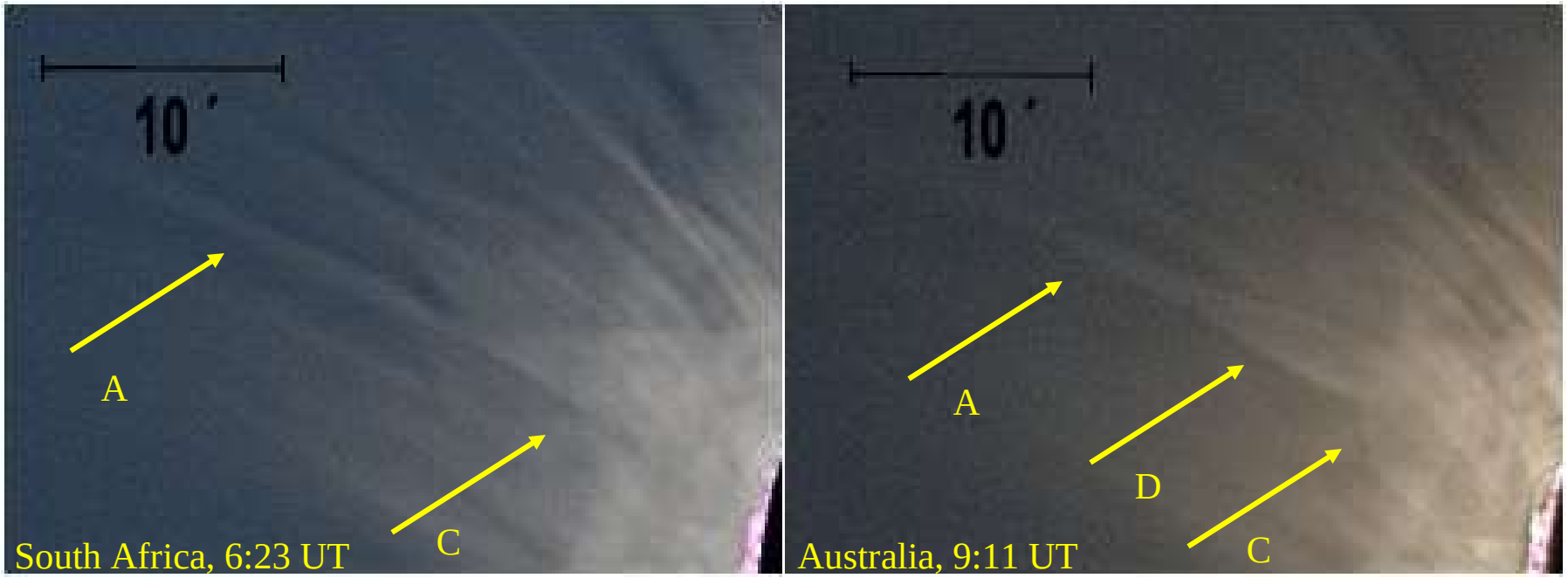


The left image was created using two series of images taken on December 4th, 2002) in Africa within a period of about 8 minutes. The first series was taken by Vojtech Rušin in South Africa, the second one was taken by Friedhelm Dorst in Mozambique. The image shows the solar corona approximately at 06:23 UT.

The right image is made from images captured by Arne Danielsen in Australia at 09:11 UT.

The time delay of about 168 minutes is relatively long and enables to study changes in the solar corona. It is possible to find a lot of changes by careful comparing of both images.

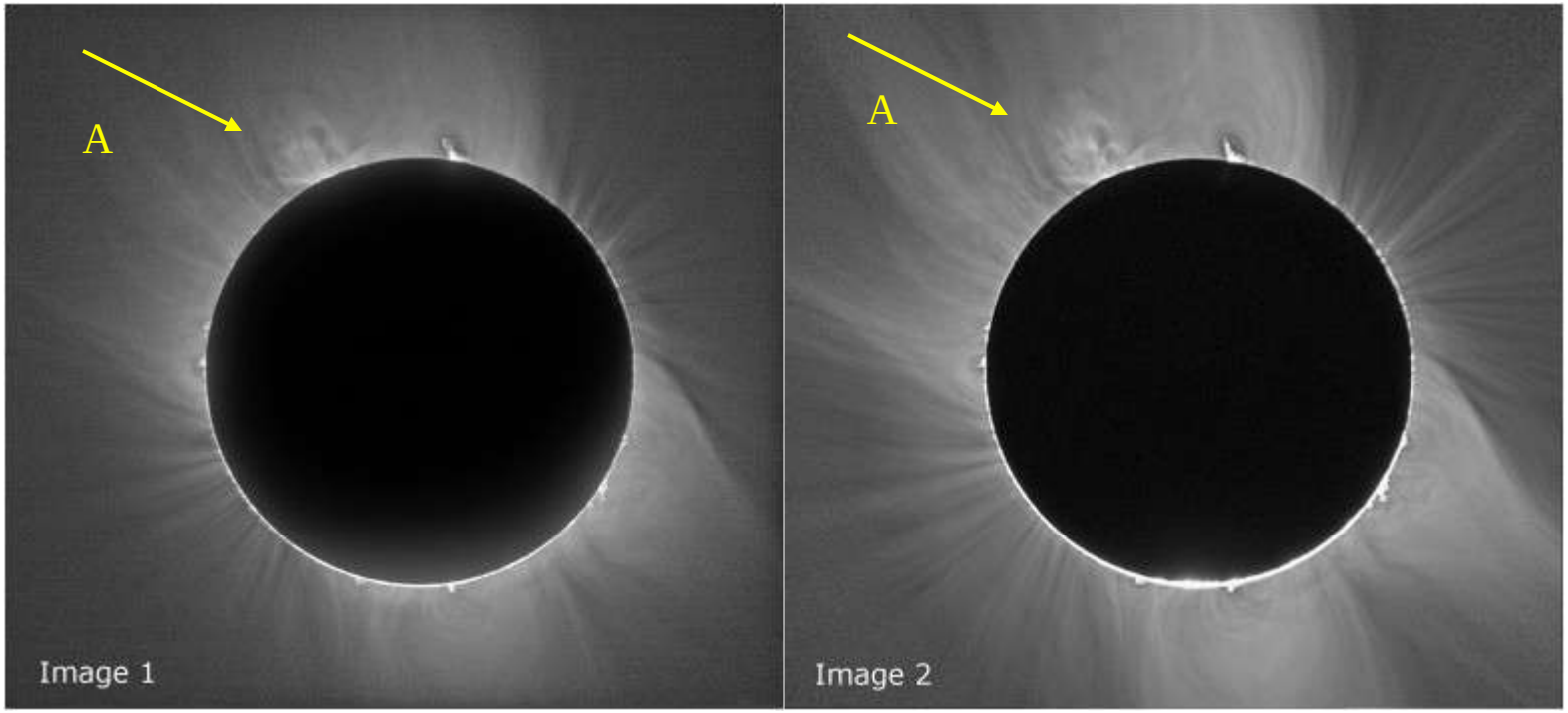
2002 total solar eclipse



The most significant one can be found in this image. We can see very thin streamer (signed A) in South Africa picture. During almost 3 hours time delay between both pictures the shape and structure of this streamer clearly changed. Above The bottom part of it had begun be more widely to the shape of thin cup (D). Some structural changes we can see above and under large arch (signed C), which is more clearly visible on Australia picture.

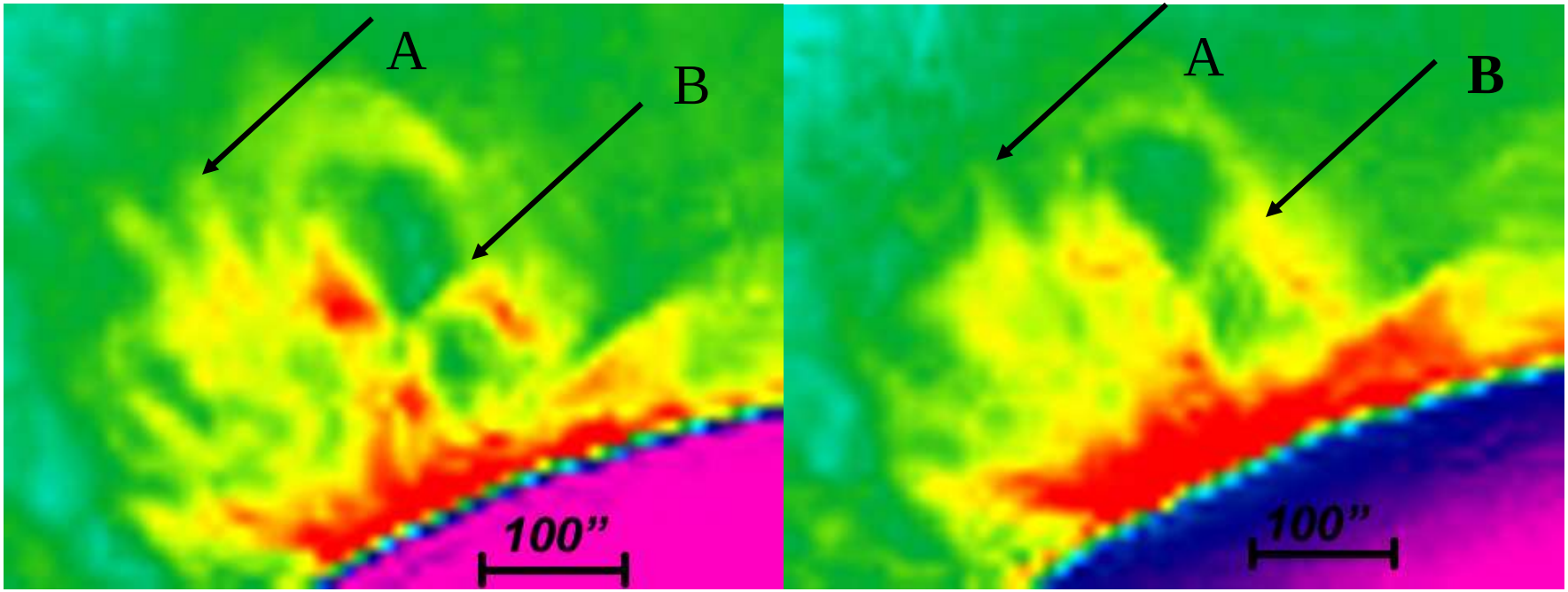
Described streamer is located above active regions NOAA10212 and 10213 where during the previous night and morning hours of December 4th the activity on SOHO EIT was observed. Next day the LASCO pictures show emphatic activity above this region (see http://sohowww.nascom.nasa.gov/).

2005 total solar eclipse



The time delay of 84 minutes between images taken by Miloslav Druckmüller and Peter Aniol aboard the Discovery ship (Image 1, April 8th, 2005, 19:51 UT) and images taken by Fred Espenak aboard the Galapagos Legend ship (Image 2, April 8th, 2005, 21:15 UT) enabled to find significant changes in the inner corona. More significant structural changes are visible on the are signed „A“ on both images, lying above active region NOAA 10747.

2005 total solar eclipse



On both enhancement pictures we can see dynamic moving of loop signed „B“ as well as the significant structural changes in the area „A“.

The speed of this moving is about 4 km/s.