We conducted high-resolution spectroscopic observation with Subaru/HDS for a G-type superflare star (KIC6934317). We selected this star from the superflare stars discovered from Kepler data. The core depth and the emission flux of the Ca II infrared triplet lines and the Hα line show high chromospheric activity in this star. This star probably has large starspots that can store a large amount of magnetic energy, sufficient to give rise to superflares. We also estimated the stellar parameters, such as effective temperature, surface gravity, metallicity, and projected rotational velocity (\(v \sin i\)). KIC6934317 is then confirmed to be an early G-type main sequence star. The value of \(v \sin i\) is estimated to be ~1.91 km s\(^{-1}\). In contrast, the rotational velocity is calculated to be ~20 km s\(^{-1}\) by using the period of the brightness variation as the rotation period. This difference can be explained by its small inclination angle (nearly pole-on). The small inclination angle is also supported by the contrast between the large superflare amplitude and the small stellar brightness variation amplitude. For more details, see Notsu, S., et al. 2013a, PASJ, 65, 112.

1. Superflares discovered by Kepler data

**Superflares**: 10-100 times more energetic (10\(^{31}-10^{38}\) erg) than the largest solar flares (10\(^{22}\) erg).

- We found many superflares on solar-type stars (G-type main sequence stars; 5100<\(T_{\text{eff}}\)<6000, log\(g\)>4.0) by using Kepler photometric data (Maehara et al. 2012, Nature & Shibayama et al. 2013). Superflares show quasi-periodic brightness variations.

**What is the cause of stellar brightness variation??**

- **Idea**: Rotation of a star with large starspots?
- **Brightness variation**
- **Period**: Stellar rotation period
- **Amplitude**: Coverage of starspots on the stellar surface (Notsu et al. 2013b, Shibata et al. 2013)

**Artistic illustration**

Lightcurve of Superflare star KIC9459362 (Maehara et al. 2012)

2. Our Subaru observation & Target star

**Details of our Subaru Observation**

- **Obs. Date**: 2011 August 3
- **Telescope**: 8.2m Subaru Telescope (NAOJ, Mauna Kea, Hawaii)
- **Equipment**: High Dispersion Spectrograph (HDS: Noguchi et al. 2002)
- **Spectral resolution (R=\(\lambda/\Delta\lambda\))**: ~97000
- **S/N ratio**: ~1400

**Target stars**: KIC6934317 (G-type superflare star, V=12.5 mag)

- Exhibited 48 superflares in ~617 days (Average: once in 13 days)

**Comparison stars**: 59Vir & 61Vir

59Vir: rather rapidly rotating, strong magnetic field (~500G).
61Vir: slowly rotating, no magnetic field could be detected.

**Atmospheric parameters of KIC6934317**

- Effective temperature (\(T_{\text{eff}}\)) = 5694±25K
- Surface gravity (log\(g\)) = 4.42±0.08
- Metallicity ([Fe/H]) = -0.03±0.07

KIC6934317 is an early G-type main sequence star, and the atmospheric parameters of this star are nearly the same as the Sun.

3. Confirm magnetic activity of G-type stars

**The core depth and emission flux of Ca II infrared triplet (8498, 8542, 8662 Å) lines indicate the chromospheric magnetic activity of the Sun and G-type stars.**

\[ \text{Olog}(\sigma(8542)) \approx -0.587 \pm 0.156 \times \text{log}(\text{IB}) \]

\(<\text{IB}>\) : mean photospheric magnetic field strength [gauss] : SDO HMI data

**Other magnetic activity indicators**

- \(r_2(8542)\) of KIC6934317 is larger than 61Vir (comparable to that of 59Vir). Using these indicators, we can confirm the presence of large starspots causing Superflare Indirectly!

4. Chromospheric activity of KIC6934317

**High Chromospheric Activity**

\(r_2(8542)\) of KIC6934317 is larger than 61Vir (comparable to that of 59Vir).

\(r_2(8542)\) = 0.5

**Spectra of target stars around Ca II 8542 lines, X-ray flux etc.**

**Using these indicators, we can confirm the presence of large starspots causing Superflare Indirectly!**

Directly observing the intensity of magnetic field of G-type stars is difficult since it needs very high precision.

5. Rotational velocity and Inclination angle

**The small inclination angle is also supported by the contrast between the large superflare amplitude and the small stellar brightness variation amplitude shown the right figure.**

(for more details of this figure, see Y. Notsu's poster.)