Starspot activity and superflares on solar-type stars

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Recent space-based observations (e.g., Kepler mission) enable us to investigate the nature of “superflares” on solar-type stars (G-type main sequence stars). The bolometric energy of superflares ranges from 10^{33} erg to 10^{36} erg which is 10-10^4 times larger than that released by a typical X10 class solar flare. Most of the stars with superflares show large-amplitude photometric variations associated with the stellar rotation which suggest that the stars with superflares have large starspots. Spectroscopic studies of superflare stars revealed that the chromospheric activity correlates with the amplitude of brightness variations.

We analyze the correlation between starspots and superflares on solar-type stars using the data from the Kepler mission. Our analysis shows that the fraction of the stars showing superflares decreases as the rotation period increases and as the amplitude of photometric variations, which is thought to correlate with the area of starspots, decreases. We found that the fraction of superflare stars among the stars with large starspots also decreases as the rotation period increases. This suggests that some of the slowly-rotating stars with large starspots show a much lower flare activity than the superflare stars with the same spot area and rotation period.
Assuming simple relations between spot area and life time and between spot temperature and photospheric temperature, we compared the size distribution of large starspots with the area of $>10^4$ MSH (micro solar hemispheres; 1 MSH=3×10^{16} cm^2) on slowly-rotating solar-type stars with that of sunspot groups. The size distribution of starspots shows the power-law distribution and that of larger sunspots lies on the same power-law line. The size distribution of spots from the Kepler data suggests that the average appearance frequency of the starspots with the area of $>3\times10^4$ MSH on the solar-type stars with the rotation period similar to that of the Sun is once in a few hundred years.
We also found that the frequency-energy distributions for flares originating from spots with different sizes are the same for solar-type stars with superflares and the Sun. These results suggest that the magnetic activity on solar-type stars with superflares and that on the Sun is caused by the same physical processes.

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