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Can superflares occur on the Sun?

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Superflares

Kepler reveals flares with total energy substantially greater than 10^{33} erg (to be compared with the highest energy, approximately 10^{32} erg, of any observed solar flares); however sometimes the reported energy is as large as 10^{36} erg.

The problems are how to store

magnetic energy and

how to transform it in a superflare.

Dynamo deals with the first problem only.

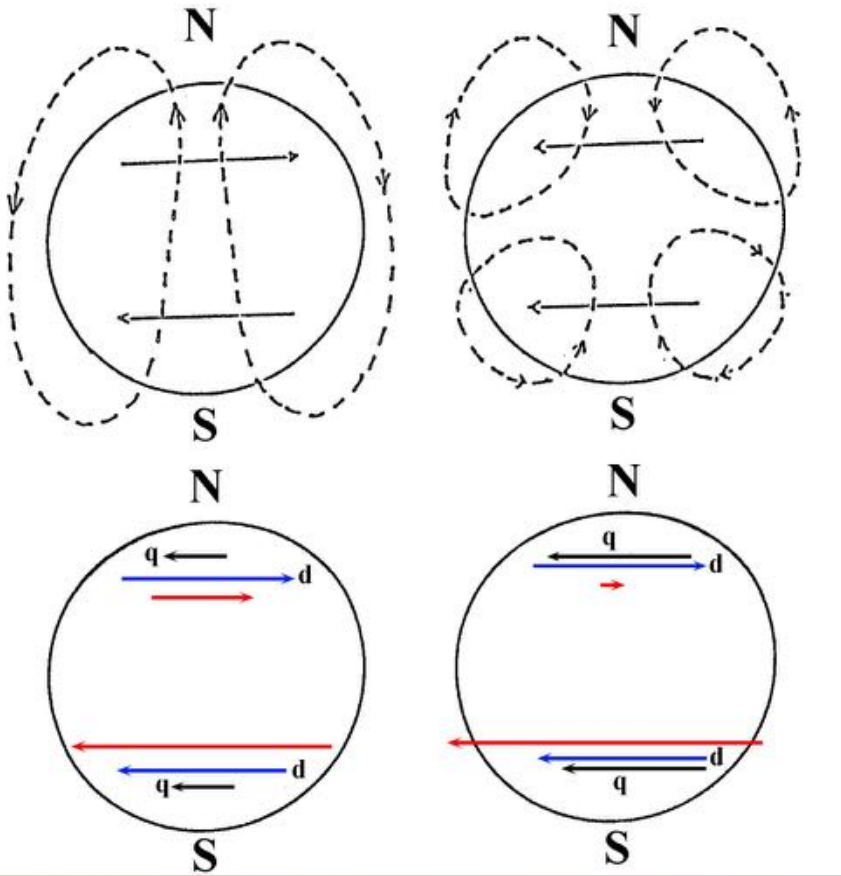
Parker Dynamo

$$B_P \xrightarrow{\Omega} B_T$$

Differential rotation

$$B_T \xrightarrow{\alpha} B_P$$

Mirror asymmetry



Kitchatinov & Olemskoy 2016
From time to time alpha changes sign.

Our suggestion:

Antisolar differential rotation

Something from dynamo studies

- Conventional dynamo based on differential rotation and mirror asymmetry can give cycles as well as growth and then saturation without oscillations.
- Non-oscillatory solutions are kown for galaxies.
- Non-oscillatory magnetic fields are much stronger rather oscillatory. Dynamo abilities are not spended to produce oscillations.

We verifyed it for simple modes.

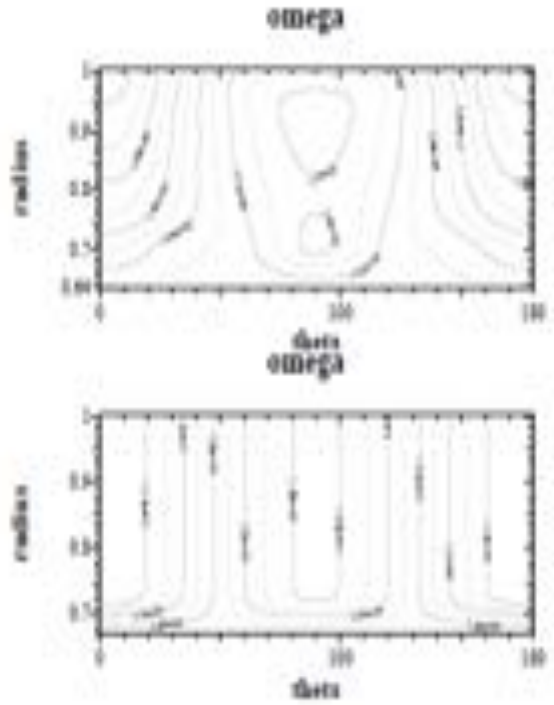


Figure 1: Stellar rotation curves: upper panel - SOHO-like rotation curve, lower panel - Jouve et al. (2008) rotation curve.

Oscillatory solutions:

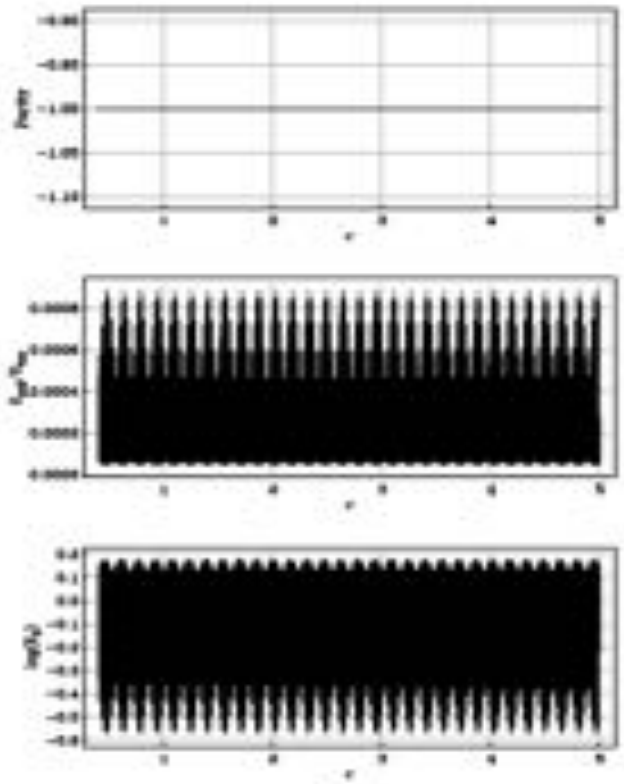


Figure 2: Magnetic field for rotation law [32], $D > 0$, timeseries for parity (top), ratio of magnetic energies of toroidal and poloidal magnetic fields (middle) and total energy of the mean magnetic field (bottom).

Non-oscillatory are indeed much stronger.

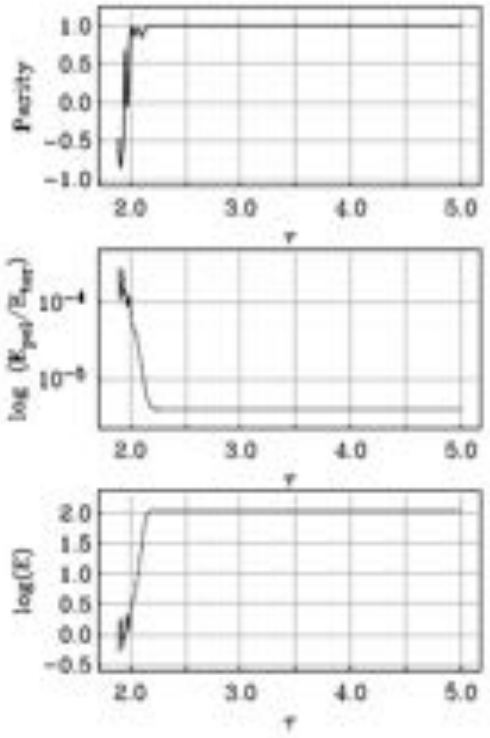


Figure 3: Summary of the fields obtained using the rotation law [32], $D < 0$, time series for parity (top), ratio of magnetic energies of toroidal and poloidal magnetic fields (middle) and total energy of the mean magnetic field (bottom). The asymptotic ratio of E_{pol}/E_{tor} is approximately 4.1×10^{-6}.

For particular stars…

Table 1: Some solar-type stars with superflares with $E > 10^{35}$ erg, after [34]. T_{eff} is the effective temperature, g is the gravity in cm s^{-2}, P_{rot} is the rotation period.

KIC number	T_{eff}, K	log g	log E	N	P_{rot}, day	Comments
			Binaries			
11560431	5090	4.511	35.06	215	3.132	Binary/multiple system [35], unusual differential rotation [36], cooler than the Sun
6441574	5712	4.487	35.06	2	0.336	eclipsing binary[1]
8752873	5665	4.017	35.03	1	15.05	eclipsing binary[1]
12156549	5541	4.378	36.50	128	3.651	binary[1]; oscillations in superflares [37]
9655129	5140	4.431	35.38	26	unknown	detached Algol-type[1]
			Subgiants			
6437385	5400	3.713	36.78	18	13.672	oscillations in superflares [37]
7350496	5453	3.744	36.43	4	9.403	
8226464	5754	4.055	36.32	15	3.101	quasi-periodic pulsations [38]
			Stars cooler than the Sun			
9945784	4854	4.441	35.09	18	15.367	Sp K2 V
			Pulsations or oscillations			
5475645	5336	4.654	35.63	6	7.452	quasi-periodic pulsations [37]
11610797	5865	4.465	35.74	34	1.625	oscillations in superflares [37]
			Very young fast rotating stars			
9652680	5618	4.602	35.56	26	1.408	

[1] Information concerning stellar variability is added from the SIMBAD database, provided by CDS, Strasbourg.

Case HK LAC

- Giant HK Lac is superflaring
- Antisolar differential rotation
- $\alpha = 0.05 \pm 0.05$
- Olah et al., 2018.

Another option: Dynamo resonances (Kalinin & Sokoloff, 2018).