Superflare Properties of G-type Kepler Eclipsing Binaries

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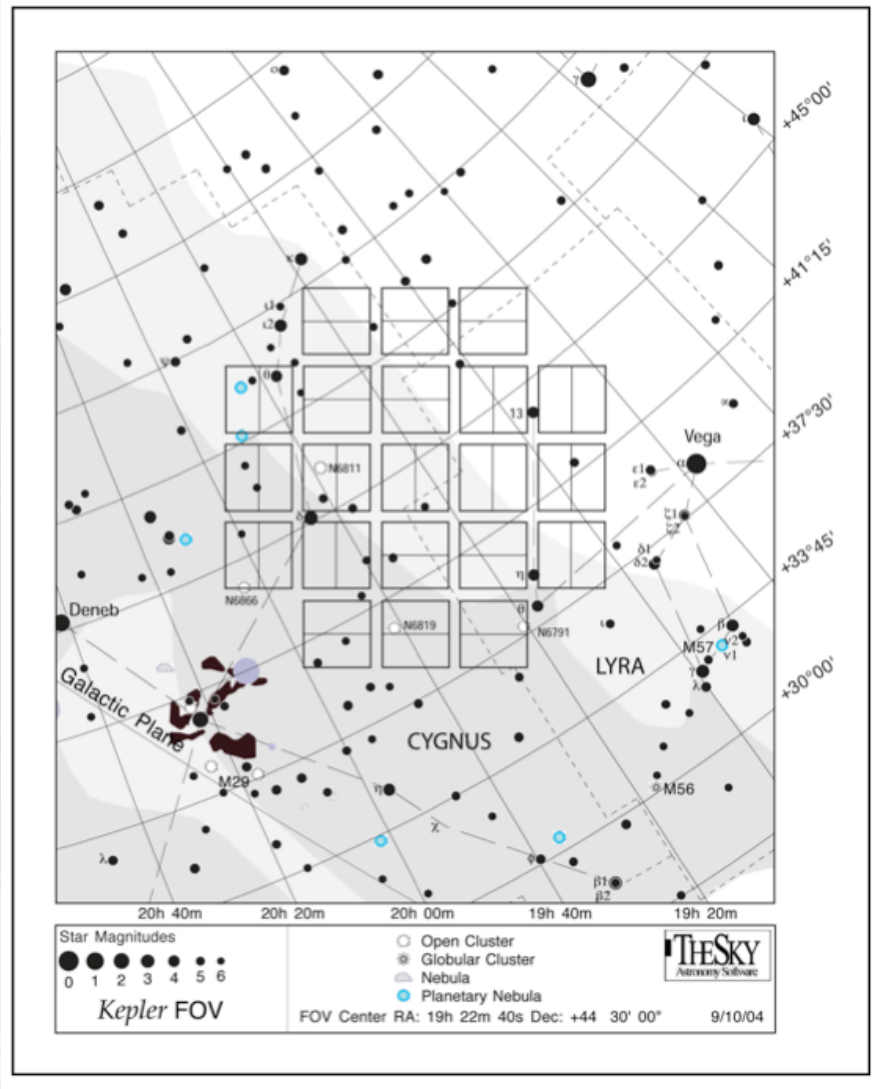
Kyoto University, March 1st, 2016

Kepler Light Curve Data

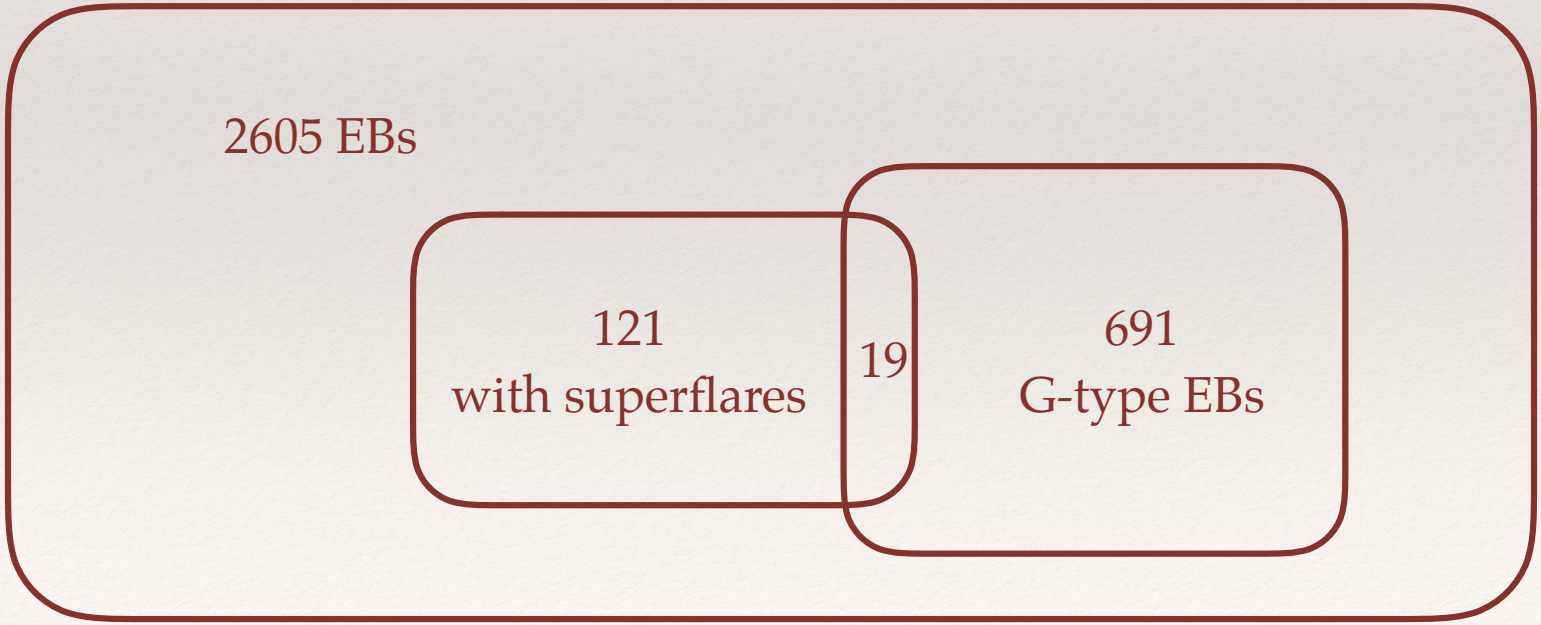
- 2009-2013 observation
- FOV: 116 square degrees
- Light curve data: long cadence (30 min.) and short cadence (1 min.)
- MAST (https://archive.stsci.edu)



Kepler Instrument handbook, 2009

Eclipsing Binaries in Kepler Field

- Data of 2605 eclipsing binaries in Kepler field are released in November 2013.
  - Kepler Eclipsing Binary Catalog (http://keplerebs.villanova.edu)
- 121 EBs (all spectral types) are with superflare events (~5%).
- 691 EBs are with G-type primary stars, 19 of them are with superflare events (~3%).



LAMOST Spectra

- Wavelength range: 3700Å - 9000Å
- Resolution: 1800
- 4000 fibers on the focal plane
- over 60,000 targets in Kepler field were observed
- 637 Kepler EBs are with high-quality spectra (SNR>10). 10 of them are G-type EBs with superflare events.

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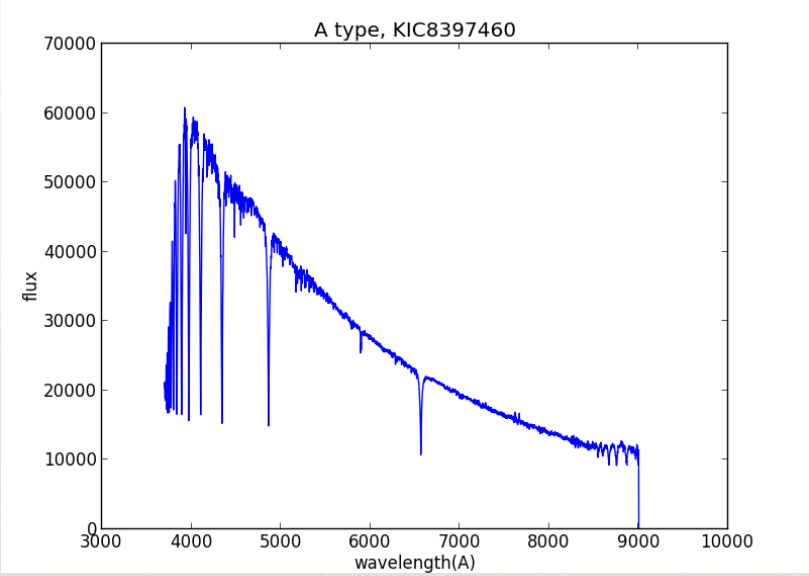
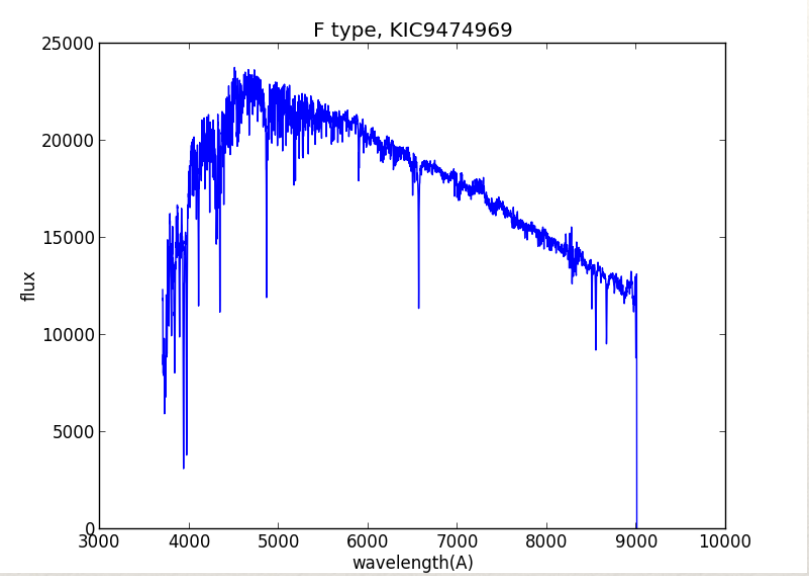
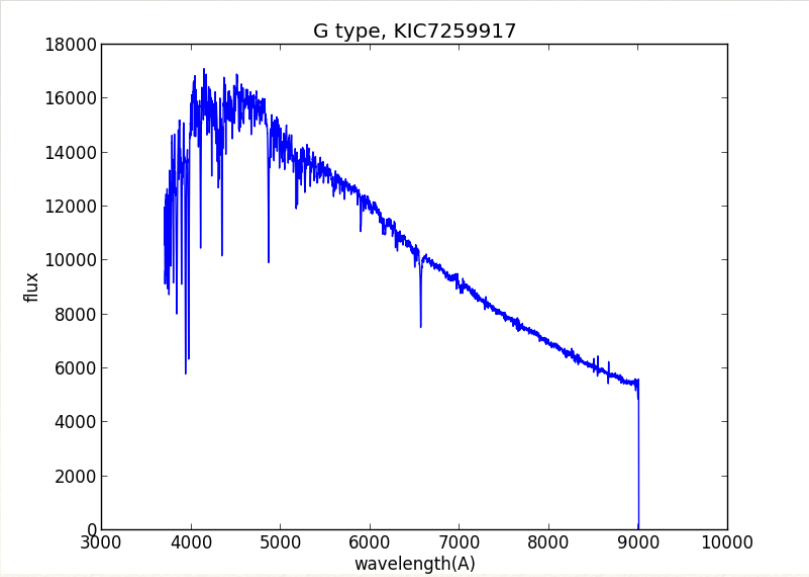
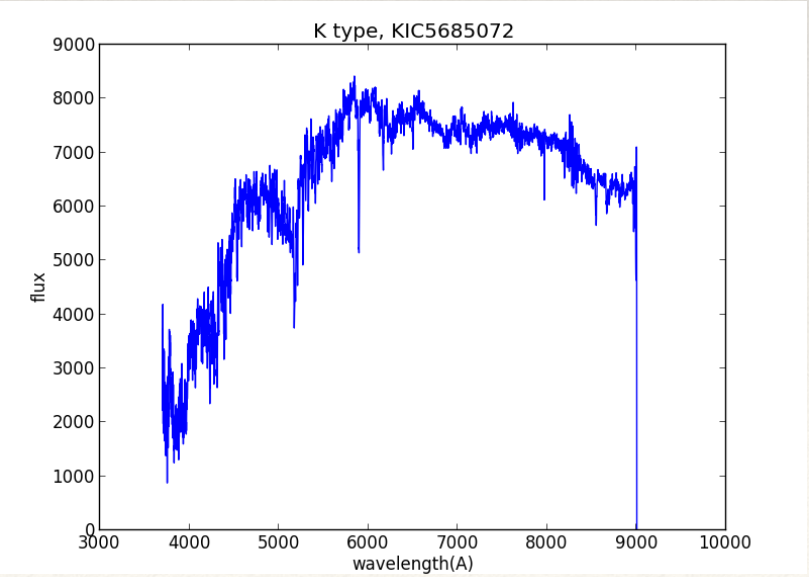
Samples of LAMOST Spectra



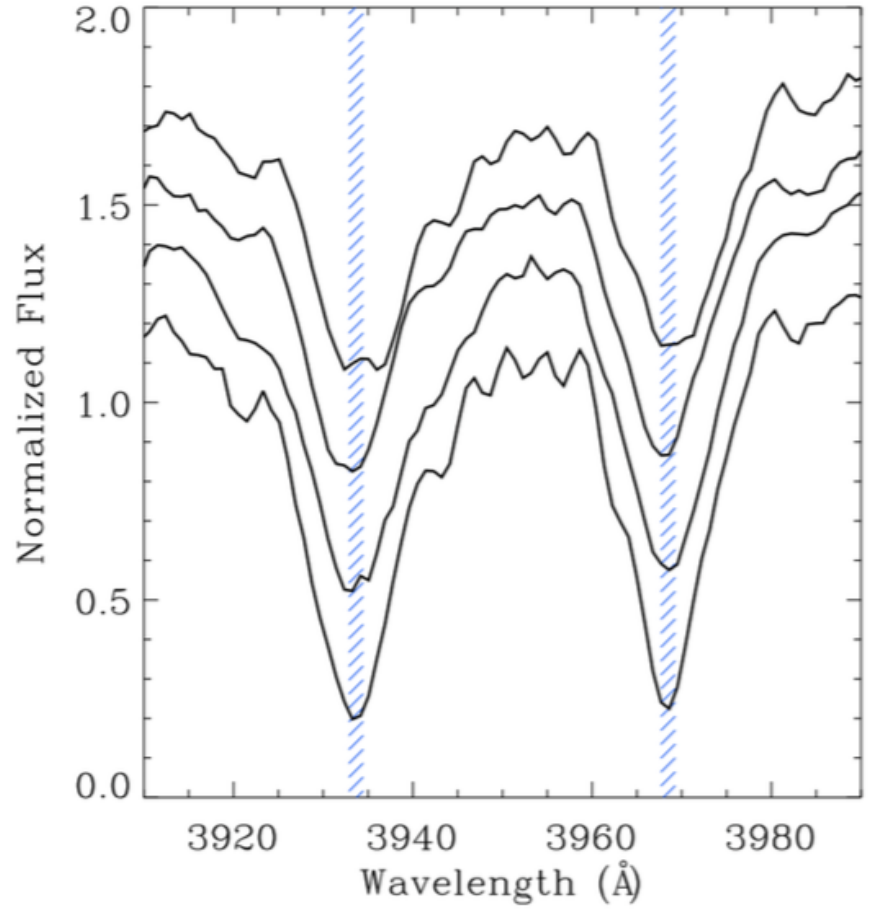






S-index

- CaII H and K absorption line depth.
- CaII H and K lines differ greatly between spot maxima and minima.
- To measure the strengths of these chromospheric emissions.

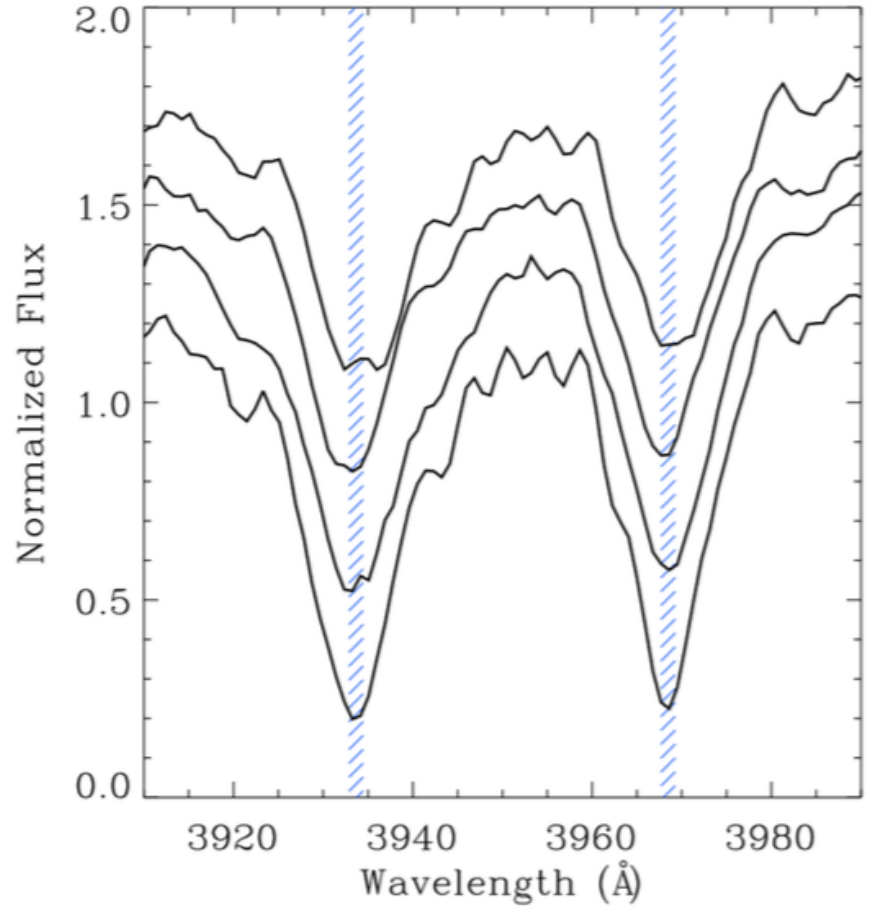


Wilson, 1968; Zhao et al., 2015

(Karoff et al., submitted)

Measuring S-index

- $S = \alpha \cdot (H+K)/(V+R)$
- α: normalization constant
  - spectral coverage, resolution
- H: the flux at 3968.5Å with 2Å width
- K: the flux at 3933.7Å with 2Å width
- V: the flux at 3901Å with 20Å width
- R: the flux at 4001Å with 20Å width



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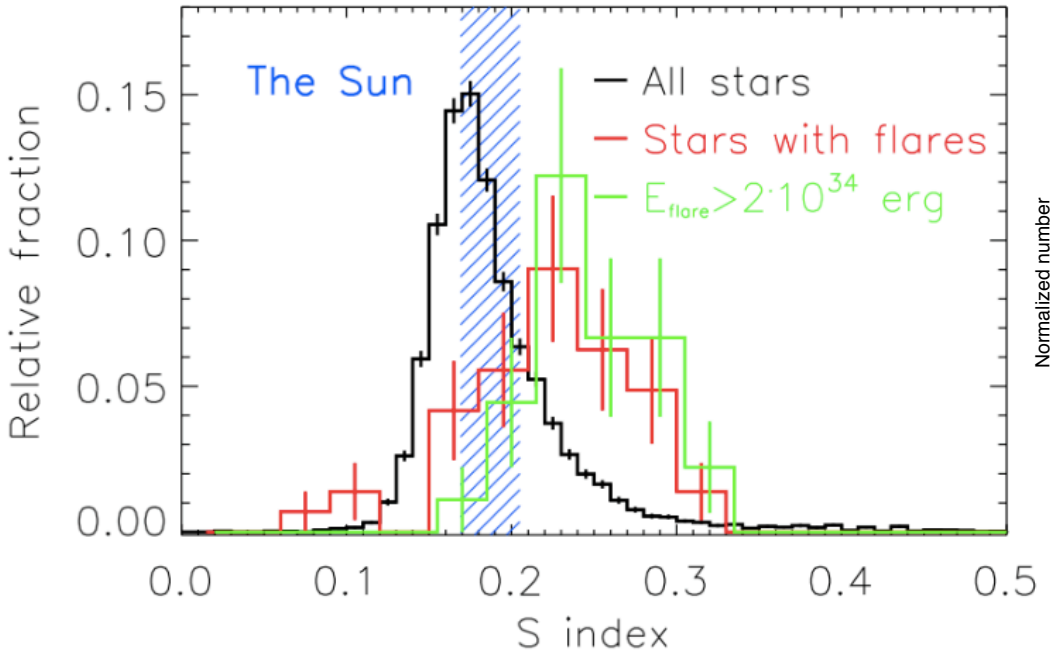
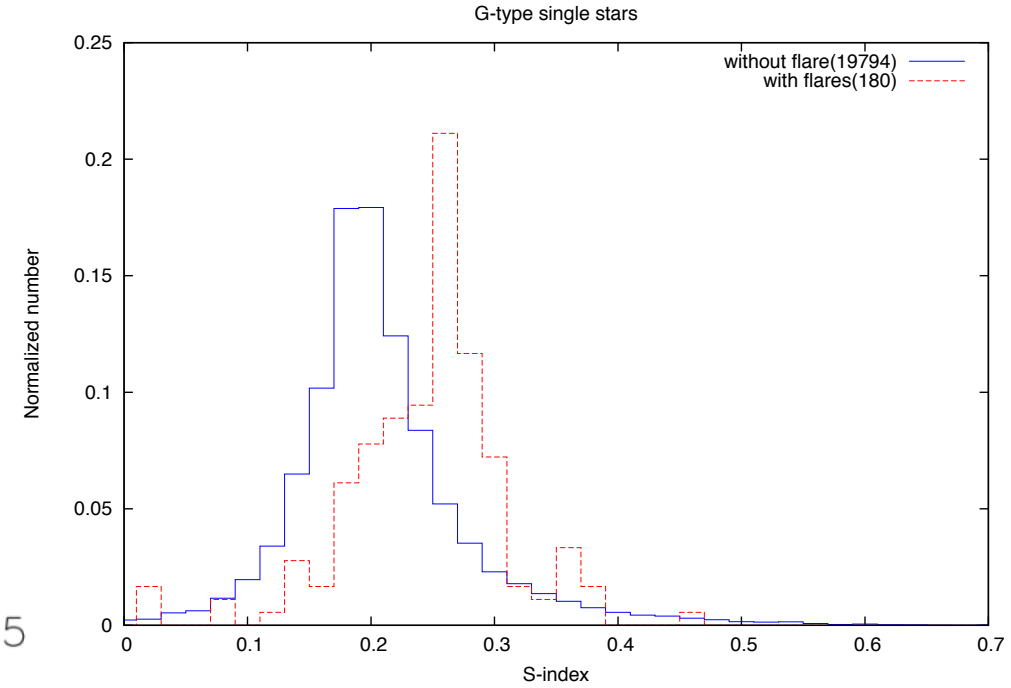
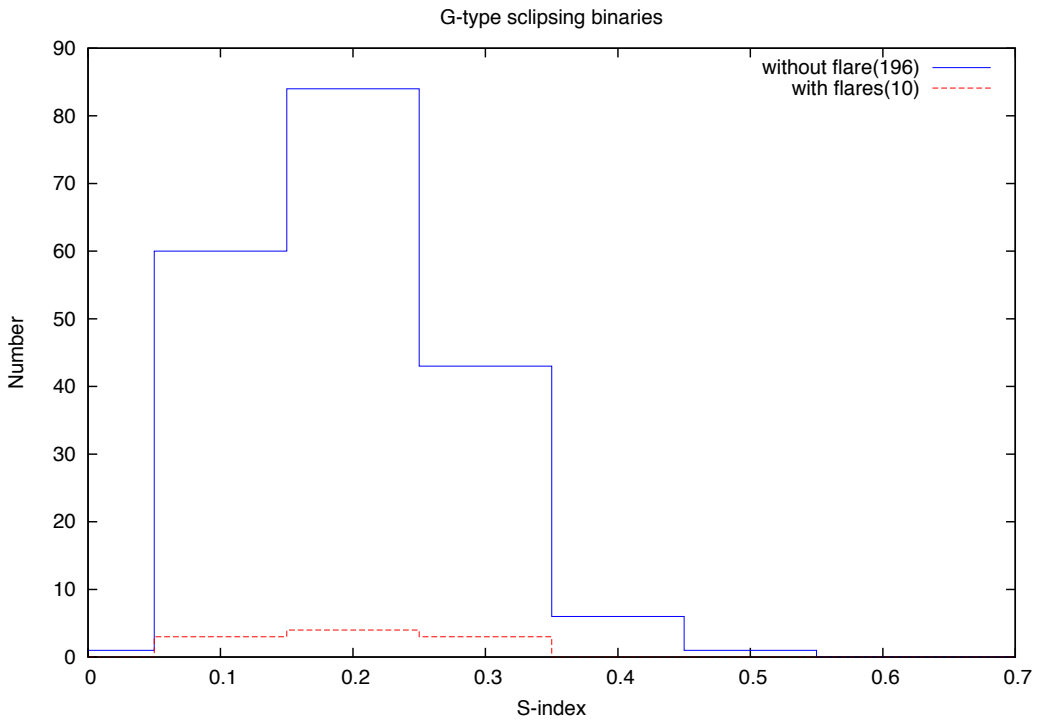
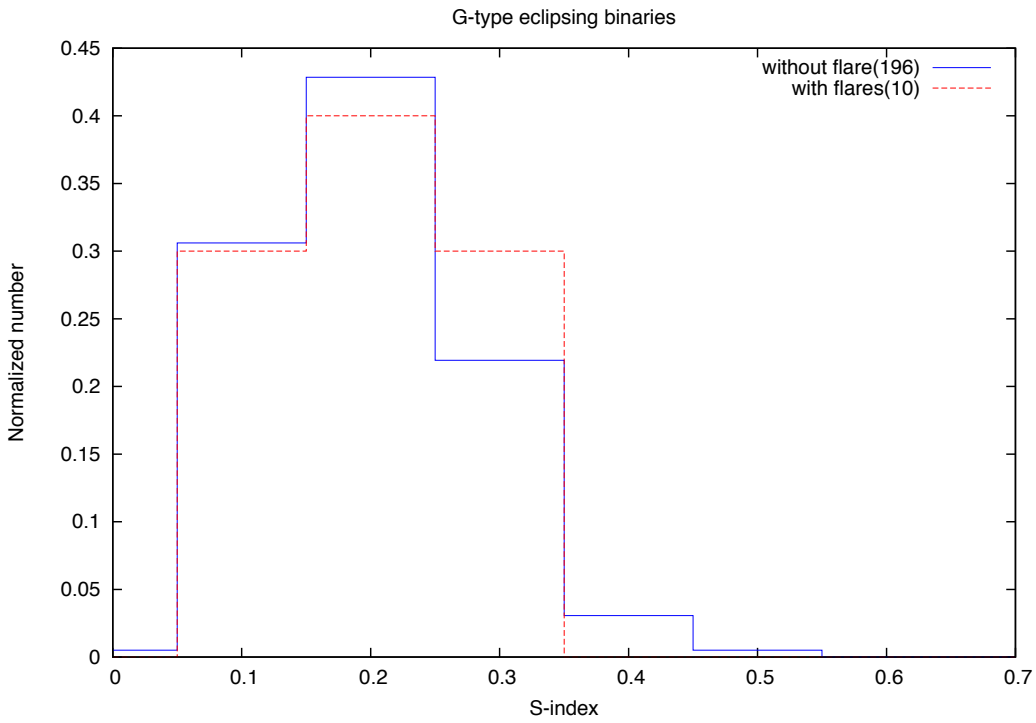




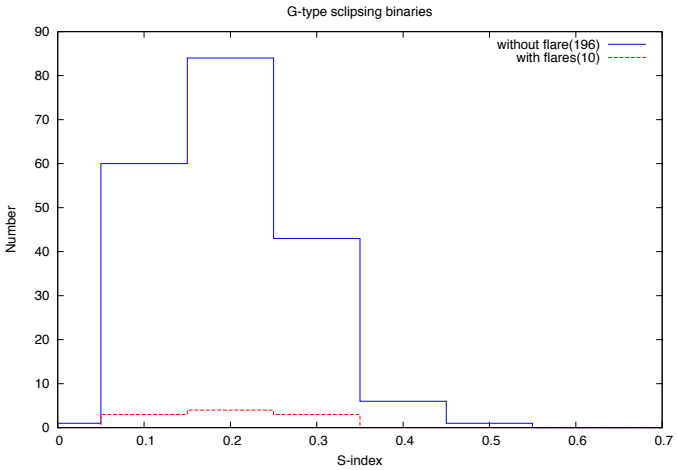
(Karoff et al., submitted)

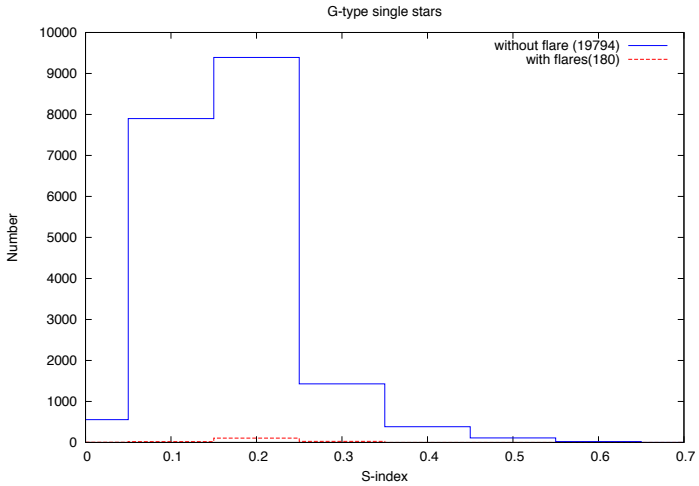
- Compare my S-index measuring with Karoff's work using the G-type single stars.

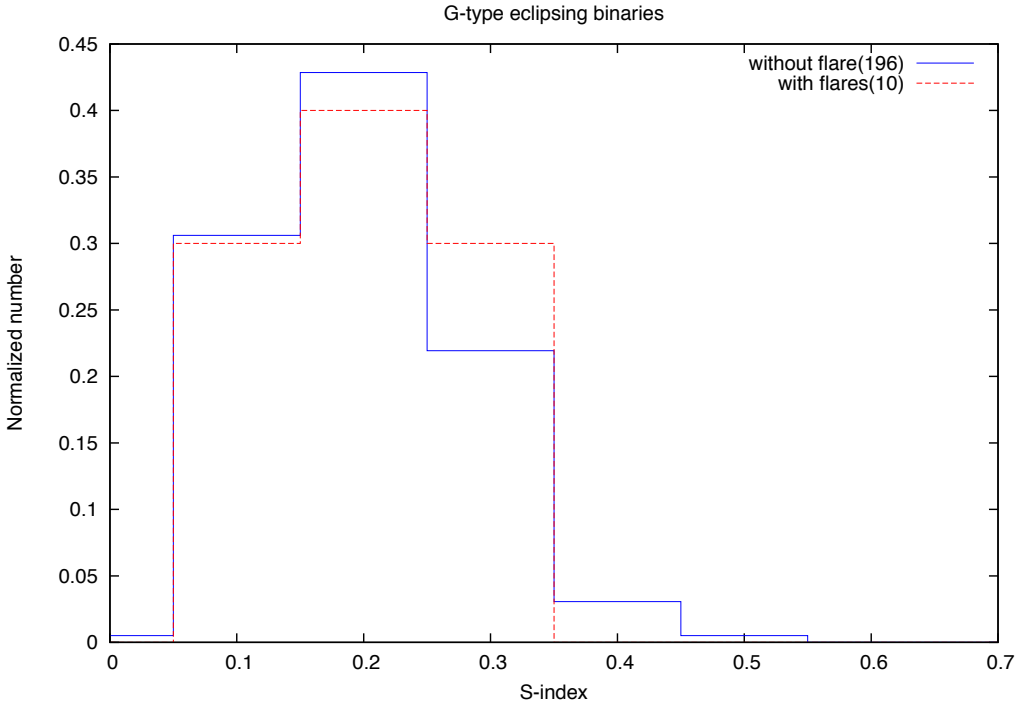


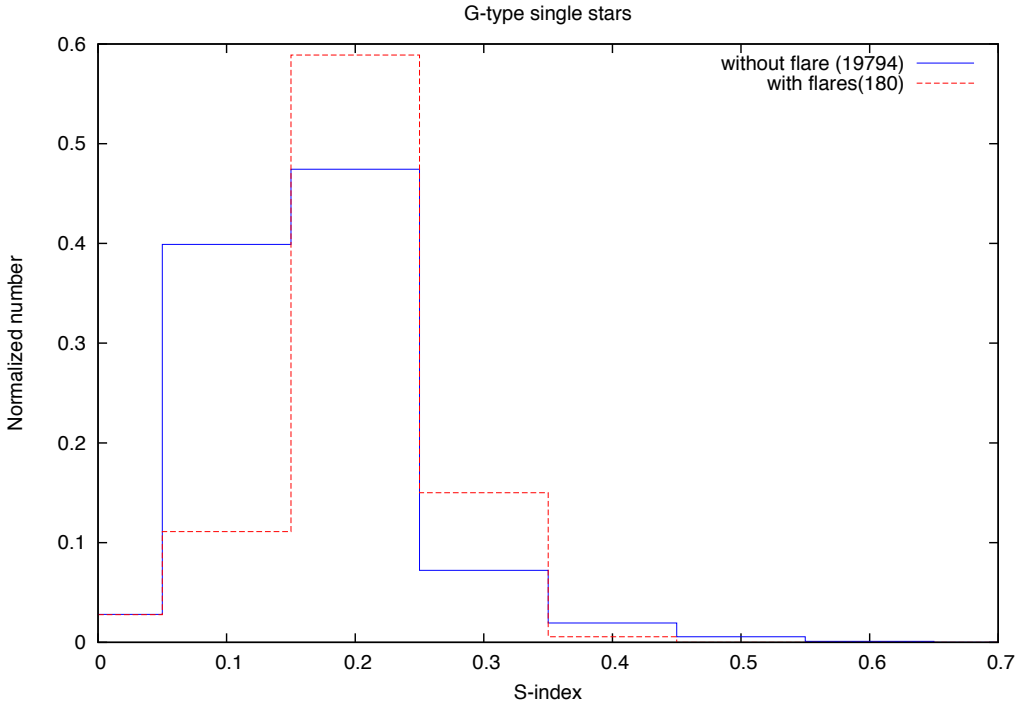


- LAMOST measurements provide high quality spectra for 206 G-type EBs in Kepler field.
- blue: 196 G-type EBs without flare , red: 10 G-type EBs with flares.









- Compare the S-index histograms of G-type EBs and single stars.
- Both of them show peaks at S = 0.2.

Summary

- Kepler observed 2605 EBs, and 691 of them with G-type primary stars. 19 G-type EBs are found with superflare events (~ 3%).
- EBs and single stars have the same S-index peak at 0.2. EBs are more active than single stars.

- Future Works:
- Superflare machenism and energy release.
- Mass ratio of EB components.
- Superflare timing and orbital phase.
- S-index of exoplanet hosts.