# Quasi-periodic oscillations observed by LYRA and other instruments

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## Abstract

Quasi-periodic oscillations have been observed in the rising phase of solar flares for many years. Here we compare the short-period oscillations (around 10 s) observed during several events by many instruments: the radiometer channels of PROBA2/LYRA (soft X-ray, Lyman al- pha, Herzberg continuum), the radiometer channels of SDO/EVE-ESP (soft X-ray, coronal and chromospheric passbands), the RHESSI passbands and short-wavelength radio observations. We consider the time/phase delay between these different channels and discuss theoretical interpretations of these results.









Check list for potential non-flare oscillation causes and their falsification		
Title	Description	Falsification
Quantization noise	During the rising phase of a flare, a quantization effect is often seen - most likely related to the used cadence.	
De-trending	By substraction a windowed average from the signal, artefacts might be introduced. These need to be excluded in the oscillation analysis.	- test with different window sizes - analyze the trend signal itself
environmental effects (e.g. orbital ones)	The analysis shall exclude that there are any effects of solar or earth environment. These effects could be any kind of disturbances caused by the SAA.	<ul> <li>confirmation of the flare by GOES flare list</li> <li>check that the s/c subsurface intersection point is not at the poles</li> <li>check that the s/c did not cross the South Atlantic Anomaly</li> </ul>
spacecraft effects I: Large Angle rotations	Effects from activities of other instruments and subsystems of the spacecraft shall be excluded.	<ul> <li>check for LARs (check with ESA Project what the reaction wheels are doing after a LAR. Would we see frequencies of 100 sec periodicity?)</li> <li>check for any other s/c activities</li> <li>check for any other payload activities during flare</li> </ul>
spacecraft effects II: jitter	can we exclude spacecraft jitter to be the cause of the oscillations?	We had a campaign that sampled attitude in 1hz. Analyze this data and check, how the attitude settles after LARs
spacecraft effects III: electronic interference	Can we exclude electronic interference from other instruments or subsystems?	<ul> <li>During non-flaring periods, the Lyra data represents the background signal and we most likely are not able to even see electronic interferences due to the low signal level. This could be solved by checking the Lyra LED campaigns.</li> <li>check the operations of the in-situ instruments</li> <li>check periods of different swap cadences used and check for oscillations within these periods</li> </ul>
oscillations caused by other solar events	How can we exclude that the oscillations are not an addition of effects from different solar activities (different ARs)?	Check for every flare analysis the amount of AR on the disk. Create virtual channels from e.g. SWAP images that represent only the individual responses of the ARs.
Systematic errors introduced by data pipeline	How can we avoid that the oscillations are caused by artefacts of the data pipeline? We discussed that in case no time information is available in Lyra packets, the data is generated. What kind of effects could be created by this time tag generation?	We should take the timetags of the attitude data and get the data values for these timetags from the lyra data. Then analyze this data and check that the same oscillations are seen.



### Quasi-periodic pulsations (QPP)

- <u>short (<sec) period</u>,
   "high quality" observations in flareaccelerated non-thermal emission in the microwave: interaction of plasma, whistler waves, particles
- <u>long (> sec) period</u>,
   "low quality" observations in EUV, soft X:
   MHD processes
- spectral evolution: ShH, HSH

Nakariakov & Melnikov, (2009) Space Sci Rev 149, 119







# Conclusions

New opportunties:

- LYRA sees QPP: 10s-200s
- Nobeyama, LYRA and SDO-EVE: new opportunities brought by high temporal sampling
- Phase shifts?
- SDO/AIA: I0s imaging! HVAR! 
   Can we see what is occillating?
- interpretation? 
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### BUKS 2011 Scientific Programme and Abstracts Booklet

#### Monday 27 June

9.00 - 9.15 Registration

9.15 - 9.30 Welcome (J. L. Ballester; A. W. Hood)

Session chair: A. W. Hood

9.30 - 9.50 Magnetic perturbations, acceleration and cross-field transport of energetic

electrons in a solar flare loop (I. G. Hannah)

9.50 - 10.10 LYRA observations and seismology of two oscillation modes in a single flare

(T. Van Doorsselaere)

10.10 - 10.30 Alfvén wave phase-mixing and damping in the ion-cyclotron range of

frequencies (J. Threlfall)

10.30 - 11.10 Coffee break and poster session

11.10 - 11-30 The importance of the FIP effect to models of coronal heating (J. Martin

Laming)

11.30 - 11.50 A comparison of quasi-periodic perturbations in different wavebands (L. Dolla)

11.50 - 12.10 The Hilbert-Huang Transform: A new approach for studying quasi-periodic pulsations in solar flares (J. Hershaw)