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Superflares on Solar Type Stars

Kazunari Shibata
(Kwasan and Hida Observatories, Kyoto University)

Abstract

The total energy of a solar flare is typically 10^29 - 10^32 erg, whereas there are much more energetic flares (10^33 - 10^38 erg) in stars, especially in young stars with rapid rotation. These are called superflares. Recently, Kepler satellite revealed many superflares (white light flares) on various stars. Maehara et al. (2012) discovered 365 superflares on 148 solar type stars (G-type main sequence stars) from 120 days Kepler observations of 83000 solar type stars. Shibayama et al. (2013) extended the survey to 500 days, finding 1547 superflares on 279 solar type stars. Interestingly, these superflare stars show brightness variation with 0.1-10 percent amplitude. This is interpreted as evidence of existence of large spots on rotating stars. If this is correct, this suggests that superflares are associated with large spots with area A = 10^3 – 10^5 in unit of one millionth of solar hemisphere, much larger than normal sunspots (with area A= 100 – 1000) on the Sun. Spectroscopic observations by Subaru telescope confirmed that some of the Sun-like stars (surface temperature 5600-6000K, and brightness variation period longer than 10 days) have actually large spots and slow rotation (Notsu et al. 2015). The superflare occurrence rate (dN/dE) – energy (E) relation (dN/dE ~ E^(-2)) is quite similar to those of solar flares, implying that superflares with energy of 10^34 – 10^35 erg occur with frequency of once in 800 – 5000 years on Sun-like stars with slow rotation. Kepler short time cadence data revealed that the flare duration (t) scales with the flare energy (E) as t ~ E^(0.39), which roughly agrees with prediction of magnetic reconnection model (Maehara et al. 2015). Using the simple theory of solar dynamo mechanism (toroidal magnetic flux generation by differential rotation), we found that the necessary time to create a large spot leading to a superflare with energy of 10^34 – 10^35 erg is 8 – 40 years, much shorter than the interval of observed superflares (800 – 5000 years) (Shibata et al. 2013). Hence we cannot reject the possibility of superflares on the present Sun. Observations of Sun-like stars (Nogami et al. 2014) and the carbon isotope 14C in tree ring (Miyake et al. 2012, 2013) also suggest the possibility of solar superflares. In this talk, we review recent development of observations of superflares on solar type stars and related studies.