News from the ISSI Team "Quasi-periodic Pulsations in Stellar Flares: a Tool for Studying the Solar-Stellar Connection”

Anne-Marie Broomhall and the rest of the ISSI team

a-m.broomhall@warwick.ac.uk

Main aims

- Combine expertise in solar and stellar physics to fundamentally improve our understanding of flares.
- Perform a comprehensive study of flares observed by a variety of instruments.
- Use Hare-and-hound exercises to develop new robust analysis techniques.
- Use QPPs to determine how analogous the physical processes occurring in solar and stellar flares are
- Determine whether QPPs can be used to make inferences about the properties of the flare associated active regions.

Solar vs stellar flares

- Energies of flares: Stellar flares orders of magnitude greater than solar flares.
- Observational differences: White light vs other wavelengths, cadence, sensitivity, resolved vs unresolved.
- Shape of flares: Can the underlying flare shape ever be reliably removed, is there a ‘standard’ shape?

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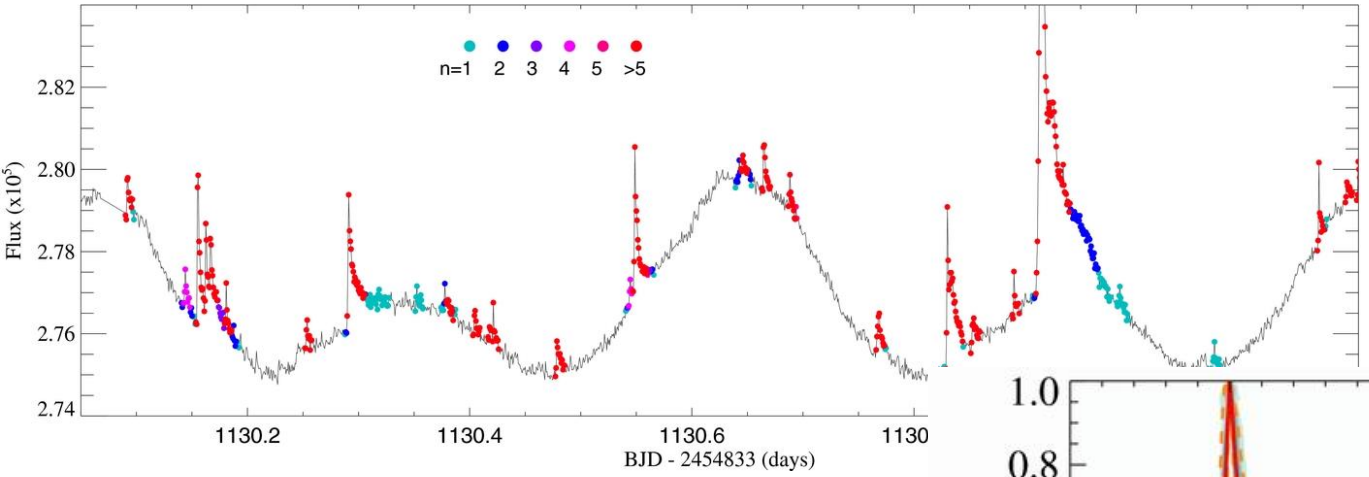
- **Are the same physical processes at work?**

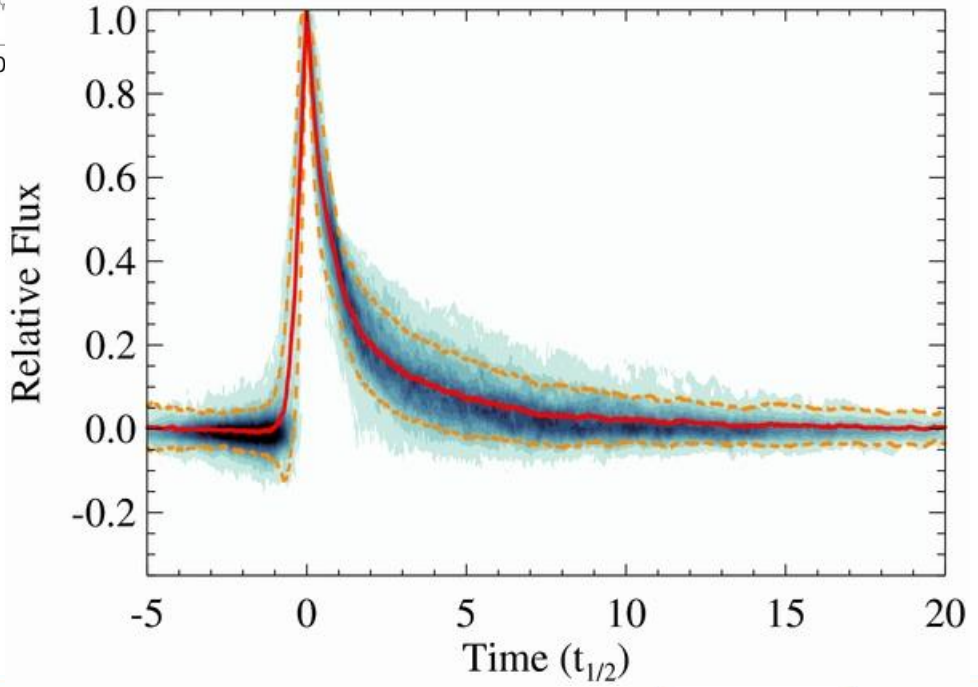
GJ1243: Davenport et al. (2014)



Section of Kepler light curve

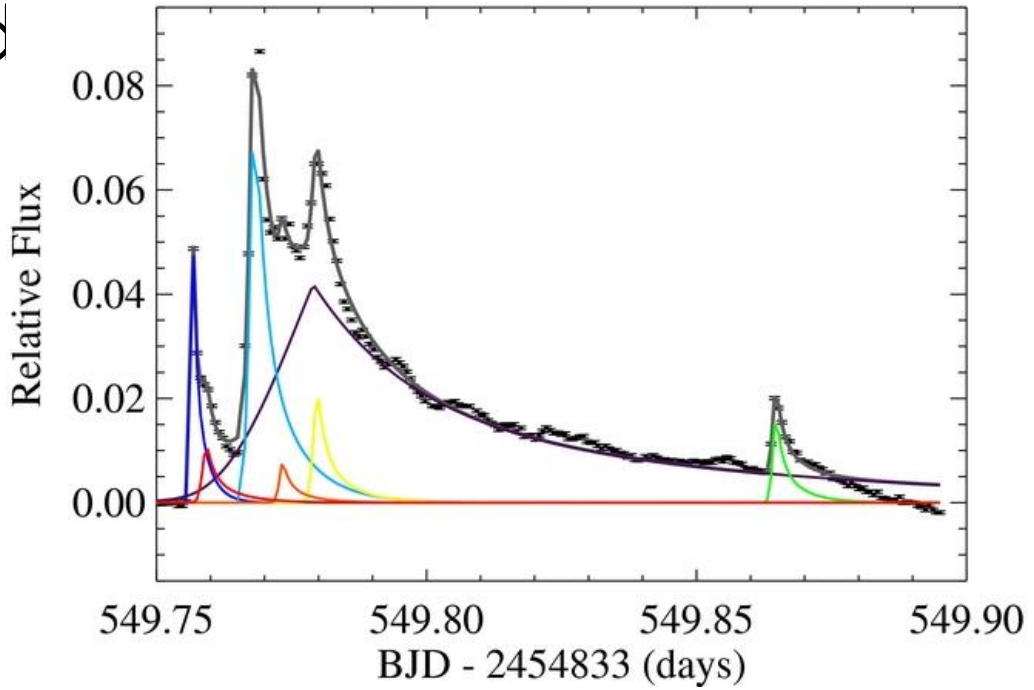
Empirical Flare model

2 decay phases

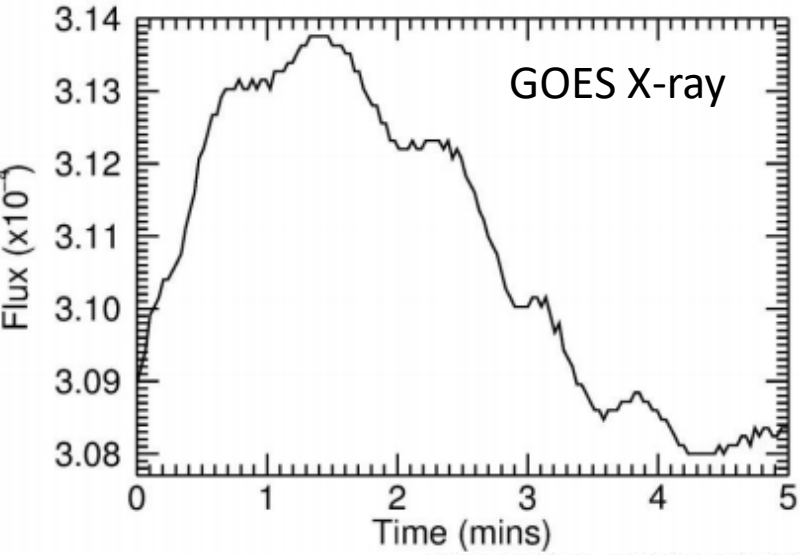


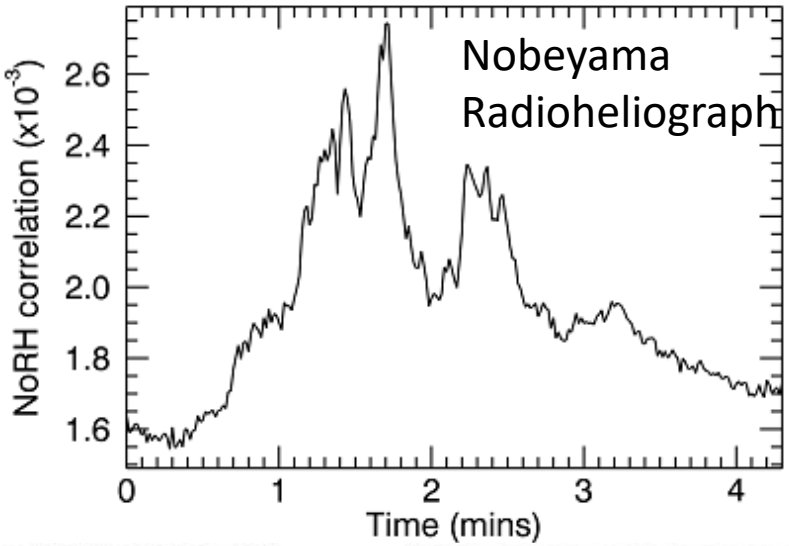
‘QPPs’ or just ‘Complex’?

- Davenport et al. (2014) & Pugh et al., (2016) both looked at flares on GJ1243.
- Davenport identified a large fraction of flares as complex: 15.5%.
- Pugh identified QPP flares.



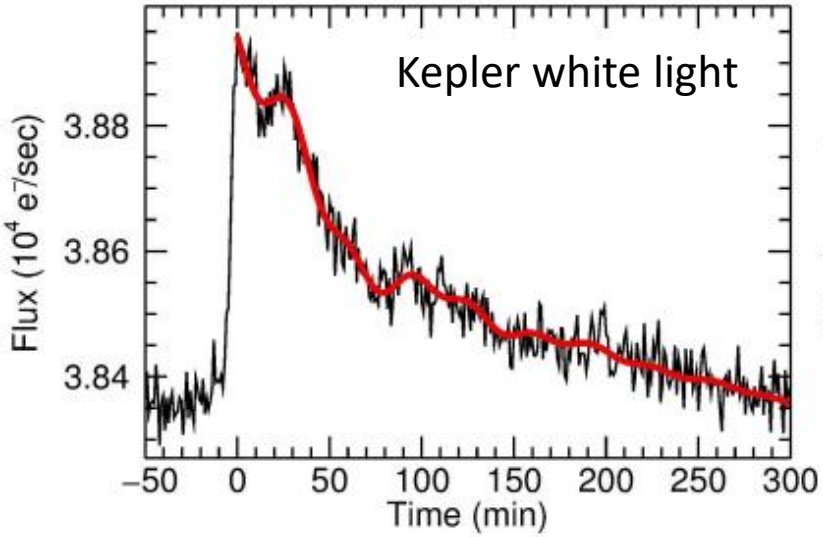
Comparison of solar & stellar QPP flares

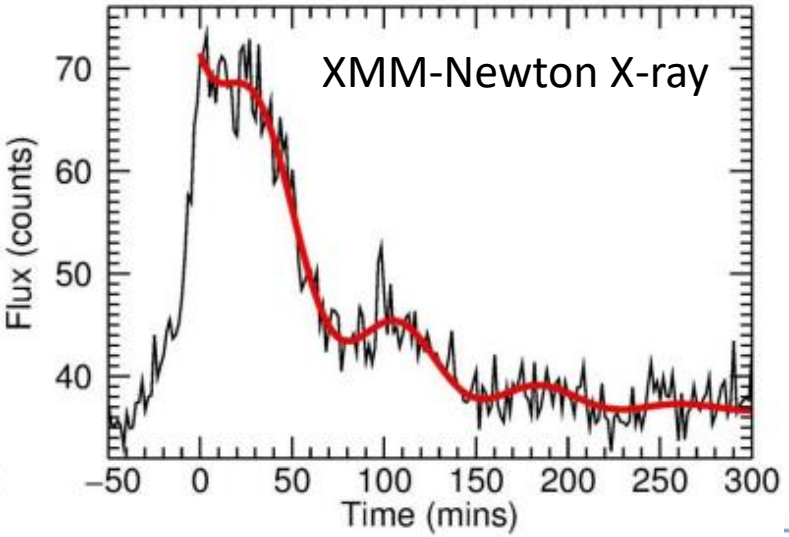




Pugh et al 2017

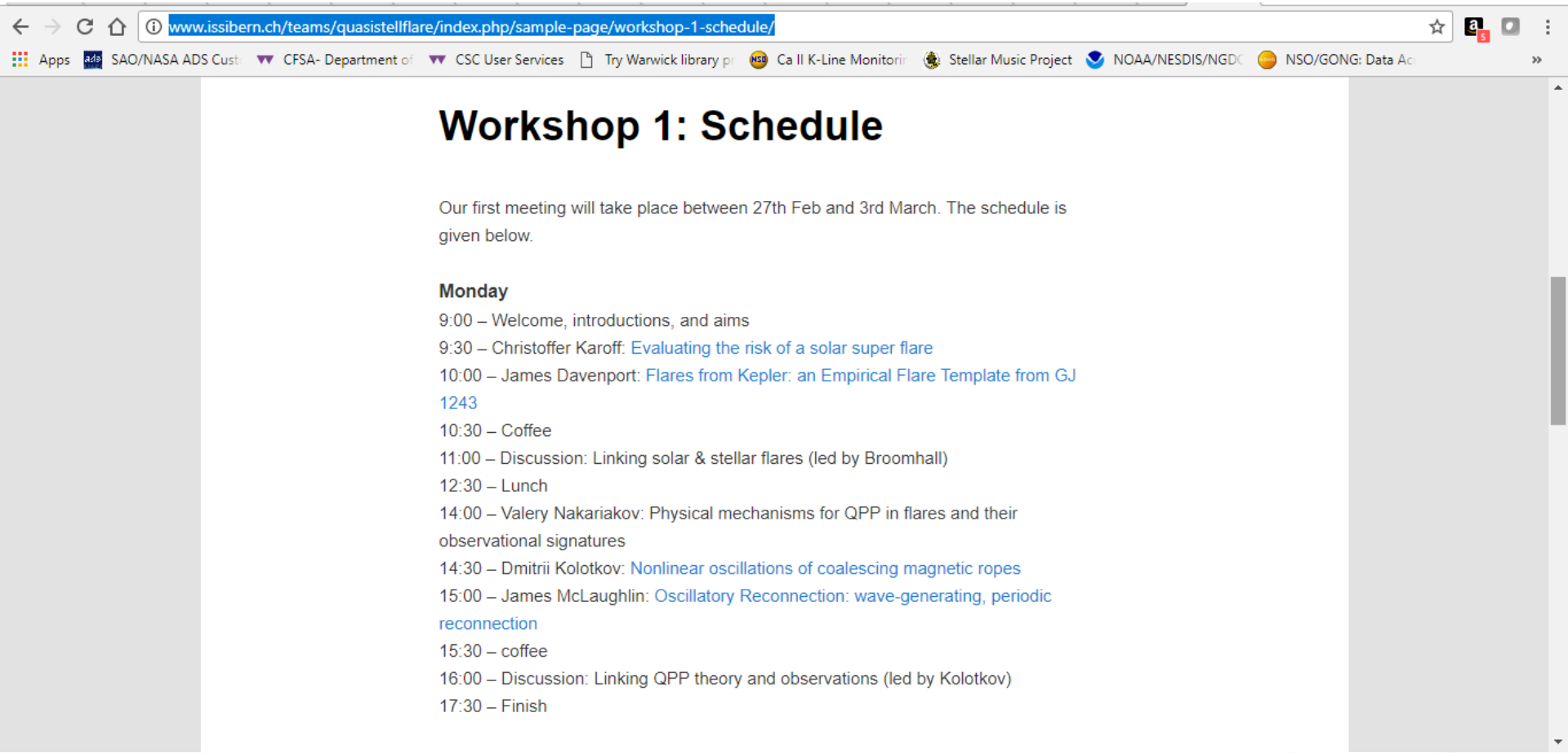
Pugh et al 2016





Team website

- http://www.issibern.ch/teams/quasistellflare/



Objectives for workshop 1

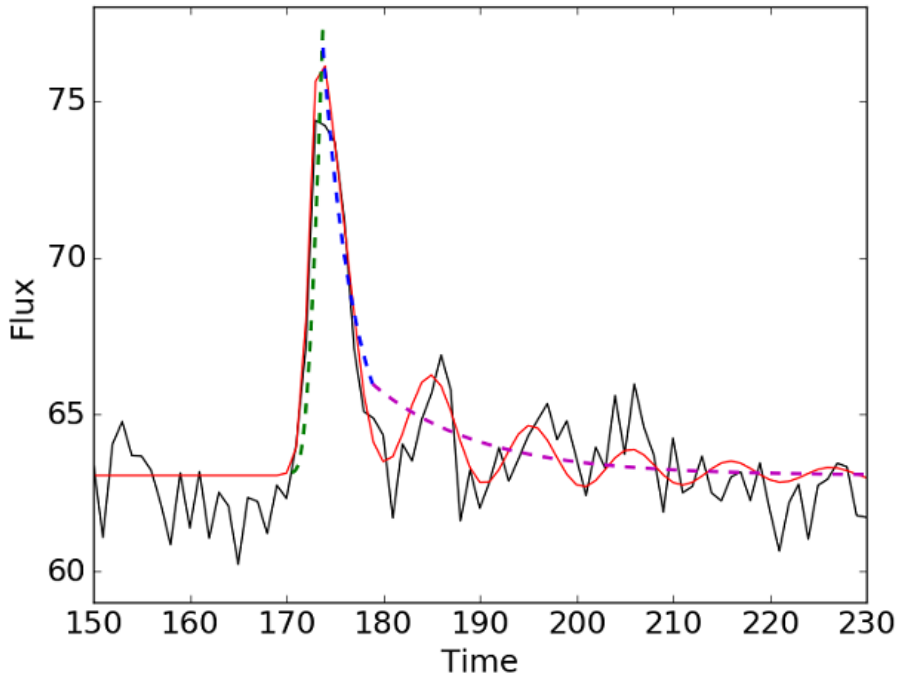
- Build a database of stellar flares
  - Identify subset of QPP flares.
- Establish hare & hounds exercise.
- Establish subset of flares for combined analysis.
- Establish a recipe for detecting flares and QPPs.
- Work towards a statistical study of QPP flares.

Hare and hound exercise

- The hare (Broomhall) creates artificial flares.
- The hounds (members of ISSI team) analyse the artificial flare light curves.
  - Fourier
  - Wavelet
  - EMD
  - Davenport's complex flare fitting routine (FBEYE)
  - Gaussian processing.

Artificial flares

- https://github.com/ambroomhall/flare_sims
- Different flare shapes.
- Different backgrounds
- Red & white noise
- Different numbers of QPPs (incl. 0).
- Different S/N



Please join the activity!

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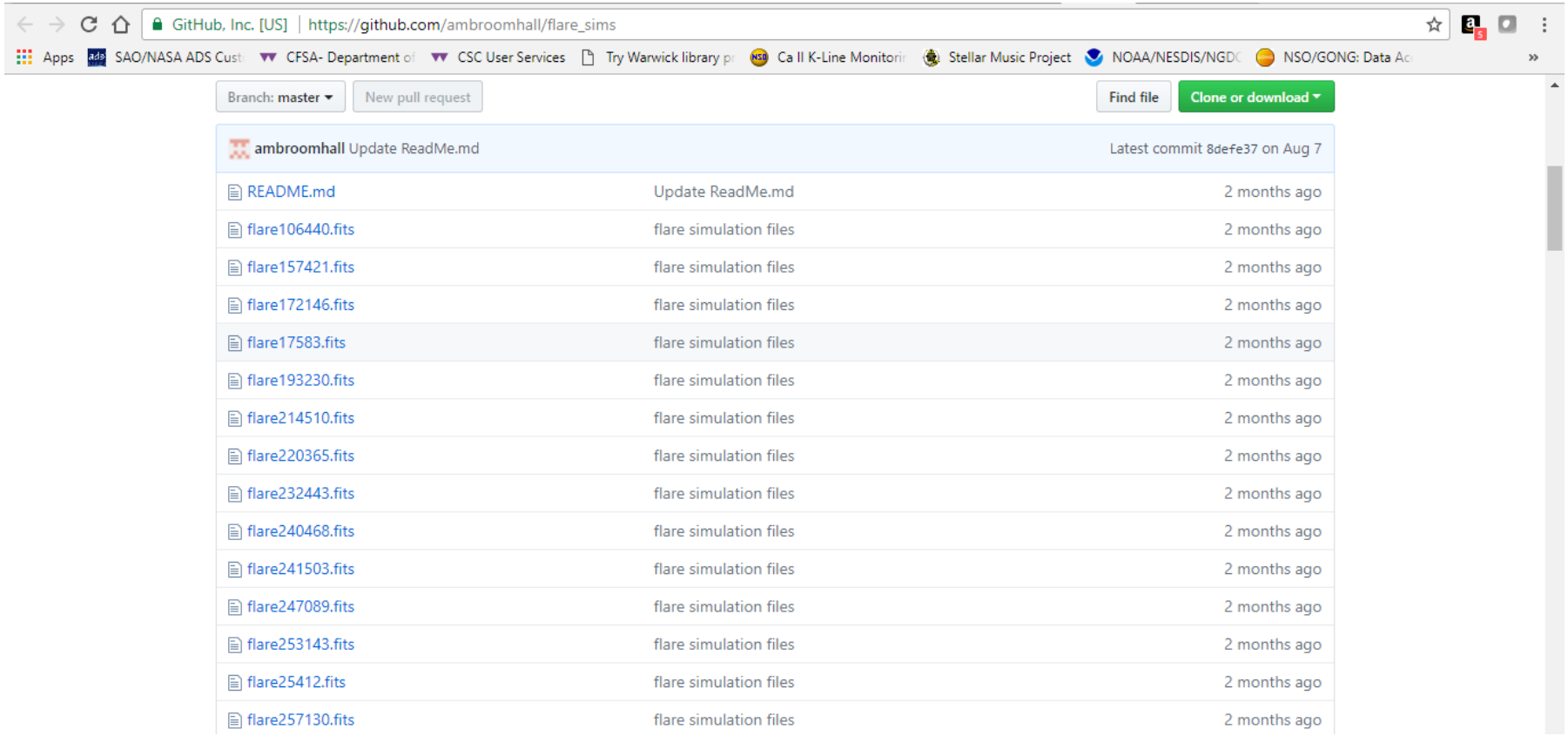

Database: Solar – Val's page

- https://www2.warwick.ac.uk/fac/sci/physics/research/cfsa/people/valery/research/qpp/

Event Date	Time Start	Time End	Flare Class	Observed Periods	Bands Observed	Related Publications
16 October 2015	10:13 UT	10:24 UT	C3.1	~32-42 s	SXR , IRIS SiIV	Zhang et al., 2016
29 September 2015	05:05		M2.9	27.2 s 21.4 s	GOES 1-8 Å Fermi/GBM, 15-25 keV	Inglis et al. 2016
21 September 2015	01:57 UT	02:08 UT	C4.2	13 s in non-thermal emission 26 s in thermal emission	12–300 keV 4.9–34 GHz GOES SXR flux derivative AIA 304 Å	Kumar et al. 2017
11 June 2015	08:49		M1.0	10 s	GOES 1-8 Å Fermi/GBM, 15-25 keV	Inglis et al. 2016
06 May	11:45		M1.9	227.7 s	GOES 1-8 Å	Inglis et al. 2016

Database - Stellar

- To be placed on ISSI team website – to include links to data as well.

Star	Data Source	Period (mins)	Publication
II Peg	Stephanion Observatory (U-band)	3.67	Mathioudakis et al. (2003)
AT Mic	XMM-Newton	12.5	Mitra-Kraev et al. (2005)
YZ CMi	New Mexico State University 1 m Telescope (U band)	32	Anfinogentov et al. (2013)
Proxima Centauri	XMM-Newton	21.0, 11.45	Srivastava et al. (2013)
KIC9655129	Kepler	78 ± 12, 32 ± 2	Pugh et al. (2015)
KIC2852961	Kepler	68 ± 2	Pugh et al. (2016)
KIC2852961	Kepler	93+27/−21	Pugh et al. (2016)
KIC3128488	Kepler	19+5/−4	Pugh et al. (2016)
KIC3540728	Kepler	43+13/−10	Pugh et al. (2016)
KIC3540728	Kepler	36.7 ± 0.3	Pugh et al. (2016)
KIC4671547	Kepler	4.6+0.9/−0.7	Pugh et al. (2016)
KIC4758595	Kepler	49+35/−20	Pugh et al. (2016)

Data for stellar flares

- Team members currently using: XMM-Newton, Kepler, K2, GALEX.
- Future plans:
  - Application submitted to TESS GI program (led by Davenport).
  - Get radio observations – RATAN-600, Nobeyama 45m dish.
  - Try and get contemporaneous multi-wavelength observations of stellar flares.

Workshop 2: 26th Feb 2018

- Compare results for hare and hounds.
- Analyse a sub-set of real data & perform a statistical analysis of the QPP flares.
- Make comparisons between observed results in different wavelengths.
- Discuss the potential of theoretical works to produce the observed results for solar & stellar flares.
- Discuss future observing strategies.