FLARES: MAGNETIC OR CONVECTIVE ORIGIN?

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ABSTRACT. I point out that the flare energetics has a central role in our understanding of the nature of the flare phenomena /see also Grandpierre,1986/. Combining the recent observational data with the values expected by the magnetic flare theories/MFT/ I show here that they are inconsistent with a lot of basic observational fact. I calculate the energies and the respective time scales of flares by the convective flare theory/CFT/ and I find that the results seem to be consistent with the observations. I present some prophecies of the CFT for the future observations as the relation between the energy liberation in central stellar regions and the flare activity, dependence of flare activity on stellar ages and spot dynamics.

1. ENERGETICAL PROBLEMS OF THE MAGNETIC THEORIES

There is some clear sign in the published papers that the MFT-s are aimed to interpret the flare energetics only because there are no known real alternative explanation. However, this state of affairs changed in the last years in publishing the CFT papers /Grandpierre,1981,1984,1986, Grandpierre, Melikyan,1985/.
Parker/1963/ wrote already in 1963 that 'the present state of the theory does not allow magnetic energy as the source of a flare', and here I present a whole - but still incomplete - list of the problems with the present day MFT-s.
There are two fundamental observations which are really restrictive for any kind of flare theories. These are the total energy of the flare and the time scale of the energy liberation. These two quantities refer to one and the same physical process and this coupling gives a stronger restriction, which fact didn't got enough interest until now.
I'm attacking here the theories saying that the flares are supplied directly and mainly by the magnetic fields.

O. Havnes et al. (eds.), Activity in Cool Star Envelopes, 159–162.

1.1. A list of some observational facts against the MFT-s

- H α flares consist of fibrils with $V_{tot} = 10^{18} cm^3$ /Suemoto,Hiei 1959, Hirayama,1961, Wentzel,1963,Svestka,1976/. This means, that for a large solar flare with $E = 10^{32}$erg the strength of the magnetic field has to be $B = 5 \times 10^7$Gauss. In contradiction, the observations tell us that the maximum field strength in the solar atmosphere is only about 4000 Gauss
- Flares of spotless regions are sometimes quite powerful/Dodson,Hedeman 1970/. For a large, spotless flare it would be necessary B = 1585 Gauss in a $V = 10^{27} cm^3$ region/this is the volume of a large flare kernel, in which the energy release is thought of/.In contradiction, the observations tell us that B = 5 - 10 Gauss at spotless flare sites
- No systematic, enduring changes of magnetic fields are observed during the flares/Rust,1984/
- Homologue flares show an independency of flare production from magnetic field strength and structure
- Temperature excesses in the photosphere during the flares /Machado, Linsky,1975/ are 'strong arguments against all theories that place the flare origin above the chromosphere' /Svestka,1976/
- A certain part of the white light flares seem to originate by convective zone perturbations/Chen et al.,1984/. Postulating the common physical nature of all kinds of solar flares this result suggests that all solar flares are originated by convective zone perturbations and not by magnetic instabilities
- X-ray deficiency before large flares /Glencross,1979/ excludes any kinds of magnetic energy accumulation before the flares at flare sites
- Generally there are no enough antiparallel field lines or twisting at flare sites to produce large flares
- There are observations showing that the magnetic field annihilation - if it happens at all - is not the cause but a result of the flare /Mouradian et al.,1983/.

1.2. Theoretical problems with the MFT-s for solar flares

- The short -1000 sec - duration of the solar flares is consistent with the magnetic energy dissipation only if the linear size of the energy dissipating region is less than 1 km /Priest,1981/. In this case it is necessary to have a $B = 1.6 \times 10^9$ Gauss magnetic field in this volume, with a ten percent effectivity of energy transformation, and all of the field lines have to be strictly antiparallelly packed. In contradiction, none of them is observed
- More energetic process needs to the current sheet production than to the flare itself /Piddington,1973/: NOT DETECTED
- Basic problem is the transfer of energy from less dense to more dense regions with a rate of 10^3 ergs $sec^{-1} cm^{-3}$/Neidig,Cliver,1983/
- The common components of the magnetic field lines act against the magnetic energy liberation/Parker,1963/.

1.3. Difficulties of MFT-s for the origin of stellar flares

- The spike flares /e.g. Tsvetkov et al.,1986/ present a crucial test for any flare theory. Engvold /1987/ suggested a way to couple the energetics to the time scales of flares as
  $E = B^2/8\pi L^3$ with $L = v_A t$
  where L is the linear dimension of the primal energy liberation, v is the Alfven speed and t is the duration of the flare. With Tsvetkov et al./1986/ data we have t = 1 sec with $E = 4 \times 10^{31}$erg which gives for the MFT-s a $B = 3.5 \times 10^7$Gauss. In contradiction, the maximum observed B in dMe stars is about 4000 Gauss
- The automatic flare production of dMe stars involves an independency of flare production from magnetic field strength and structures /Grandpierre,1987/
- The flares of non-classical flare stars /Oskanian,1986/ present difficulties for the MFT-s especially in the case of the stars where the dynamo action is absent.

2. ENERGETICS OF FLARES BY THE CFT

The CFT is able to give flare energies properly. For example, in the case of the Sun, with $L = 10^4$km, I got $E = 3.31 \times 10^{32}$erg for d /denoting the level of the disruption of the convective cell by shocks under the photosphere/ equal 33 km /here I used the data of Spruit,1970/. The CFT can give $E = 2.2 \times 10^{33}$erg for d = 513 km at the Sun. In regarding the Orion flare stars one can easily get even $E = 10^{37}$erg.
Now let us look the time-energy coupling. When a convective cell approaches the local sound speed, a shock develops in front of it, which means that a convective cell with linear dimensions L produces a shock front with a thickness 'l'. At the dissipation of the convective cell's energy the inner energy surplus and the kinetic energy of the cell liberates in a region with a characteristic thickness l = L/C where C is a compression factor. At the sound speed now this gives for the time of the energy liberation $t = L/C/v_s$ and so the coupling means that
$E = \rho L^3 v_s = \rho t^3 C^3 v_s^5$
Fitting this formulae to the spike flare of EV Lac above mentioned, we need for C the usual value C = 150 /DeFeiter,1974,Svestka,1976/. Regarding the fact, that the destruction of convective cells means a cascade of nonlinear local relaxation processes, the CFT seems to be able to interpret the observed energetics and time behaviour of solar and stellar flares.
The CFT suggests for the ultimate cause of the flare phenomena the positive feedback mechanisms working at the stellar cores.In the case of the Sun this feedback is provided by the unstable character of the nuclear energy production by the proton-proton cycle /Grandpierre,1984/ while in the case of the pre-main-sequence stars this feedback is gravitationally supplied/Grandpierre,1988/. The primal convection at stellar cores starts always explosively/Grandpierre, 1984/,and sometimes ceases explosively/ Grandpierre,1981,1986/ and then produces flares. We observe a flare, when the high energy par-

ticle beams, generated by explosive convection, collide with the local concentrations of magnetic fields/masses.
In this way the CFT predicts that the stars having energy producing mechanisms of different character, have to show flare activity with different energetics and time scales. The CFT predicts, that as a young star contracts and its gravitational energy liberation decreases at the inner regions, it has to show less and less flare activity. The CFT predicts, that the magnetic flux tubes are transported to the surface by convection and therefore the time behaviour of their emerging to the surface tells us a lot about the subphotospheric velocity fields and therefore about the generation of flares.

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