

40. Zjazd PTA
Szczecin 13-17.09.2021



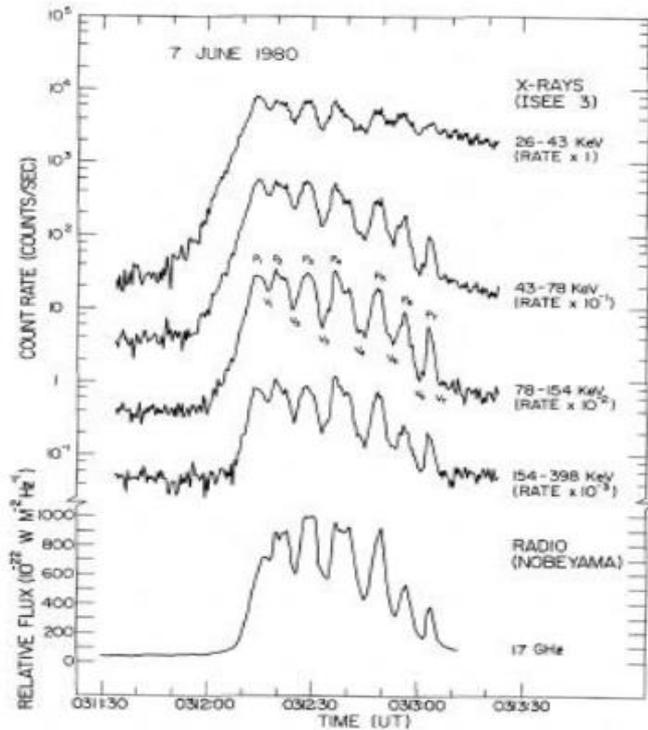
Quasi-periodic pulsations visible in the STIX light curves

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Quasi-periodic pulsations



Quasi-periodic pulsations (QPPs) - nearly periodic changes of intensity in the electromagnetic radiation, have been observed in light curves of many solar and stellar flares. Although QPPs have been encountered in almost all energy ranges, the most significant observations come from the hard X-ray (HXR) and microwave radiation, where the quasi-periodic changes are often very clear. The periods of oscillations vary from fractions of a second to tens of minutes.

QPPs are commonly interpreted as the manifestation of magnetohydrodynamic (MHD) processes in flaring magnetic structures or as the result of repetitive regimes of magnetic reconnection (Kupriyanova et al. 2020).

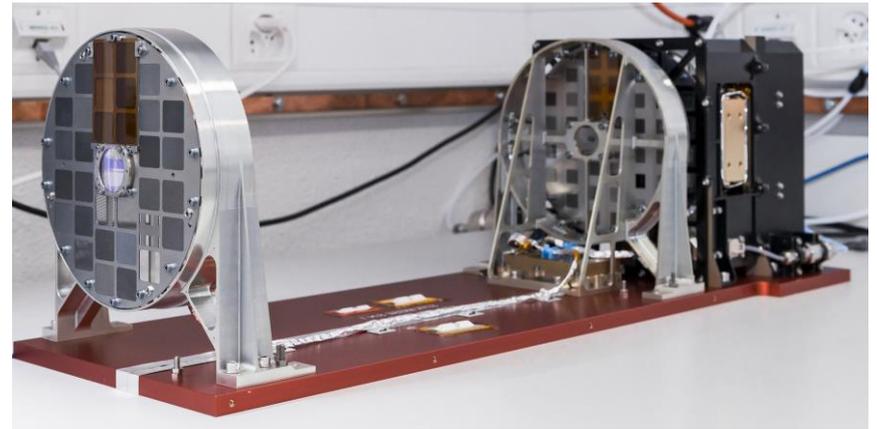
Classical example of QPPs- "Seven Sisters", 7 June 1980
(Kane et.al., 1983, ApJ 271, 376)

STIX

The Spectrometer Telescope for Imaging X-rays (STIX) is one of the instruments on board the ESA Solar Orbiter mission, launched on February 10, 2020.

The STIX is a hard X-ray imaging spectrometer covering the energy range from 4 to 150 keV.

STIX applies an indirect Fourier imaging technique to provide information on angular scales from 7 to 180 arcsec with 1 keV energy resolution (at 6 keV).

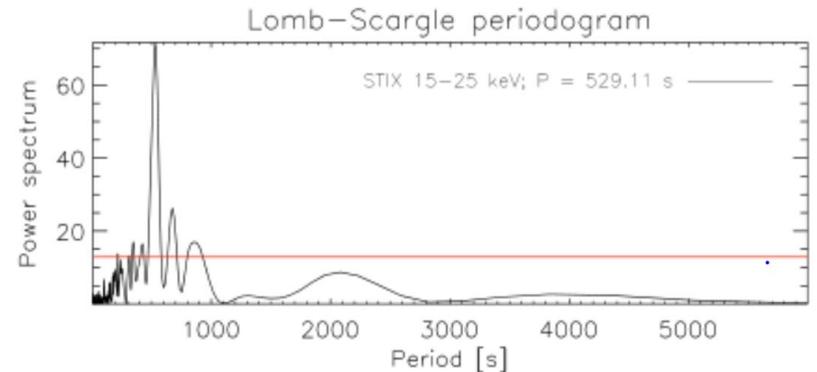
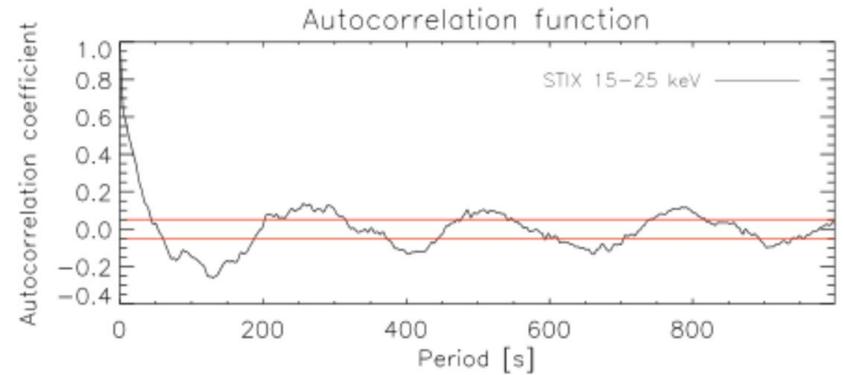
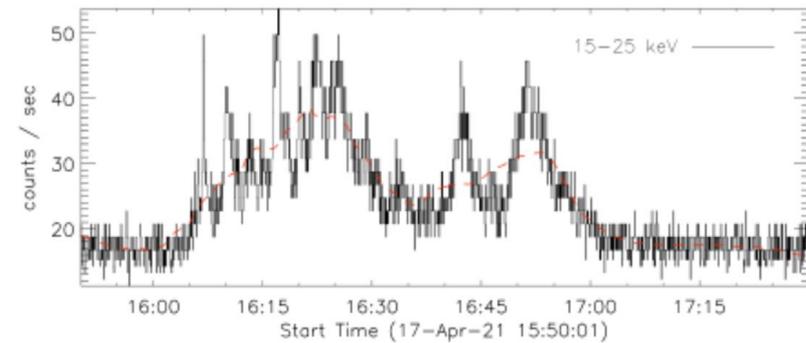
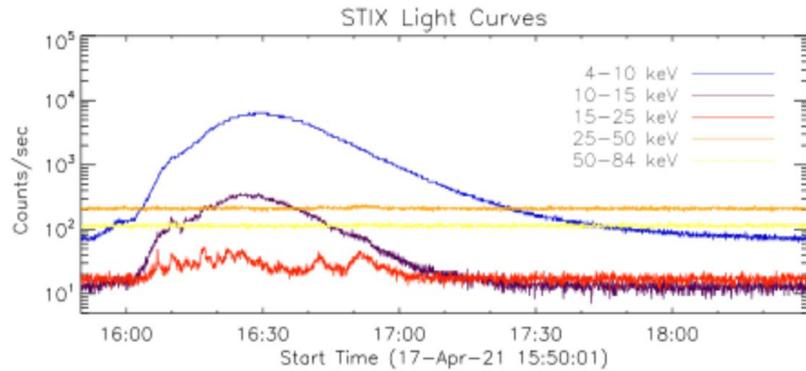


QPPs observed by STIX

We present examples of QPPs observed during solar flares registered by STIX instrument. We used STIX quick-look light curves, which provide almost continuous data in 5 energy bands within 4-150 keV, with a time resolution of 4 s.

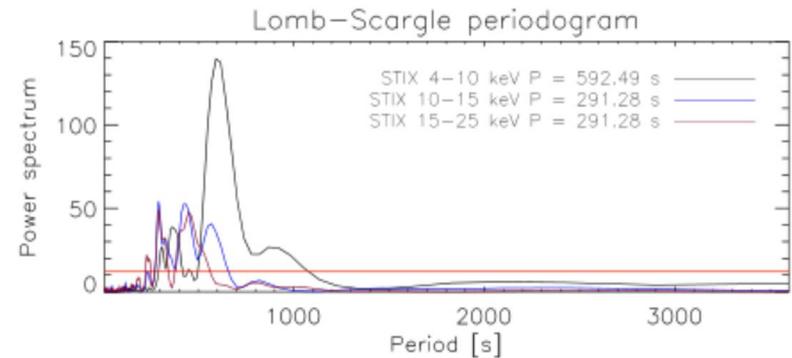
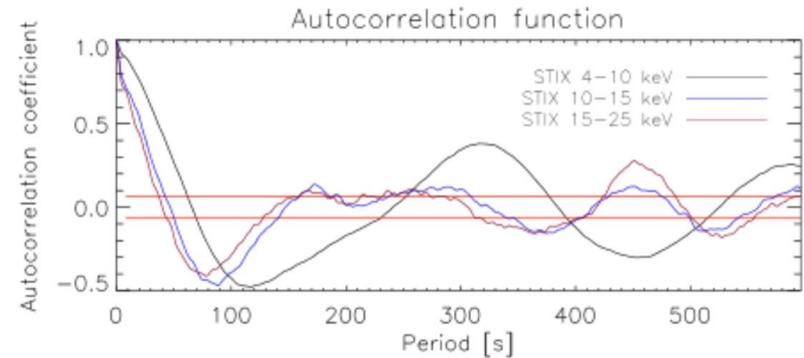
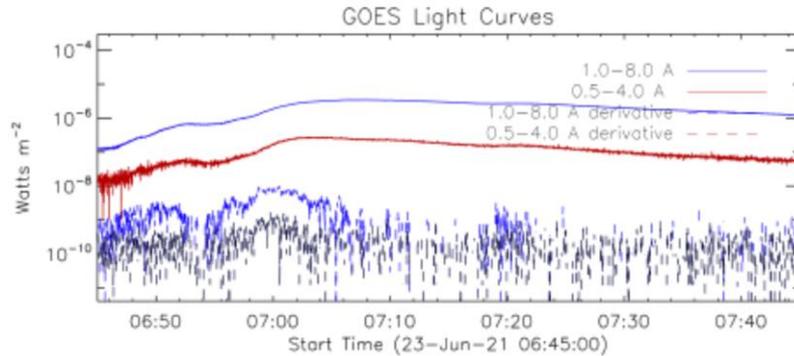
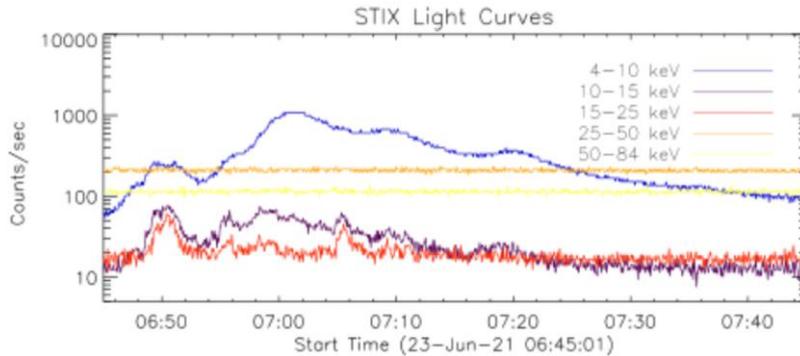
We separated the HXR pulses from the smooth HXR component by a trend subtraction. The periods were obtained using two methods: by determining the autocorrelation function and by calculating the Lomb-Scargle periodogram. Red horizontal lines on the autocorrelation and Lomb-Scargle periodogram plots represent the level of significance (0.99 and 0.95 respectively).

17 April 2021 Solar Flare



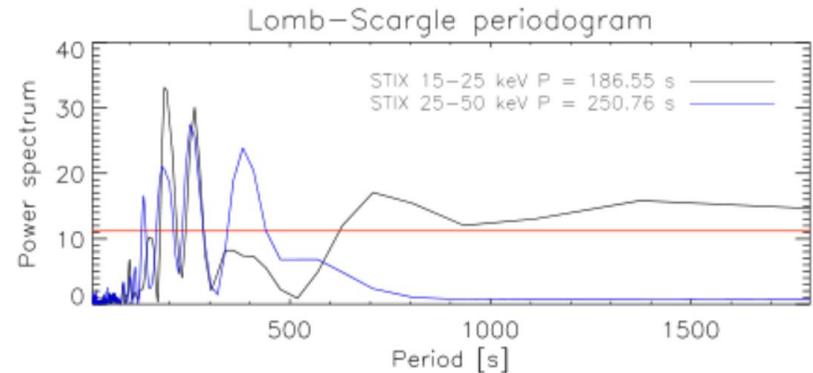
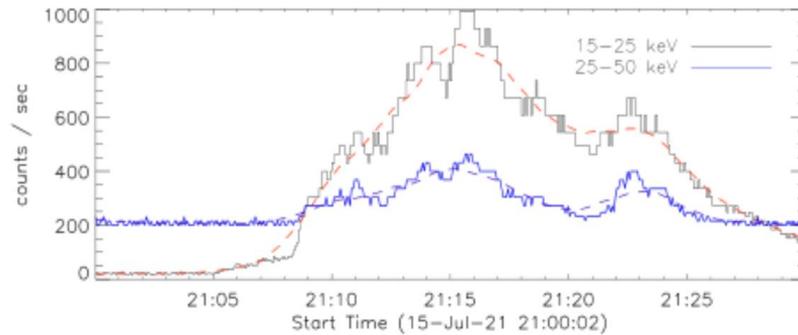
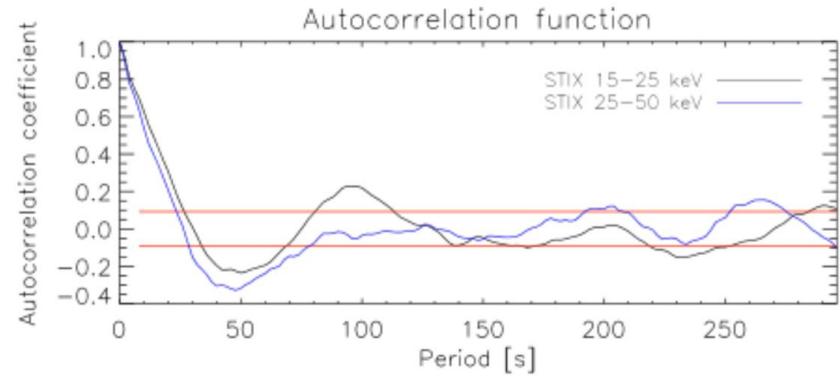
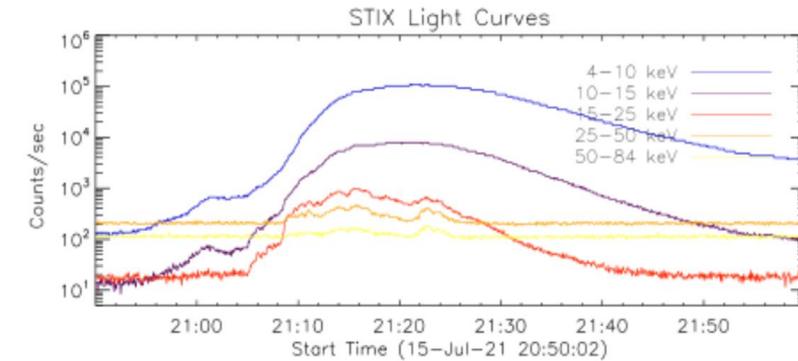
A long series of pulses, with the period of $P \sim 530$ s, was observed in the 15-25 keV STIX light curve. This Energy range corresponds mainly to non-thermal emission.

23 June 2021 Solar Flare



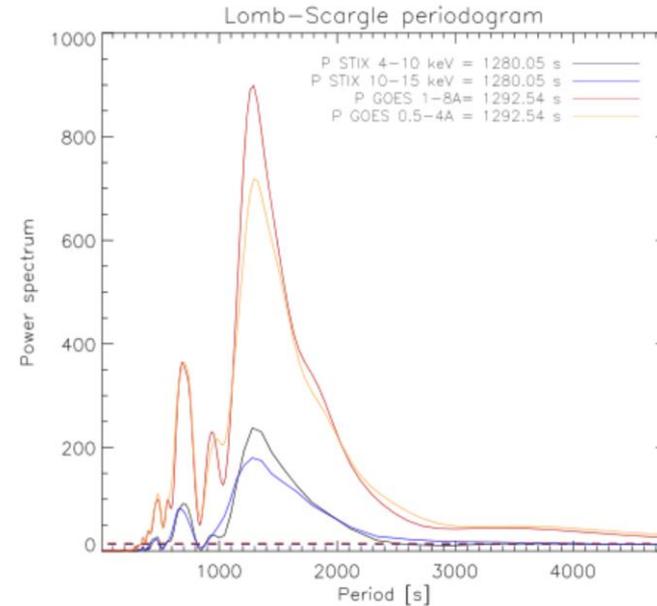
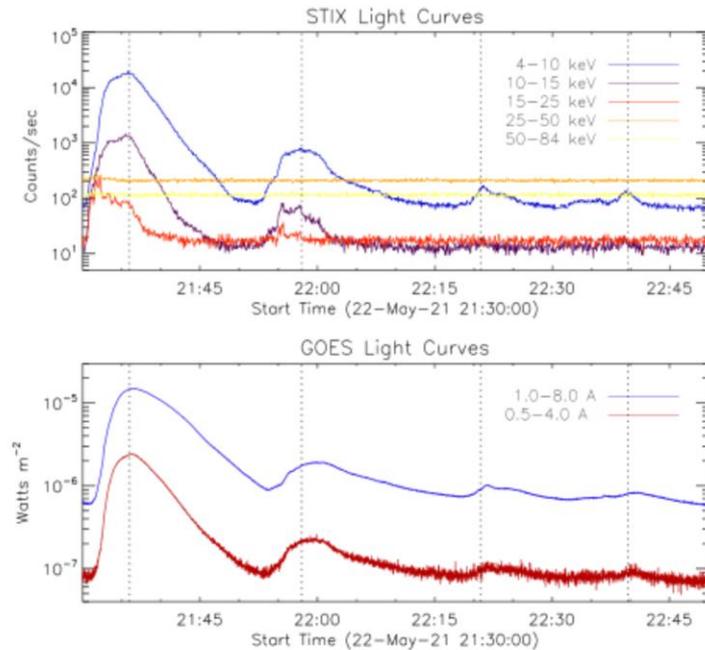
In the 4-10 keV energy range two maxima were pronounced on the Lomb-Scargle periodogram: $P \sim 600$ s and $P \sim 300$ s. In the energy ranges 10-15 keV and 15-25 keV only the second maximum $P \sim 300$ s was visible. Some of the changes of fluxes observed in STIX light curves were also visible on GOES light curves and their derivatives.

15 July 2021 Solar Flare



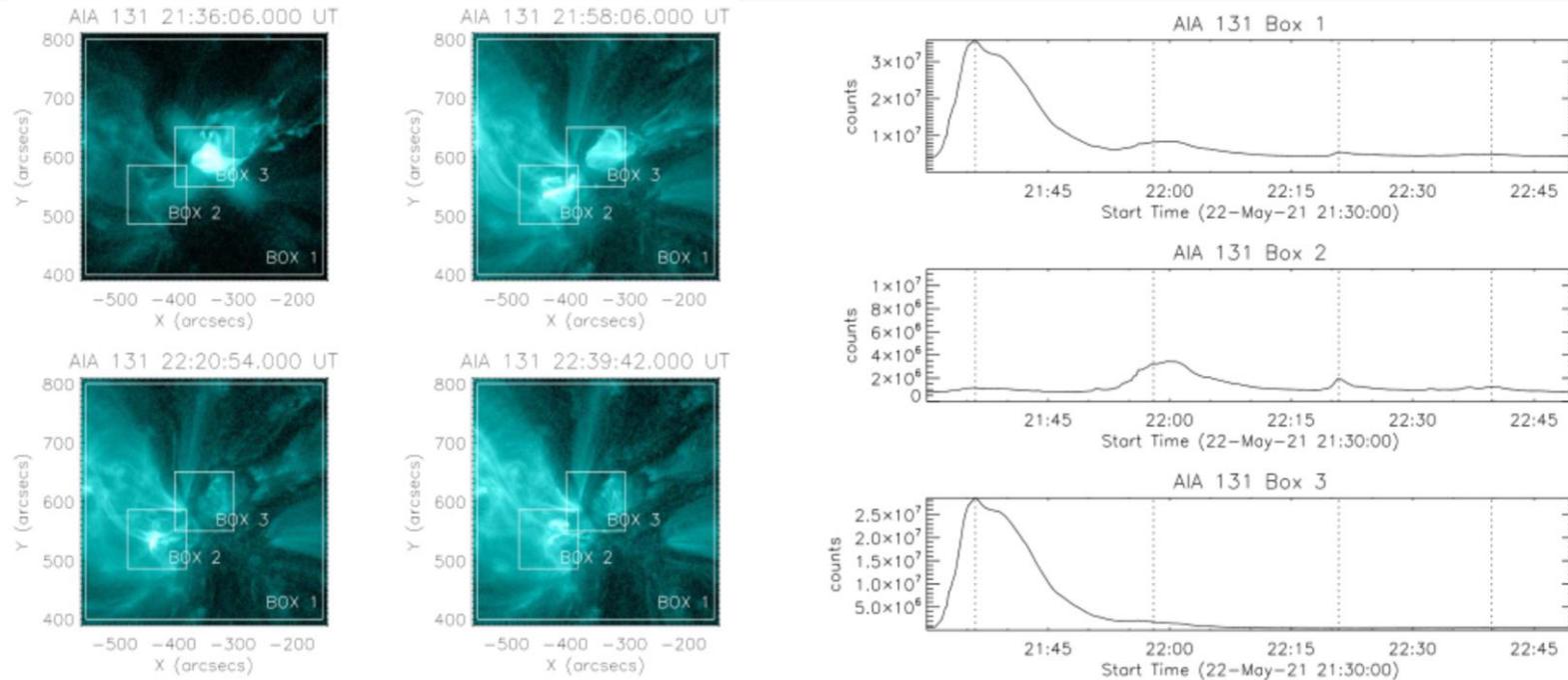
Another example of QPPs visible in hard X-rays. The periods of pulses in the energies 15-25 keV and 25-50 keV were 186 and 250 s respectively.

22 May 2021 solar flare



The event which starts 22 May 2021 at 21:30 shows four regular increases of the HXR radiation in the energy ranges 4-10 keV and 10-15 keV. The Lomb-Scargle periodogram gives the period of 1280 s in both cases. A similar pattern was observed on GOES light curves. In the energy range 15-25 keV of STIX observations there is additional series of pulses during the time of the first maximum. Lomb-Scargle periodogram gives the period of ~ 60 s, although slightly below the 0.99 level of significance.

22 May 2021 solar flare



Above we present AIA/SDO 131 Å fluxes inside three boxes marked on the images. AIA images shows, that although all the HXR impulses comes from this same active region, the first maximum was produced by a bit different magnetic structure than the other three. It is therefore unclear if this is QPPs flare or a series of homologous flares.

Conclusions

STIX instrument provides an excellent tool to observe QPPs of solar flares. It can provide spectroscopic information in the 4-150 keV range with the 1keV resolution and time resolution up to 0.1s. Due to telemetry limitations, the high-resolution data are however available only for selected flares. On this poster we have presented QPPs observed on the STIX quick-look light curves- they have a worse temporal and spectral resolution, but are provided almost continuously.

The 22 May 2021 solar flare proves, that during QPPs analysis spatial information is essential. Without spatial information, it is difficult to distinguish if the observed increases of radiation all come from the same magnetic structure. Unfortunately, the STIX imaging system still undergoes tests and calibration. The MARLIN algorithm, currently being developed in the Solar Physics Division of the polish Space Research Centre, will soon allow the reproduction of X-ray images of the Sun from STIX data.