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Research Program of International Geophysical Year (Igy-1957) Have Ended In the Millennium Beginning By Discovery of the Theoretical Current Sheets in the Nature

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Abstract: *We declare about the discovery in the Nature of theoretical current sheets by S. I. Syrovatskij. The first "natural" current sheet was discovered in flare spectrum, calculated and researched experimentally. The current sheets (CS) are found in chromosphere and downward levels in optical range data. The main problem of physics of solar flares has been solved. Magnetic field energy is a primary source of active processes in solar plasma. Current sheet (CS) of S. I. Syrovatskij is the mechanism of magnetic energy transformation into plasma energy. The current sheet is not discovered in a flare, as expected. As a matter of fact, solar flare is in itself a current sheet, its direct observed development in chromosphere plasma. Continuous current sheet radiation is the «black» (BLF) and the «white» (WLF) flare (like light of Sun photosphere). It is the* **negative hydrogen ion excitation** *upon reaching hydrogen plasma density of >5 10^{17} cm^{-3}.*

Keywords: *current sheet, solar flare, optical spectra, flare "kernel", pinch-effect, line profiles, CME, tsunami, the Sun, multichannel photometry, hydrogen negative ions.*

I. INTRODUCTION

During 50 years of active study of solar flares close relationships between flares and magnetic fields have been established well (Severny, 1954, 1957, 1958). In 50-60th years, the large solar flares have look to like chromosphere increases of brightness only, which occupy large areas (up to 10^{-3} of a visible hemisphere of the Sun) (fig.1.5.1) and often in the form of two ribbon flares (fig.6.1.1). Only indirect spectral and temporal data on flares pointed to the close linkage of this phenomenon with magnetic fields. These ribbons are located in areas of magnetic fields of opposite polarity. Profiles of spectral lines in the models of spatial heterogeneous entities, as well as detailed theoretical calculation of radiation of solar flares of varying power, convincingly reiterated the magnetic nature of flare events (Ostapenko, 1981, 1985, 1997). All these international studies the previous 50 years, especially of Severny A. B. and Syrovatskij S. I. investigations, showed that the most likely mechanism of flare occurrence may to believe the current sheets. Namely the *CS is able of to* provide the conversion of magnetic fields energy in the energies of plasma radiation, accelerated plasma flows, and charged particles (Heyvaerts, 1985). The real existence of the current sheets in the nature proven in result of directed researches by Ostapenko (2011, 2012).

This is "giant leap in plasma physics" (Matthaeus W. H., 2016) that allowed the appearing of large scientific programs with the using og most modern and costs space equipment. Delaware Space Group Co are involved in the project, which aims to understand magnetic reconnection, a process that produces powerful phenomena including solar flares and large releases of plasma from the Sun's corona (fig.1&2). Enormous amounts of new quality data now are arriving daily from NASA's Magnetospheric Multiscale Mission (MMS), which was launched in March 2015. Flare observations have showed that this is one event out of thousands so it is just the beginning (Severny, 1954-1958). Shay M. studies the electron diffusion regions, areas where the Earth's magnetic field breaks and reconnects with the interplanetary magnetic field. It is in those regions that scientists hope to learn how reconnection occurs. Using four identical spacecraft, flying in formation, the MMS Mission makes it possible to get high-resolution measurements of the particles and the electric and magnetic fields at the electron scale, with time stamps marked in milliseconds. To do it, the spacecraft sensors gather measurements of the plasma and the electric and magnetic fields within a very narrow (2-kilometer) and fast-moving area (50 km/sec) where the Earth's magnetic field and the solar wind meet. Those areas are called electron diffusion regions. Magnetic reconnection, which releases kinetic energy and heat, is most likely to be observed in those regions. Understanding the area where the reconnection occurs has been impossible without computer and laboratory modeling. With these instruments now on duty, direct observation is possible.

II. THEORETICAL CONCEPTS OF CURRENT SHEETS

Solar flares are believed by co-workers of Syrovatskij in the 70th arise in result of the current sheet breaking. The zero line of the magnetic field with an electric field directed along this line is arisen in the breaking place (Somov, Syrovatskij, 1974). The acceleration process of particles is consisted of both the direct acceleration of electric fields near the neutral line and the Betatron acceleration in the drifted area. The parameters of plasma flows of near the zero line have been obtained by S. I. Syrovatskij (1975). The rapid conversion of magnetic energy into heat can occur if conditions at the edge of the neutral line change fast enough (Priest, Raadu, 1975; Priest, 1976).

Сыроватский
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The current sheet that arose as a result of the new magnetic flow emerging has a lower temperature than the environment (Heyvaerts, Priest, 1976). But low-temperature equilibrium is impossible in some critical height. A current sheet starts to heat up quickly, trying to find a new state of thermal equilibrium. Then, in the plasma can be aroused non-stationary processes that must lead to anomalous resistance. The rapid restructuring of the flows on the zero line induces the electric field accelerated the particles to high energies.

Theoretical models are widely used the hypotheses that the main flaring process driven by the current sheet formation in the corona (Syrovatskij, 1977). The presence of oncoming magnetic fields is by the condition of the creation of the *CS*. An excess occurrence of magnetic energy and their currents over photosphere are believed by next manner. Movements of sources (currents) under photosphere change the potential magnetic fields in the atmosphere of the Sun. In suitable magnetic configurations arise so-called the boundary force line. They are common for several independent magnetic fluxes. Redistributing magnetic fluxes are resulted through these boundary lines. This process is a necessary consequence of the trend of magnetic fields into least energy state. The field must remain potential while its sources changing at photosphere. But, since the advent of current lines, the electric field induced by changing magnetic fields has caused currents along these lines.

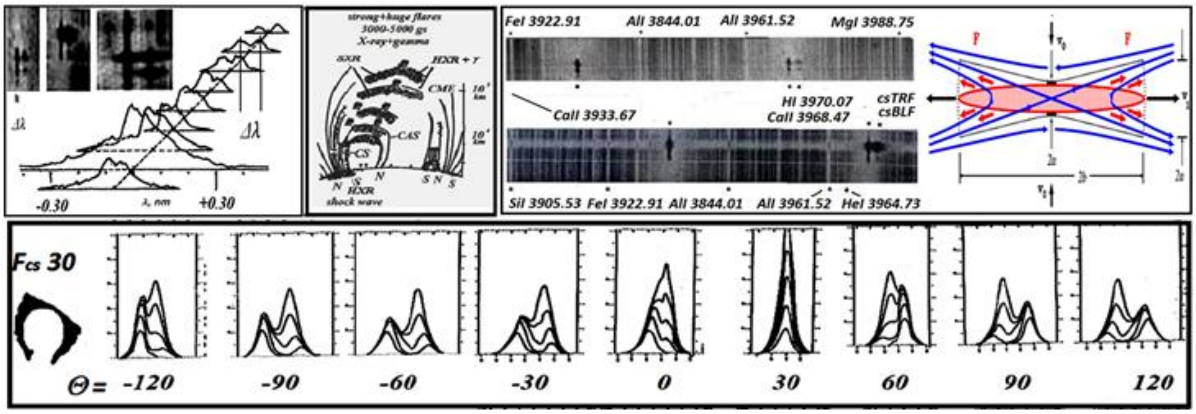


***Fig.1a.* The manifestations of current sheets in flare spectra**: The (importance *Sn*) 06.09.1957 faint flare (in top; Kurochka & Ostapenko, 1970); and the (importance 2n) 12.07.1961 big flare (Svestka, 1976). The *CAS* is shown by both discrete emission of the broad lines of hydrogen, and narrow emission of metals lines, as well as by BLF (or WLF) strips radiation in the continuous spectrum. The flare «kernel» or the new compact arch system (*CAS*) has emerged under extended arch systems (*EAS*) of active regions and in the contact and interaction place between *CAS* and *EAS* magnetic fields is formed the current sheet (*CS*).

***Fig.1b.* There are of two states of the CS (current sheet)**. (a) A before-flaring current sheet has shielded the interacting magnetic flows of opposite directions. (b) A flaring «super-hot» current turbulent layer that has an abnormally low conductivity. This leads to a rapid process of reconnection during flares. The short thick arrows v_0 are a speed of plasma that coming into the layer, the long arrows v_1 are a velocity of plasma that coming out from the layer. *2a* is thickness of the CS layer, *2b* is its width. Arrow keys *F* are heat fluxes «superhot» plasma and accelerated particles along field lines (Somov, 2006).

These currents, due to the interaction with the magnetic field, take the form of a current sheet. Even in the conditions of any high conductivity, the current sheet provides fast dissipation of magnetic fields (Syrovatskij, 1977). This effect caused by the emergence of large gradient of a magnetic field in the *CS* and is very significant for processes in space plasma. In current sheets the restructuring of magnetic force lines is made. The process is accompanied by a change in the topology of magnetic fields. *Flares is believed occur in* *result of the current sheet restructuring*. The flare energy accumulation is done in the form of the magnetic energy so as the *CS* prevents redistributions of the magnetic flows.

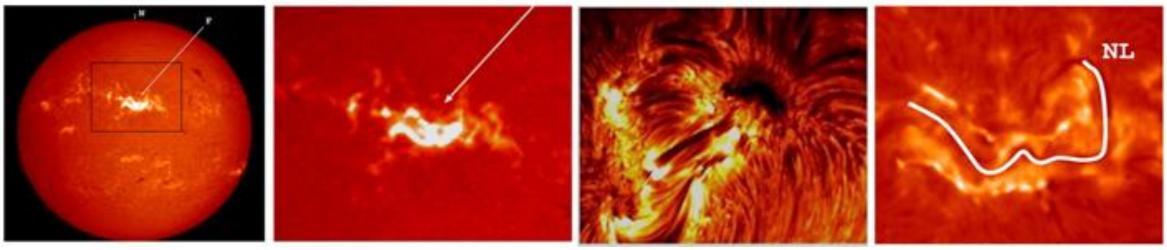


Fig.2. **Solar flares on the solar disk and the neutral line of the Separator** (Somov, 2006).

A, *b*. A large solar flare of July 14, 2000 is photographed at a spectral line H_α (6563 Angstroms).

c. The Sun's chromosphere structure of 22.08.2003 in the hydrogen H_α-line (Solar 1-m telescope of the Swedish Academy of Sciences).

d. The «two-ribbons» July 14, 2000 solar flare as in the chromosphere, located on opposite sides of the neutral line NL of the magnetic field. The neutral line is by the line of the change of sign of the vertical component of the magnetic field.

The development of space researches showed that solar flares are a very wide range of processes and phenomena in all ranges of wavelengths from radio to *γ*-ranges on all virtually altitudes in the atmosphere of the Sun. The main part of the flare power is released in the form of kinetic energy of plasma flows of the velocities in the space up to 1000-2000 km/s. In the chromosphere lines (H_α) solar flares observed as significant brightness increase of restricted areas of the solar surface. So, during many years has used the term «chromosphere flare».

In General, the current sheet is magnetic plasma two-dimensional structure because of input plasma in a layer and output from it are in orthogonal directions (fig.1b). In strong magnetic fields the layer width (2b) is a lot more than its thickness (2a). This is important because the wider current sheet the more energy it can accumulate in the interaction of the magnetic fluxes. Meanwhile, the thicker layer the greater the dissipation speed of accumulated energy (Pikel'ner & Tsytovitch, 1975). The role of topological large scale magnetic fields and plasma phenomena in the process of reconnection has been revealed in result of space researches. Somov (1985) proposed the model that connects the vortex plasma flows in the photosphere with the advent in the corona of special magnetic lines (separators). The separator may to appear on magnetic field maps by S-shaped bending of photosphere neutral line.

III. SHOCK WAVES ARE THE EXPLOSIVE DESTRUCTION OF CURRENT SHEETS

Shock waves (tsunami) move very quickly, passing for minutes of all the Sun and destroying the fibrils. But powerful tsunamis are by rare events. In *CAS* models with a *CS* compacted layer of plasma the appearance of shock waves on photosphere and flares with cumulative plasma ejections are associated with the model of a vertical *CS*. In this model, coronal mass ejections (*CME*) and shock waves (tsunami) are by phenomena that accompany of each other. But the tsunamis have difficulty fixed then as *CME* are registered by *SXR* & *HXR* bursts. The set of 9 images AR 10930 obtained (18:15-18:51 UT) with OSPAN in H_α 6562.82 Å line, shows the development of tsunami-like phenomena together with the CMEs (plasma flows in upward) during the *csWLF* 06.12.2006 (NSO/AURA/ NSF&USAF Research Laboratory- APOD-13.12.2006). The solar telescope in New Mexico also registered the tsunami on 06.12.2006 at 18:28 UT, which have been gone around the visible surface of the Sun.

A large solar flare can be associated with radio emission, depending of the frequency and time after the flare. The impulsive flare phase lasts ~10 minutes and is associated with a strong microwave burst. Dynamic spectra at frequencies of about 10^8 Hz, show type II and type III bursts that drift from high to low frequencies as time goes on, but at different rates depending on the type of burst. It is the height at which the coronal electron density yields a plasma frequency. Continuous emission of negative ions of hydrogen shows both the photosphere and CS layer. Shock waves, plasma and charged particles are the second side of the energetics of hydrogen plasma with magnetic fields.

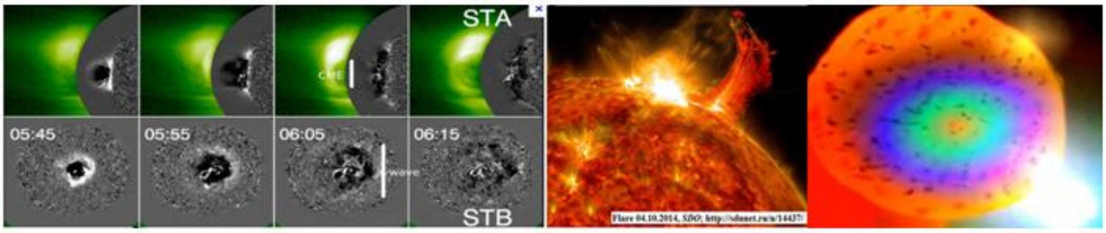


Fig.3. Shock waves and tsunami of powerful flare events.

a. Solar Flare on 28.07.2010. The *STEREO* views of the coronal wave event. http://www.nasa.gov/ mission _pages/stereo/news/solar_tsunami.html

b. The CS area of the 04.10.2014 powerful solar flare.

c. The most powerful flare on 02.08.2010 - www.youtube.com/watch?v= MPxBIYSYCUQ& feature=related.

CME-1 (plasma clouds, the shock wave) & *SME-2* (red, down) is the tsunami on the photosphere.

The solar blast that NASA classified as an *M-2* explosion erupted from the Sun in an impressive display captured by the space agency's cameras (fig.3). A large plasma cloud mushroomed up out of the Sun and fell back down, appearing to cover half of the solar surface. The great amount of material has been lifted up in solar corona. There wasn't much going on with this spot, but as it came from behind the Sun, all of the sudden there was a flare and huge *CME*. Spectral data analysis that is performed by the author shows the confidence that solar flares (chromosphere current sheets) are by 3D phenomena in the optical range also. Large flares scenario and principal physical processes of the *CS* followed by S. I. Syrovatskij conclusions. The *CS* is formed in chromosphere in the place of contact of the new compact (*CAS*) magnetic field and pre-existing extended (EAS) arch systems in active regions as it follows yet from the first observations (Priest, 1976; Rust, 1976).

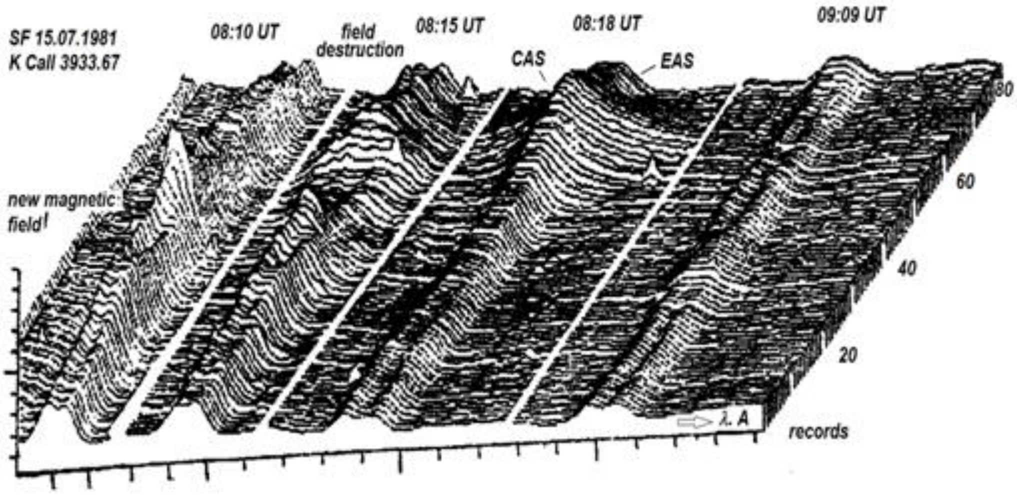


Fig.4. The emergence process of the new magnetic flux (08:10 UT), destruction of the magnetic field of extend arch systems (*EAS*) of the active region (08:15 UT), and the formation of the compact arch systems (*CAS*) with the current sheet (08:18 UT) in the 15.07.1981 flare in *K CaII* 3933.67 (Ostapenko, 1997; 2011, 2012).

The first moment of the CS forming is detected has means already time of the flare beginning (fig.4). Own the CS compacted layer is observed in the continuous spectrum as the *csBLF* or *csWLF* flare strip. Metals lines (many of them in radiation) are formed in the CS layer. The *CAS* model of the compact arch with the *CS* (Ostapenko, 2011) allows explaining a whole range of related flaring phenomena. So, the flow of plasma *4* (to upward) is registered as the surge or the radio burst of III type. The flow *2* is throwing a return ejection. The plasma flow from the CS downward is manifested as intense X-ray radiation (*HXR*) and specific profiles of spectral lines in the optical range (Ostapemko, 2011, 2012).

The contact place of *CAS* & *EAS* arch systems is the so-called flare «kernel» in the spectrum (fig.4; 08:18 UT). Especially powerful *csWLF* flares occur in strong magnetic fields, when the *CS* plasma density N_{cs} $>10^{18}$ cm^{-3}. Strong plasma turbulences are resulted in the *CS* the explosive destruction of *CAS* & *EAS* arch tops that we see as the coronal mass ejection (*CME*) and tsunami as well as the huge *SXR* & *HXR* emissions and radio IV type bursts in the corona. The shock wave (tsunami) has passed over the surface of the Sun with a speed of >600 km/s (APOD-13.12.2006). The majority of flares never reach the stage of plasma turbulence. Everything depends only of the effective strengths of magnetic fields. This fact allows us to connect the observed flare view and its importance (or power), extension wings of hydrogen and *H&K CaII* lines and the presence of white (*WLF*) or black (*BLF*) emissions in *CS* layers with strengths of magnetic fields of the *CAS* & *EAS* arch systems.

IV. THE OBSERVED PHYSICAL CHARACTERISTICS OF FLARE CURRENT SHEETS

Current sheets (the *CS*) are well observed in the spectrum of optical wavelength range. A flare (or a *CS*) is located in chromosphere (but not in corona) with all the consequences that this entails. The discovery in the spectrum and the explanation of the «black» *csBLF* flare (Ostapenko, 1997) has been allowed to identifications the *CS* after the *UST* solution. The all scenario is done in accordance to the *CS* Syrovatskij theory (1974). The current sheet is representing in the spectrum in the form of flat compacted layer of chromosphere plasma (Ostapenko, 2006). Radiations of metals lines are arising namely in this CS layer (in the background of the *csBLF* strip). Their thermal radiation is providing by «photosphere» plasma densities ($10^{14}<N_H<10^{18}$ cm^{-3}) and by more high temperatures (9000 ºK) relatively quiet photosphere (6000 °K). Physical CS characteristics are found by coherent solution system of *UST* equations both for discrete emissions of hydrogen atom and radiation transfer of the negative ion of hydrogen in a continuous spectrum. The original model of flat plasma layer is a inadequate model of the formation conditions of the hydrogen line profiles that are formed in the spatial *CAS* structures of a new magnetic flux. Moreover, the correct obtaining of these profiles (impulse components) on the background of extended systems of the arch arcades of the active region (slow emissions components) is practically impossible (fig.1).

But solutions of the system of *UST* equations are acceptable fully for the analysis of the CS layer. The emission of the hydrogen negative ion in a continuous spectrum is responsible for the appearance of photospheres of the most stars. Maximum of the continuous radiation lies in the optical range that is provided by real plasma parameters: ($n_e=n_p$; temperature ~9000 °K, and plasma density of ~10^{18} cm^{-3}). Real spectra of stars actually confirm this low temperature dependence of spectrum. From the theory of the internal structure of the Sun it is known that the plasma density 10^{18}-10^{22} cm^{-3} corresponds to the upper and lower bounds of the convective zone and diapason of highs in 0.7-1.0 R_Θ. The coincidence of our calculations results of the *UST* equations system and the standard model of the Sun is a testament to the accuracy of our data. Spectra flares photometry with the *MF4A* shows (fig.5, 6) that the appearance of the *csWLF* (reaching the plasma density of 10^{18} cm^{-3}) means the beginning of plasma turbulence in CS that is accompanied by a sharp change in the conductivity of the plasma and, as a consequence, the disappearance of metal lines in the spectrum. The start of turbulence in CS proved connected with the destruction of the current sheet and it means the end of the flare, but not its beginning, as it believes of the flares theory. Photometry shows the end of the plasma acceleration in CS (the disappearance of wings of hydrogen and H&K CaII lines).

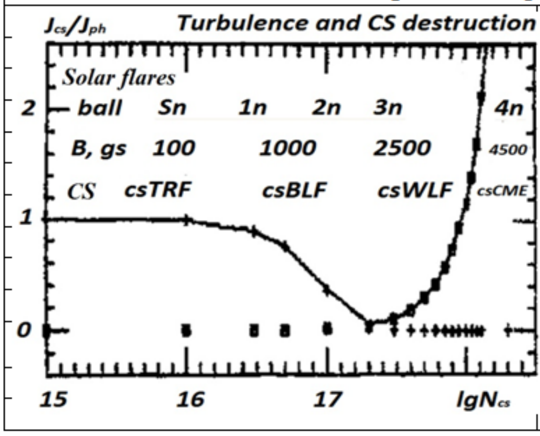
A compacted CS layer (fig.1b) has been formed at the contact place of the magnetic fields of opposite directions. Plasma by freeze-in magnetic fields is compacted in the contact place of oncoming magnetic fields and is thrown out of both CS ends and is accelerated by the magnetic pull of force lines after their reconnection in a compacted layer of the *CS*. The initial CS plasma density of the natural way is equal to the ambient chromosphere density (10^{11}-10^{13} cm^{-3}). The informative picture (the fig.5 has been obtained for L_{cs} = 10^3 cm) for intensity of current layer shows that for most flares the current layer is transparent (*csTRF*) for the photosphere radiation (for N_{cs} <10^{16} cm^{-3}). These densities are resulted by relatively weak magnetic fields that cause the speed of plasma flows V_{cs} ~80-250 km/s (Северный, 1958). At the same time, the first Balmer hydrogen lines and some stronger metal lines are already observed in the weak flares. For their appearance plasma densities are sufficient of N_{cs} >10^{14} cm^{-3}. The required emergence of new magnetic flux at the beginning of the flare (Rust, 1976; Priest, 1976) and the *csBLF* flare appearance (Ostapenko, 1997) as well as the our simulations of the continuous emission allow to present the fact of the flare beginning as the occurrence of the CS.

Solar flare itself is by the current sheet. Observations are well showing the allegiance of the calculated evolution of the current sheet (fig.6). The spectra of 15.07.1981 flare (Ostapenko, 1997) for the first time demonstrating the new emergence magnetic flux as the causal evidence of this flare. The flare evolution (read as the current sheet) is the process by progressive growth of plasma density in the CS layer to its maximum value, which is determined by only the strength of magnetic fields in the place of their clash. If so, we should observe a similar global development of any flare. And it is really so we see both in fig.5, 6 and in observations summary of spectral patterns, the appearance and the evolution of flares (Svestka, 1976, p,51 & p.300). The initial phase of the development of a strong flare will be identical by a weak flare. But, more power flares will be to evolve more to the limit, which is only determined by the value of plasma density in CS layer (magnetic fields strength according to the ratios of $B^2/8\pi=N_{cs}kT$). Most flares occur in magnetic fields strength <1000 Gs and this CS is transparent (*csTRF*) for photosphere continuous radiation. Any flare ending means a complete emergence a new flux and the processes ending of power lines reconnection. Any *csBLF* flare occurs only for middle and strong flares (fields ~2000 Gs). The most powerful «white» *csWLF* flares are associated with plenty of strong magnetic fields (>3000 Gs), when the CS plasma density reach values of N_{cs} >10^{18} cm^{-3}. But, then the plasma of the CS layer is turbulence and the CS collapses. Especially powerful flares are accompanied by the same powerful plasma ejections (fig.3): CMEs (upward), tsunami (downward), and radio bursts IV type. But it always comes to one and the same process of the CS formation and evolution of the flares that generally regarded as the one *cs(TRF-BLF-WLF)* evolutionary development of the CS.

V. THE CS(TRF-BLF-WLF) EVOLUTION OF CURRENT SHEETS

For 50 years of solar flares studies the spectral flares features of all powers and evaluated physical and spatial characteristics of optical emission are investigated in details. Summary of observed flares characteristics that should consider any flare theory is represented in works (Svestka, 1976; Ostapenko, 1981, 2011). Analysis of spectral lines profiles of compact arch systems (*CAS*) of a new magnetic flux (fig.1, 4; Ostapenko, 1997, 2011) and extended arch systems (*EAS*) of active regions is made by Остапенко et al. (1985). Calculations of the line profiles of hydrogen have shown the complex three-dimensional structures and the presence of intense plasma flows in the range of optical emission. This leads of the author to the model of flare in the form of a compact arch with the current sheet (fig.1).

Table 1. Magnetic and optical classifications of solar flares



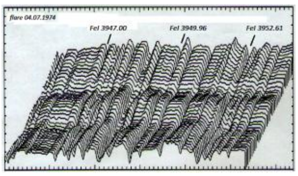
Ball	*Sn*	*1n*	*2m*	*3n*	*4n*
CS	csTRF	csTRF	csTRF	csBLF	csWLF
m.field, gs	200	500	1100	2300	4600
H_α $\Delta\lambda$ Å	2	5	10	20	40
V_{cs} ***km/s***	80	150	250	500	1000
N_{cs} ***см***$^{-3}$	10^{14}	10^{15}	10^{16}	10^{17}	10^{18}
T_{cs} ***°K***	7000	7500	8000	8500	9000
radio	III т.	III тип	III т.	III, II т.	II,IVт.
X-ray	HXR	HXR	HXR	HXR	HXR
image	jet	surge	spray	CME + tsunami	
$I_{32}/I_\lambda^\oplus$	*0.5*	*0.7*	*1.0*	*1.5*	*2.5*
m_v	*7*	*9*	*11*	*12*	*13*
T_e ***°K***	*7500*	*9000*	*12500*	*16000*	*18000*

Fig.5. Changing of the external manifestation of the CS with increasing of the plasma density N_{cs} from 10^{15} to 5 10^{18} cm^{-3} for $\boldsymbol{L_{cs}} = 10^3$ cm. Observations are allowed to link the observed values of plasma flows velocity $\boldsymbol{V_{cs}}$ and the calculation of $\boldsymbol{N_{cs}}$ by flares of various powers or by strengths of interacting magnetic fields $\boldsymbol{B}$, Gauss ($B^2/8\pi=N_{cs}kT$). The flare class *csCME* (fig.3) is by flares of strongest power (fig.5).

The necessary condition of a *CS* formation is the presence of oncoming magnetic fields of different polarities. This ability is provided by the Nature itself. Active regions (cyclones or the *EAS* for us) on the Sun (as well as changing of their number during the 22-year period) are resulted by consequence of the existence of the planet system. In other hand, new compact magnetic fluxes (or the *CAS* for us) have been emerged regularly and in a large number everywhere on the solar surface from the convective zone. The convective zone is formed (in heights 0.7-1.0 R_Θ) near the surface of the Sun, where the irradiative transfer itself may not to support any longer of the energy transfer from the internal layers of the Sun. The detection of «black» flares allowed to discover of the current sheet on the Sun and to link all the flare phenomena in a single process of both *cs(TRF-BLF-WLF)* formation and the evolution of the *CS*. It also appeared that the current sheet itself is directly the solar flare.

Many metals lines in the flares are by radiation lines in the difference from the photosphere lines. On forming in compacted (current) layer they are only observed on the background of csBLF «black» flare (fig.1, 6). As the current sheet model the stable condensed layer of plasma can be chosen to describe the metal lines. The metal line profiles are always narrow and symmetrical. Emergence and reinforcement of the *csWLF* «white» flare is accompanied by the disappearance of the metal lines (fig.6). Hydrogen and H&K CaII lines with extended wings are also disappeared. At the same time the flare «kernel» (source for the impulsive radiation component) is also disappears. This means by the stopping of plasma ejections out of the *CS*.

The disappearance of emission lines accompanies the start of plasma turbulence in *csWLF* flares (fig.5, 6). This follows from the comparison of the results of our model calculations of continuous emission (fig.6) and the theory of irradiative transfer for internal layers of the Sun. This is also supported by our photometry of flares spectra across the dispersion that indicates the decreasing of plasma density in the *CS* layer from its center to the periphery. Namely on the periphery of the *CS* layer, where plasma densities are minimal, the wings of *H&K CaII* lines are yet available. And at certain stages of flare development, conditions are creating for simultaneous occurrence of the CS and as both the *csWLF* and the *csBLF* (fig.6). In the theory and in the observations, the own width of the CS layer is increased with the increase of flares power. Plasma density is maximal at the center of the CS and reduced to its edges.



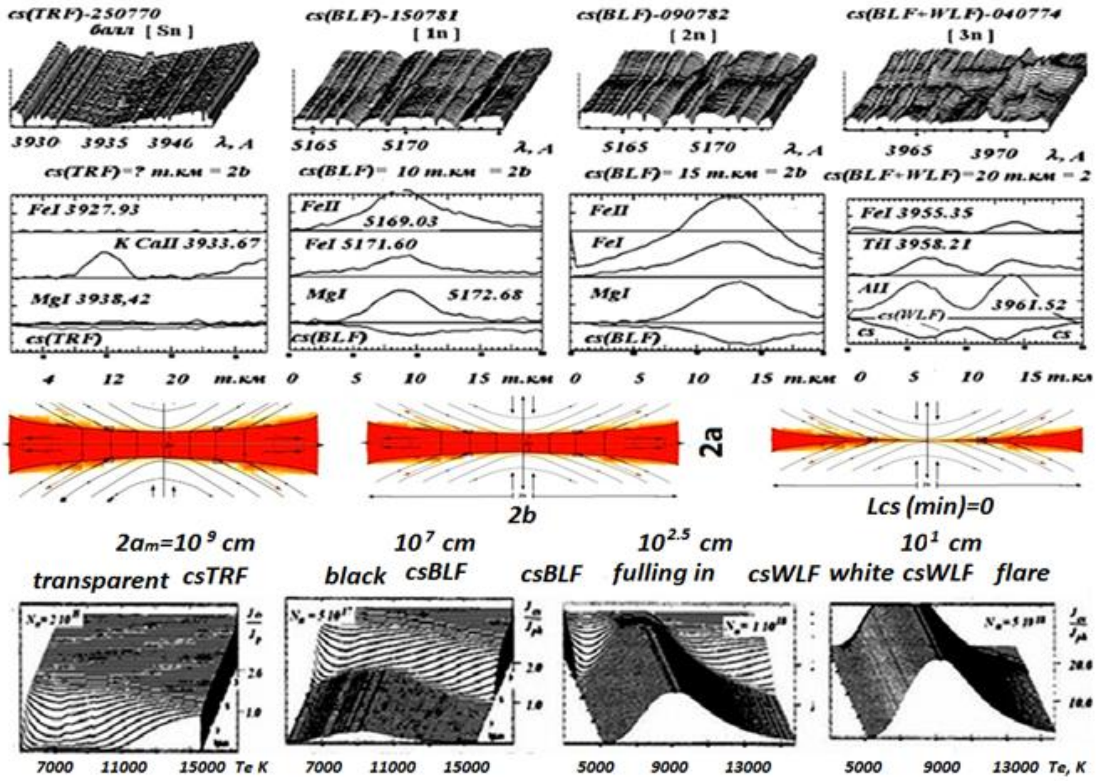


Fig.6. The *cs(TRF-BLF-WLF)* development of the current sheet with the change of the flares power (Ostapenko, 2007; 2011, 2012). In top panel are the flares spectra by the *MF4A* photometry. Lower are the records of the same fragments along the spectral line (along the surface of the Sun). The CS layer width *2b* is increased while its thickness *2a* and is decreased with increasing of flares power. The maximal plasma density it is appeared to be in the middle layer and reduced to chromosphere densities on its periphery.

Steshenko (1971) had examined in spectra by solar flares the position of 47 *csWLF* «kernels». He noticed that the *csWLF* emission most often occurs not accurately in those locations where there are metals lines. Their separation is carried out in the horizontal direction along the surface of the Sun. In these years (in 1970s) of the phenomenon of the *csBLF* flare still nothing was known. In fact, Steshenko has observed the second effect. This is the disappearance of metal lines in the *csWLF* band, and their simultaneous presence in the same CS, which shows itself as a *csBLF* formation (fig.6). The *WLF* emission stream in the visible range (~2 10^{10} erg/cm^2 cm) is in two orders of magnitude larger than the flow of H_α hydrogen emission line. The power of the 10.09.1974 *csWLF* flare «kernel» amounted to 10^{27} erg/s (Neidig et al., 1993). The H_α line width was 40 Å and the intensity of the *WLF* flare «kernels» was 36% of the intensity of the photosphere.

Magnetic induction B (strength $\mu_0 H$) is a measure of the maximum density of the N_{cs}, which is achieved in the active region in accordance with the relation $B=V_{cs}(B)\sqrt{4\pi m_p N_{cs}}$ of the *CS* theory. The $V_{cs}(B)$ parameter is the speed of plasma ejection out of the CS, which in turn depends on the *B*. The setting $m_p = 1.67\ 10^{-27}$ kg is the mass of the proton. If *B* does not exceed hundreds Gauss (magnitude $N_{cs}<5\ 10^{16}$ cm^{-3}), the *CS* layer is transparent (*csTRF*) for photosphere continuous radiation and it is observed as sub-flares (fig.5). «Black» csBLF-flare occurs when tension *B* ~2000 Gauss, which ensure N_{cs}~$5\ 10^{16}$-$8\ 10^{17}$ cm^{-3}. The *csWLF* flare occurs when *B* >3000 Gauss ($N_{cs}>10^{18}$ cm^{-3}). But every of flares must pass all stages of the *cs(TRF-BLF-WLF)* development. The maximum stage of flare (*CS*) development is determined only by the magnitude of the magnetic field (the maximum attainable value of the N_{cs} is in accordance to $B^2/8\pi=N_{cs}kT$). Metals lines of flares emission have been arisen (in the *CS* strip on the *cs(TRF-BLF)* stage and disappear by reaching of the *csWLF* stage of development) in the CS compacted layer in temperature of 8000-10000 °K and the density of 10^{14}-10^{18}

cm^{-3}. The metal lines disappearance is rather resulted of the development of the plasma turbulence when it reaching of $N_{cs}>10^{18}$ cm^{-3} and of B >3000 Gs. At the same time, the flare «kernels» both hydrogen and *H&K CaII* lines and their extended wings are disappearing in spectra. This means the breaking of the reconnection of force lines and the stopping of throwing plasma flows out from the *CS* as a result of turbulence.

VI. THE MULTI PINCH-EFFECTS IN FLARE "KERNELS"

The arising of flares occurs in the following order (Harrison & Simmnet, 1984). An area of primary energy release is limited by compact magnetic loop ("core"), which is the place of the impulse radiation of the flare. The "kernel" radiation is a collection of "moustache" in flare spectra, which was the basis for the study of the pinch effect (Severny, 1958). Observations from space observatories detect always discrete structure (see, Shklovsky, 1958) of separate arches of active region (fig. 7). Discrete characteristic and structure should be for the new magnetic flux associated with the initiation of the flare. But then, the power-supply system becomes clear as a set of individual Severny' "moustache" (Elementary acts reconnection) in the area of the new magnetic flux (the flare "kernel").

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If to make strong electric field to plasma, it arisen discharge current and the magnetic field surrounding a current. The interaction of the magnetic field with current leads to compressive forces exerted on charged particles of plasma. If the current goes along the plasma cord, emerging radial forces compress the cord like rubber cords. *This phenomenon and named as pinch effect*. Within tens of seconds hot plasma fills big loops, the grounds of which are several thousand kilometers. Such loops can connect as an elongated part of the active region so and neighboring active regions. There is a hierarchical structure of the magnetic field, which glow is called by flare.

We found that the compacted layer really is by the current sheet (or by the flare). By the direct observation we are also found evidences of the destruction of the magnetic fields (the second photometry record of the range from 08:15 UT) of 15.07.1981 disc flare (fig.4; Ostapenko, 1997).

The four prominent *EAS* fragments (Ostapenko (1997) spectrograms of the 15.07.1981 flare) are selected in the *K CaII* line. In the first selection (08:10 UT, the beginning of the flare 4 of 24), we see the picture of the extensive range of the *EAS* extended arch systems of the active region (fig.1, 7; Ostapenko, Palush, 1982). In the middle part of the first fragment the new compact magnetic flux of the *CAS* is located, which just emerged and still does not show explicit interaction with the *EAS*. The bright *CAS* compact source the flare («kernel») with extended *K CaII* wings line are seen in the third selection from 08:18 UT. The formation process of the current sheet in result of the reconnection of the *EAS* and *CAS* force lines and as a consequence, the direct destruction of the *EAS* structure we see in the fragment for 08:15 UT. There is the secondary arch subsystem CAS_m (fig.1b). It is already disappeared on the third selection (08:18 UT) and we can to expect of the plasma flow from the *CS* to downward.

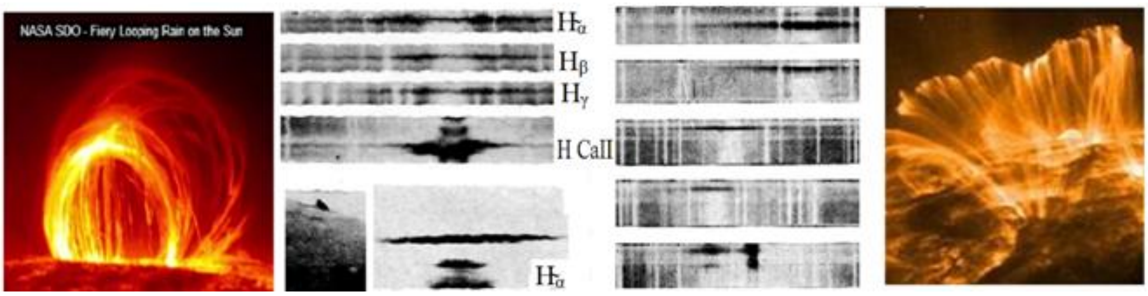

Fig.7. In spectra of the flare "kernels" consist of close collections of Severny "moustache" but they revealed in visual observations only because the photo has much more exposition.

a. The image from the movie of "the coronal rain". APOD 26.02.2013 Solar Dynamics Observatory, SVS, GSFC, NASA

The flare disk CAS + EAS emission on 06.09.1957 in hydrogen and calcium lines (Ostapenko, 2011). The limb 24.09.1957 flare mage (field $\boldsymbol{B}$ ~ 2000 GS, bottom). The photo and spectrum range in H_{α} line are given (Severny, 1959).

Emission (CAS + EAS) flashes on the drive 03.09.1957 in lines of hydrogen and calcium (Severny, 1959).

d. Active region 09.11.2000 in *EUV*. The flare produced *CME* that reached the Earth. (APOD-15.11.2000-Coronal rain, Solar storm-Trace,Nasa).

Consequential changes to the structure of the magnetic fields due to the flare onset were observed not once well before. Chromosphere fibrils inside super granulation cells being parallel before the flare have been changed of their orientation on radial after the flare (which have directed inside to cells). The observation data in the $H_\alpha+1$ *Å* line for 46 flares (Shilova, 1985) have detected the movements of plasma masses (before-flare flows in the wings), which have been formed before the flare and are connected with shear fields of new magnetic fluxes (Rust, 1976). The initial moment of the magnetic reconnection in flares is maybe marked by elementary HXR bursts. The authors (Desai & Orwig, 1989) has informed about the discovery of the *HXR* before-impulses registered during 8 flares of the *SMM*. The before-impulses are registered to be of short (2-6 s) impulses, which are arisen before of flare. The before-impulse (as the flare pre-cursor) is a spike with a symmetrical radiation.

VII. MAIN CONCLUSIONS

The *current sheets (CS)* are found in chromosphere and downward levels in optical range data. *The main problem of physics of solar flares has been solved*. Magnetic field energy is a primary source of active processes in solar plasma. Current sheet (*CS*) of S. I. Syrovatskij is the mechanism of magnetic energy transformation into plasma energy. The current sheet is not discovered in a flare, as expected. *As a matter of fact, solar flare is in itself a current sheet*, its direct observed development in chromosphere plasma. Continuous current sheet radiation is the «black» (*BLF*) and the «white» (*WLF*) flare (like light of Sun photosphere). It is the ***negative hydrogen ion excitation*** upon reaching hydrogen plasma density of >5 10^{17} cm^{-3}.

The simultaneous calculations of lines emission of hydrogen atoms and the continuous emission of hydrogen negative ions as well as the flares spectra MF4A photometry have shown:

The *CS* is transparent (in *csTRF* view) for photosphere continuous radiation as plasma densities in the *CS* layer of $N_{cs} < 5\ 10^{16}\ cm^{-3}$. The own continuous emission of flares is appeared of the first as a «black» (*csBLF*) flare when $5\ 10^{16} < N_{cs} < 5\ 10^{17}$ cm^{-3} and, later, on sometimes, and a «white» (*csWLF*) flare in $5\ 10^{17} < N_{cs} < 2\ 10^{18}$ cm^{-3} occurs in the *CS*. It displays the single *cs(TRF-BLF-WLF)* process by progressively increasing of plasma density from the chromosphere density (~10^{13} cm^{-3}) until the arising of the turbulence stage and destruction of the *CS* at $2\ 10^{18}$ cm^{-3}. A geometric *CS* thickness changes in the evolution process of the *CS* compacted layer depth from L_{cs} ~10^5 cm to the layer depth of the most powerful flares $L_{cs} \rightarrow 0$ cm (that results the *CS* destruction). Namely the process of sequential increase of the *CS* plasma density displays the dynamic collision of magnetic fields and represents the *cs(TRF-BLF-WLF)* evolution of any flare. The ended stage of the flare evolution and the largest *CS* plasma density are defined only by strengths of magnetic fields. The importance classification of solar optical flares is, therefore, the magnetic classification.

The *CS* development is shown in spectra examples of two strong disc flares on 15.07.1981 and 09.07.1982. Calculations highlighted the following points. The *CS* layer extends further along the Sun than it is seen on the recording *csBLF* strips. Indeed, the emission lines of metals observed wider along the surface of the Sun. According to our calculations, the current sheet is still presented in these places. It is also characterized by higher temperature, but has less value of plasma density because of the continuous *csBLF* radiation is not observed. Plasma density, therefore, varies along the transverse cut of the CS. It is minimal at the *CS* periphery and the maximal in the middle area.

We explained why the hydrogen H_α line wings reach of 20 Å widths at the moment *csBLF* appearance, and why they have achieved the 40 Å widths and have disappeared together with same narrow lines of metals in the background of the *csWLF* appearing. The metals occur in a stable compacted *CS* layer and there are until the appearing of the *CS* turbulence in significant magnetic fields on the *csWLF* background. The widths of hydrogen and *H&K CAII* lines are increased with the growing of flare powers and they are depend on the speed of throwing CS plasma flows, which are a function of the magnetic field strengths. The appearing of the plasma turbulence means the CS own destruction. The initial of the 15.07.1981 flare is associated with emergence of the new magnetic flux. This process is associated with the force lines destruction. The 15.07.1981 and 09.07.1982 disc flares are the basis of discovering of the current sheets on the Sun.

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