Superflares on G-, K-, M- type stars

*Yuta Notsu[1], Hiroyuki Maehara[2], Namekata Kosuke[1], Shota Notsu[1], Kai Ikuta[1], Satoshi Honda[3], Daisaku Nogami[1], Kazunari Shibata[4]

1. Department of Astronomy, Graduate School of Science, Kyoto University, 2. Okayama Astrophysical Observatory, NAOJ, 3. Center for Astronomy, University of Hyogo, 4. Kwasan and Hida Observatories, Graduate School of Science, Kyoto University

Flares on G, K, M-type stars are sudden releases of the magnetic energy stored around the starspots, like solar flares. Recent high-precision photometry from space shows that "superflares", which are 10-10^4 times more energetic than the largest solar flares, occur on many G, K, M-type stars including Sun-like stars (slowly-rotating G-type main-sequence stars like the Sun) (e.g., Maehara et al. 2012 Nature). Such superflares emit harmful UV/X-ray radiation and high-energy particles such as protons, and may suggest that exoplanet host stars have severe effects on the physical and chemical evolution of exoplanetary atmospheres (cf. Segura et al. 2010 Astrobiology, Takahashi et al. 2016 ApJL). It is then important to know the detailed properties of such superflare events for considering the habitability of planets.

In this presentation, we present statistical properties of superflares on G, K, M-type stars on the basis of our analyses of Kepler photometric data (cf. Maehara et al. 2012 Nature, Shibayama et al. 2013 ApJS, Notsu et al. 2013 ApJ, Maehara et al. 2015 EPS). We found more than 5000 superflares on 800 G, K, M-type main-sequence stars, and the occurrence frequency (dN/dE) of superflares as a function of flare energy (E) shows the power-law distribution with the power-law index of -1.8~-1.9. This power-law distribution is consistent with that of solar flares.
Flare frequency increases as stellar temperature decreases. As for M-type stars, energy of the largest flares is smaller (~10^{35} erg) compared with G,K-type stars, but more frequent "hazardous" flares for the habitable planets since the habitable zone around M-type stars is much smaller compared with G, K-types stars.

Flare frequency has a correlation with rotation period, and this suggests young rapidly-rotating stars (like "young Sun") have more severe impacts of flares on the planetary atmosphere (cf. Airapetian et al. 2016 Nature Geoscience). Maximum energy of flares and flare frequency also depends on the area of starspots, and this suggest existence of large starspots is important factor of superflares.
The statistical properties of superflares discussed here can be one of the basic information for considering the impacts of flares on planet-host stars.

Keywords: flare, Kepler, habitability

