ON THE EXPLANATION OF THE CONFINED TWO-RIBBON FLARE WITHOUT FILAMENT ERUPTION

Vasyl' B. Yurchishin
Crimean Astrophysical Observatory, 334413, Nauchny, Crimea, Ukraine

ABSTRACT

The model of the magnetic field configuration in two-ribbon flare is presented. The model is based on the reconnection of two large-scale closed magnetic field structures. In difference of the Kopp and Pneuman configuration, the model discussed does not suggest destabilization and eruption of the active region filament. Calculations of coronal linear force-free field shown that in the corona the necessary magnetic structures exist, and chromospheric flare ribbons in two-ribbon flare are located on the intersection of the separatrices with the photosphere. This inference strongly support the idea that some two-ribbon flares are result as reconnection process between two (or more) large-scale closed magnetic field structures.

1. Introduction

It is widely accepted that two-ribbon flare (TRF) is due to reconnection process which happened in previously opened magnetic field (Sturrock, 1968; Hirayama, 1974; Kopp and Pneuman, 1976). Now it is well known as Kopp&Pneuman model (K&P) (Kopp and Pneuman, 1976).It is suggested there that after the filament destabilization and eruption the opening of the stretched magnetic field lines took place. This process is accompanied by the IV type radio burst.

However, there are some observational aspects that cannot be resolved in the frame of the K&P configuration: 1) approximately 30% of TRFs rise without the filament destabilization and eruption (Hirayama, 1974); 2) it is well established that the IV type radio burst does not accompany some TRFs (Ogir, 1967); 3) what is the relation between TRF and the giant X-ray arch appearance (Švestka, 1984)?; 4) why do the chromospheric flare ribbons extend to the leading spot?; 5) why the footpoints of the post-flare loops do not cover whole area of the chromospheric ribbons (in some TRF) as one may expect from K&P configuration?.

According to above we suggest that some TRFs require a magnetic configuration that differ from K&P model.

2. Model Proposed

Proposed configuration is based on: 1) thermal fronts and accelerated particles travel down to the chromosphere along the magnetic field lines; 2) flaring sites indicate the magnetic flux which take part in the reconnection process (Demoulin et al., 1993); 3) reconnection of the two (or more) *closed* magnetic loops.

So, if we observe a TRF with the flare ribbon extended into the spot (like that on the Fig. 1, see figure captions) we may suggest that some fraction of the magnetic field of the sunspot takes part in the reconnection process. Besides, if there is no filament eruption (as in our case) this may imply that there is some other magnetic field configuration, and the reconnection process in it can form the observed features. What is this magnetic configuration? Let us try to discover it by using the linear force-free field (LFFF) approximation.

3. Observational Data and Calculations

According to B.C. Low (1996) in decaying phase of the active region evolution some of the biggest flares occur, usually in the form of TRF. The same is for the TRF on October 16, 1993 that has been observed in the Hα line center with the Crimean chromospheric telescope KG-1 (Fig. 1).

Theoretical findings by Heyvaerts and Priest (1984) led us to a conclusion that the coronal magnetic field configuration close corresponds to the LFFF configuration in the decaying phase of an AR evolution. It allows us to use the numerical method for the LFFF calculation recently proposed by Abramenko and Yurchishin (1996, 1997). As photospheric boundary conditions we took the vertical magnetic field of the AR 7597 obtained on October 16, 1993 with the SMFT of HSOS of Beijing Astronomical Observatory in the FeI λ 5324.19 Å (Fig. 2). The numerical solution was obtained inside some 3D volume above the active region. This enable us to calculate the location and shape of lines of force of the LFFF. Further, we have calculated the locations of the intersections of the separatrices with the photosphere (ISPh). Such a procedure was made as follow: calculating the lines of force we determined the locations where there is strong change in field-line linkage (Demoulin et al., 1996). It is worth to note that we have determined the location of the ISPh only in places related to the strong vertical magnetic field. The results of the calculations are presented on the Fig. 3 (see notifications in the figure caption).

From the Fig. 3a one can see that in the atmosphere of the AR 7597 there are two large-scale magnetic structures which connect the main spots with the magnetic islands inside the AR. From analysis of the daily magnetograms we have inferred that the magnetic S polarity island (dashed line at the middle of the magnetogram) moved forward to the magnetic structure of N polarity. As a result, the large scale magnetic structures become more deformed and stressed. We suggest that the reconnection between two (or more is some complicated cases) large-scale magnetic structures can give rise to the TRF. The good correspondence (apart from poor coincidence in south-eastern part of the AR) between the locations of the ISPh and the chromospheric flare ribbons is a evidence for such a suggestion (Fig. 3b).

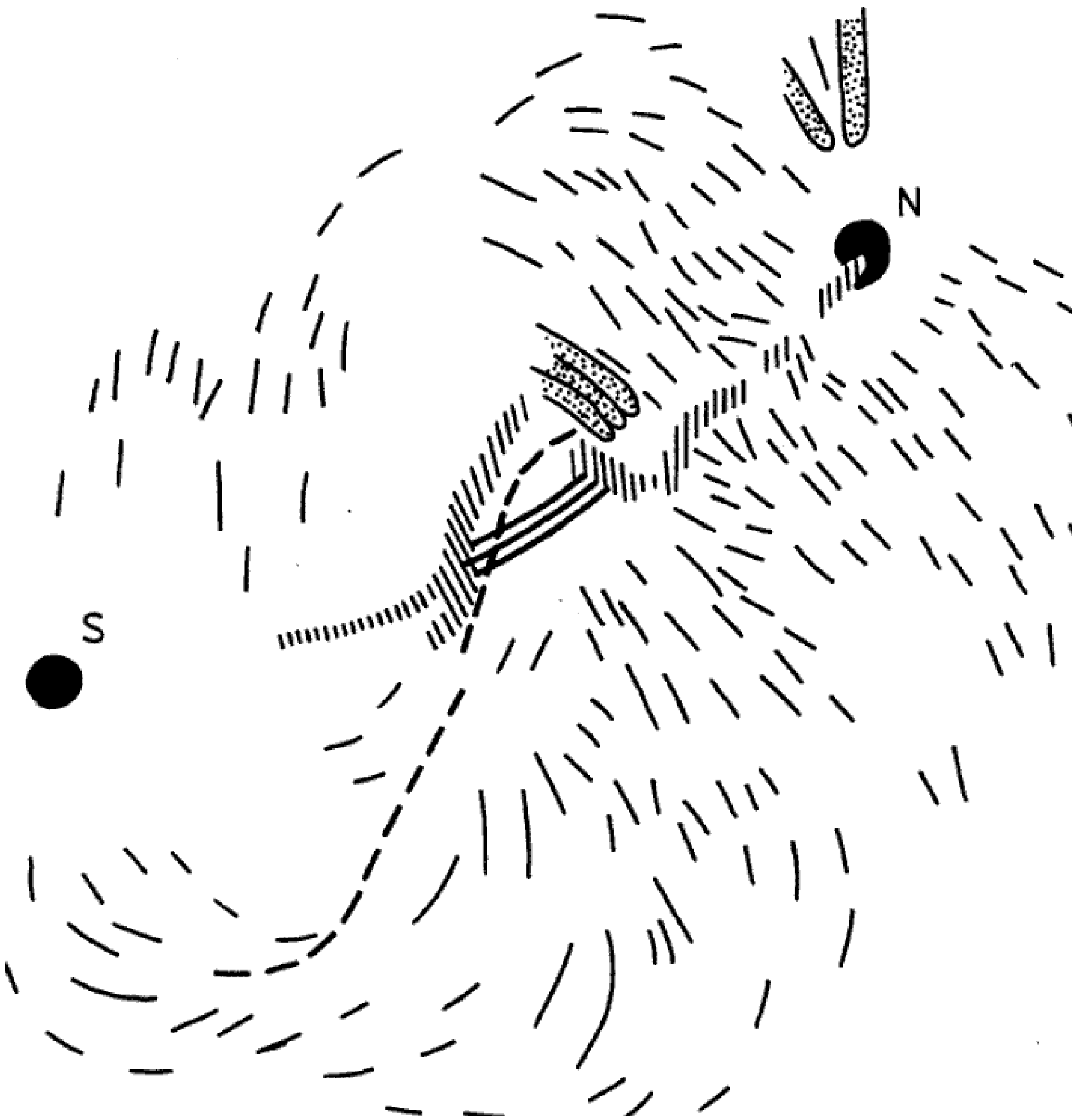

Fig. 1.— The cartoon of two ribbon flare on October 16, 1993. The dashed area marks the location of the flare ribbons.Short havy segments — chromospheric fibrils. Dark areas — sunspots. Dotted area — location of chromospheric surges. havy dashed line denote location of photospheric neutral line, while havy lines in the middle of picture show location and orientation of the post-flare loops system

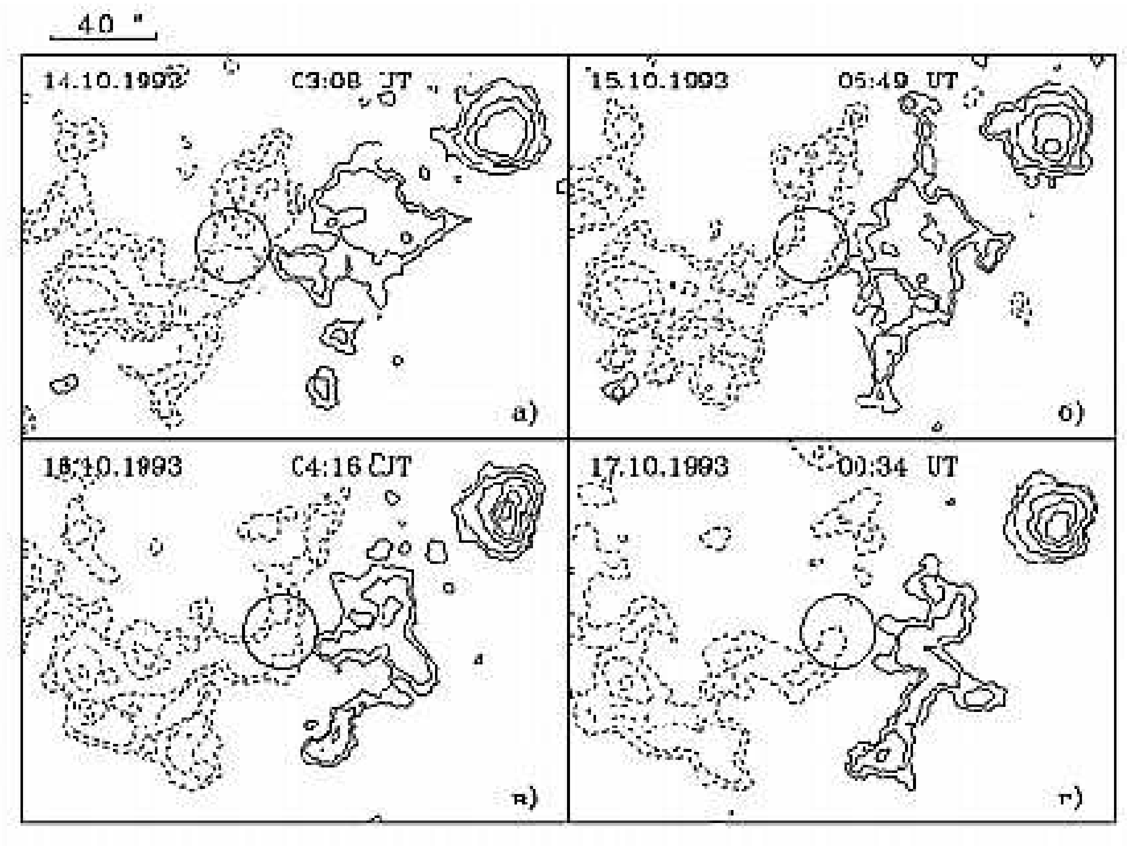

Fig. 2.— Maps of vertical magnetic field of anAR 7597. Circle marks a magnetic structure which moved westward during several days before the flare

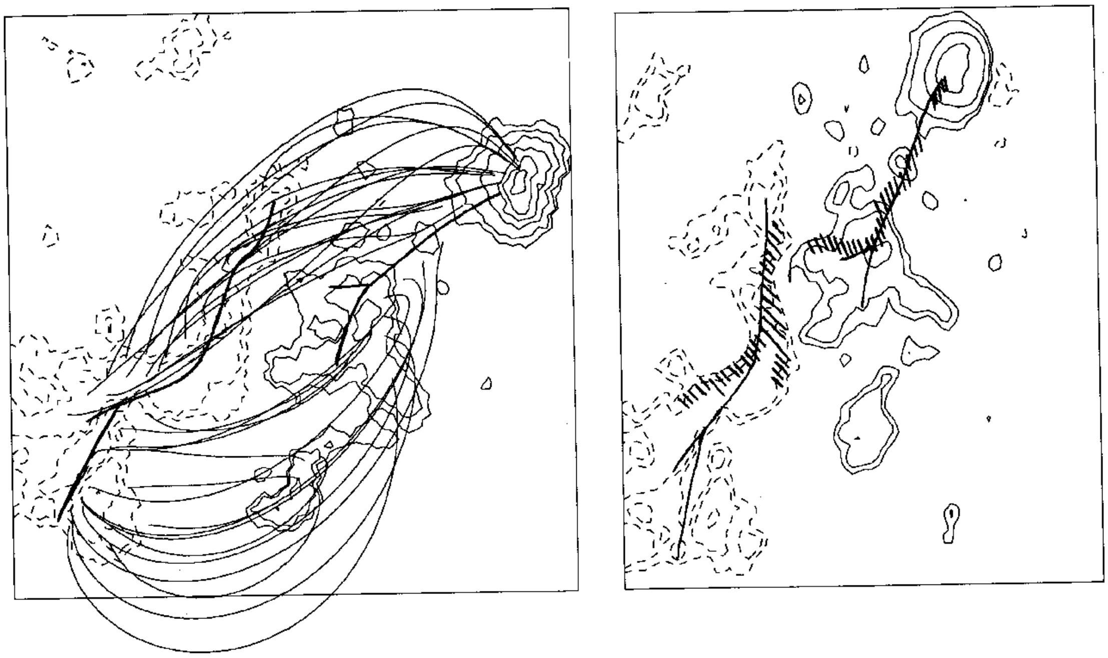

Fig. 3.— The map of vertical magnetic field (helio plane, N polarity – solid line) is overlapped by the lines of force of the linear force-free field. The intersections of the separatrices with the photosphere are plotted by heavy lines (Fig. 3a). For the best fit between the flare ribbons and the intersections of the separatrices with the photosphere the last ones where projected into the image plane (Fig. 3b, heavy lines). The dashed area marks the location of the flare ribbons

After the reconnection ended we may obtain two new loops systems (Fig. 4). The small low laying loops system (loop 1) corresponds to the post-flare loops system that is observed in X-ray and visual spectral lines. The large scale magnetic structure (loop 2) that connects two main spots may be a giant coronal arch that is observed in X-ray after the flare onset (Švestka et al., 1982). This suggestion is also in a good agreement with the Šimberova, Karlicky and Švestka (1993), conclusion that the giant arch is the result of "progressive reconnection of elementary flux tubes of two (or more) interacting loops".

REFERENCES

Abramenko, V.I., Yurchishin, V.B.: 1996, *Sol. Phys.* **168**, 47

Abramenko, V.I., Yurchishin, V.B.: 1997, *Kinematics and Phys. Celect. Bodies.* **13**, N. 3, 49

Demoulin, P., van Driel-Gesztelyi, L., Schmider, B., Henoux, J.-C., Scepura, C., Hagyard, M.J.: 1993, *Astron. Astrophys.* **271**, 392

Demoulin, P., Henoux, J.C., Priest, E.R., Mandrini, C.H.: 1996, *Astron. Astrophys.* **308**, 643

Heyvaerts, J., Priest, E.R.: 1984, *Astron. Astrophys.* **137**, 63

Hirayama, T.: 1974, *Sol. Phys.* **34**, 323

Kopp, R.A., Pneuman, G.W.: 1976, *Sol. Phys.* **50**, 85

Low, B.C.: 1996, *Sol. Phys.* **167**, 217

Ogir, M.B.: 1967, *Izv. Krym. Astrofiz. Obs.* **37**, 94

Šimberova, S., Karlicky, M., Švestka, Z.: 1993, *Sol. Phys.* **146**, 343

Sturrock, P.A.: 1968, in *IAU Symp. 35: Structure and development of solar active regions*, ed. K.O. Kiepenheuer, 471

Švestka, Z., Srewart, R.T, Hoyng, P., van Tend, W., Acton, L.W., Gabriel, A.H., Rapley, C.G. and 8 authors: 1982, *Sol. Phys.* **75**, 305

Švestka, Z.: 1984, *Sol. Phys.* **94**, 171

This preprint was prepared with the AAS LaTeX macros v4.0.

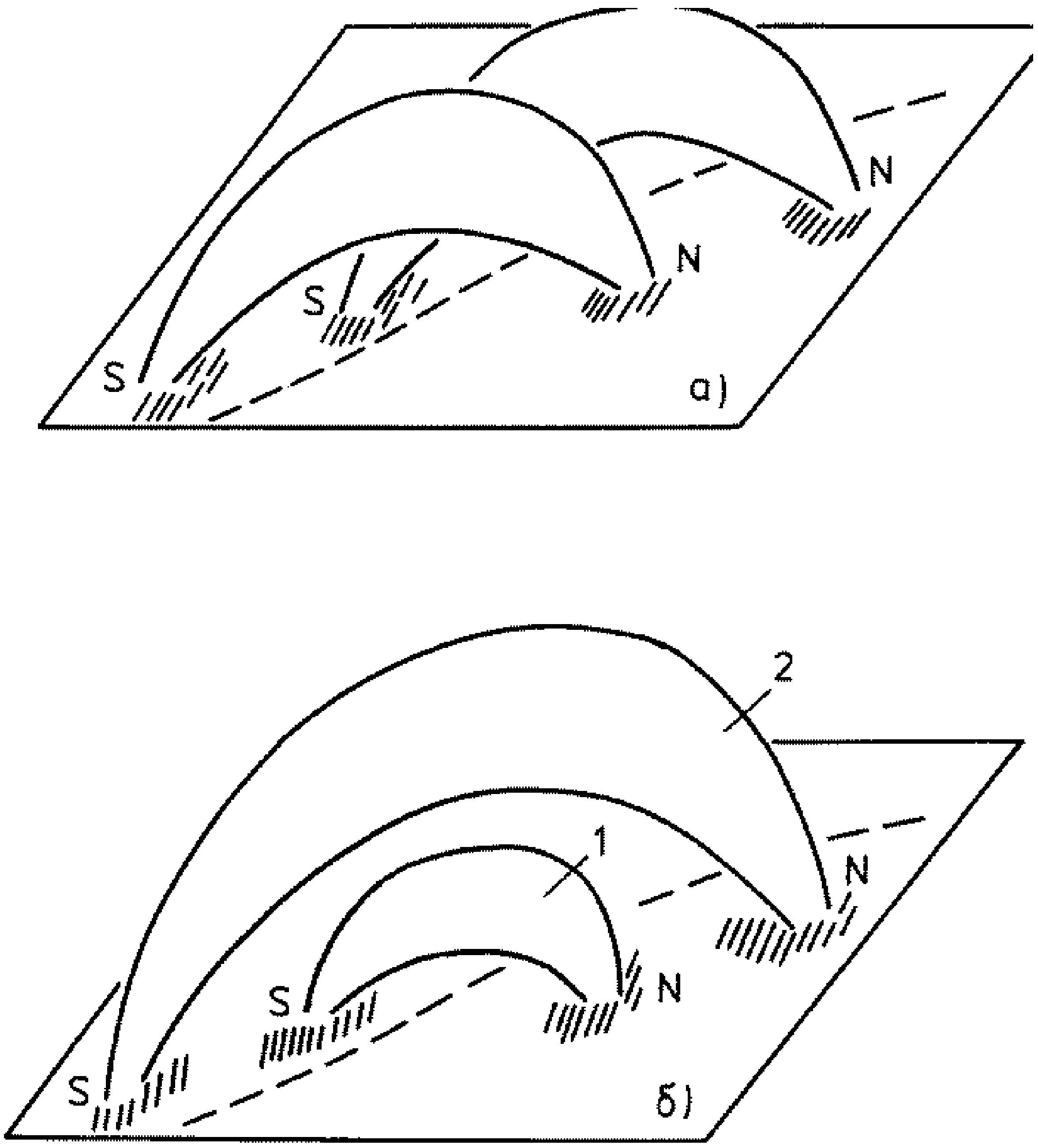

Fig. 4.— The sketch of possible magnetic configuration in the October 16, 1993 two-ribbon flare

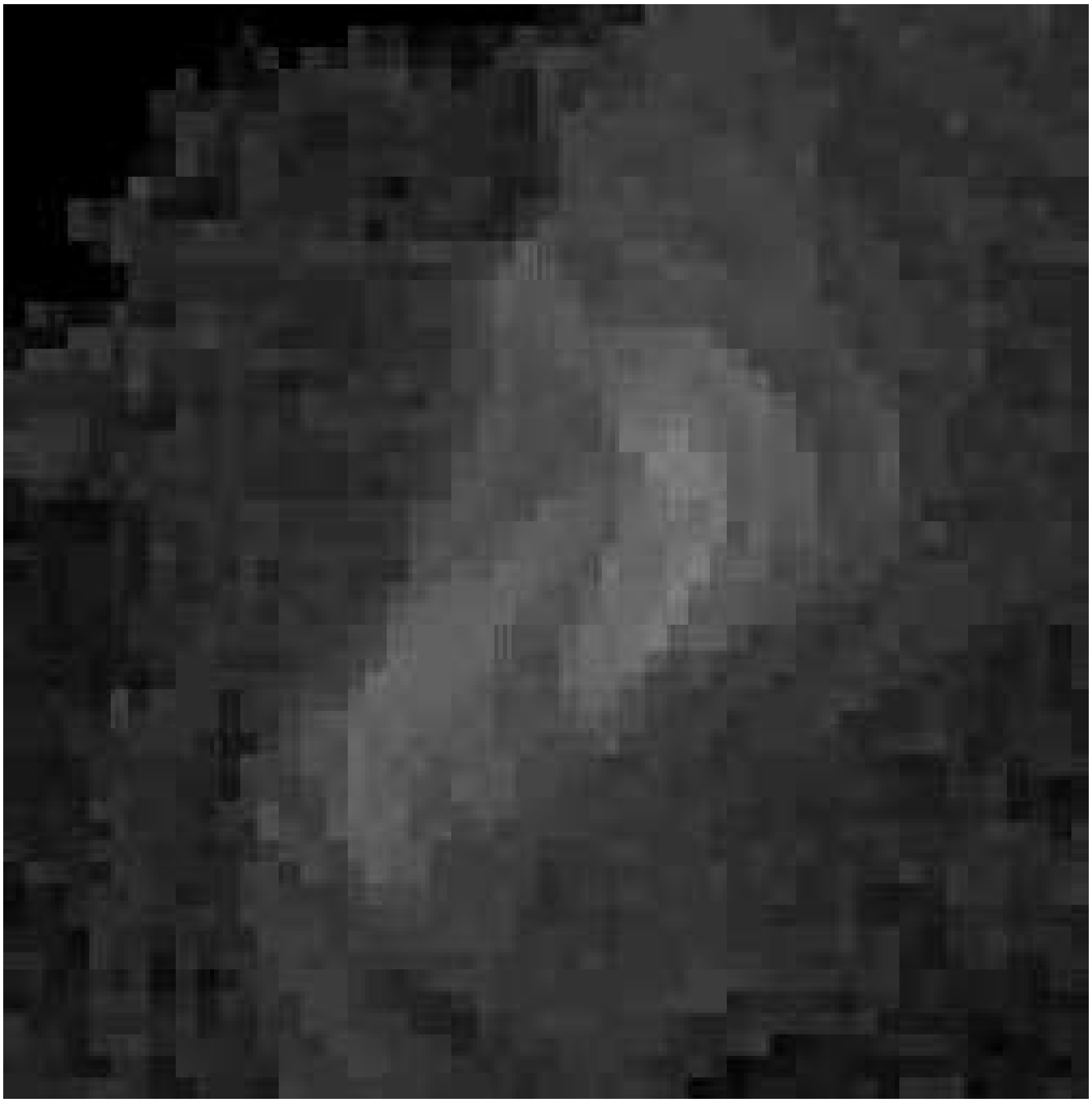

Fig. 5.— An example of SXT/YOHKOH coronal magnetic loop (AR unknown) which closely resembles the calculated force-free loops (Fig. 3)