LYRA Mid-term Periodicities

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The spectra of the PROBA2/LYRA data, similarly to every other solar time series, show predominant periodicities that can be of solar or instrumental origin. We compare the main periodicities characterizing the LYRA spectrum to those found in the sunspot number, in the 10.7 cm flux, in an X-ray flare index, and in the sunspot area evolution. We focused on the 2010 to 2014 time range, for which the LYRA data are available, although we also briefly address the evolution of the main periodicities in the longer range. The mid-term periodicities at ∼28, ∼44, ∼54, ∼59, ∼100, ∼110, and ∼150 days appear as highly significant in several analyzed datasets. The consistency of distinct periodicities between datasets provides characteristics for the global Sun. This consistency also strengthens the reliability of LYRA data.

Spectrum content for LYRA timeseries and other solar indices

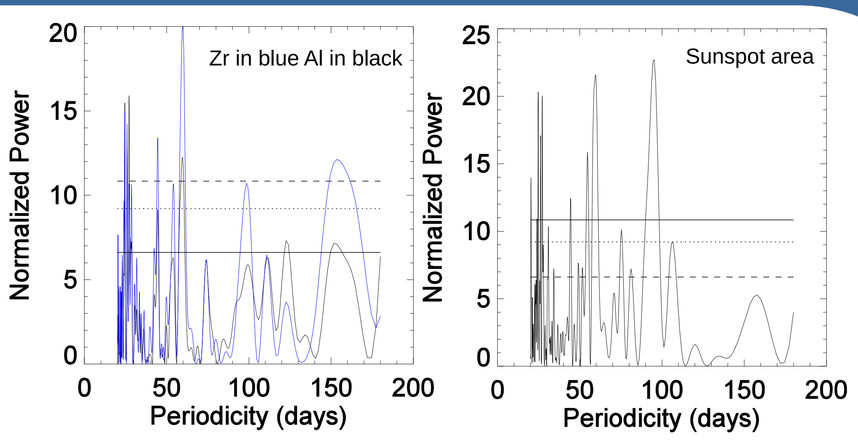


Table 1 Periodicities found in the Lomb–Scargle periodograms with the uncertainty Δt and the false-alarm probability in % (only the peaks with a fap < 5 % are listed) for the zirconium (Zr), the aluminum (Al), the sunspot number (R_z), the 10.7 cm flux (F10.7), the flare index (flares), and the sunspot area.

Zr	Δt	fap(%)	Al	Δt	fap(%)	R_z	Δt	fap(%)	F10.7	Δt	fap(%)	Flares	Δt	fap(%)	Area	Δt	fap(%)
27.2	0.4	<0.01	27.2	0.41	<0.01	27.2	0.41	<0.01	27.2	0.35	<0.01	27	0.4	1.3	27.2	0.3	<0.01
–			44.8	1.4	0.4	44.8	1.1	<0.01	–			–			44.6	0.9	1.7
–			54.3	2.1	2.0	54.5	1.8	0.3	–			54.5	1.6	<0.01	54.8	1.4	0.01
59.9	2.8	0.4	59.9	2.3	<0.01	59.6	2.2	<0.01	59.9	2.8	1.2	58	1.6	0.6	59.6	2.2	<0.01
–			99.8	6.8	3.4	–			–			99.0	3.7	0.2	95.7	6.3	<0.01
–			–			113.6	5.8	0.02	–			–			–		
–			156.8	14.5	0.4	–			–			158.9	11.2	<0.01	–		

The **periodicities detected are the same for each set of data**, nevertheless the amplitudes change.

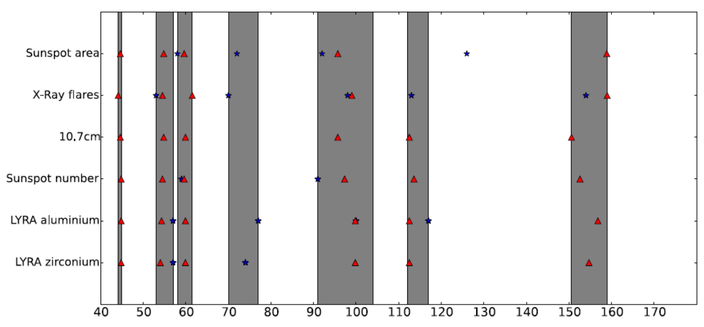
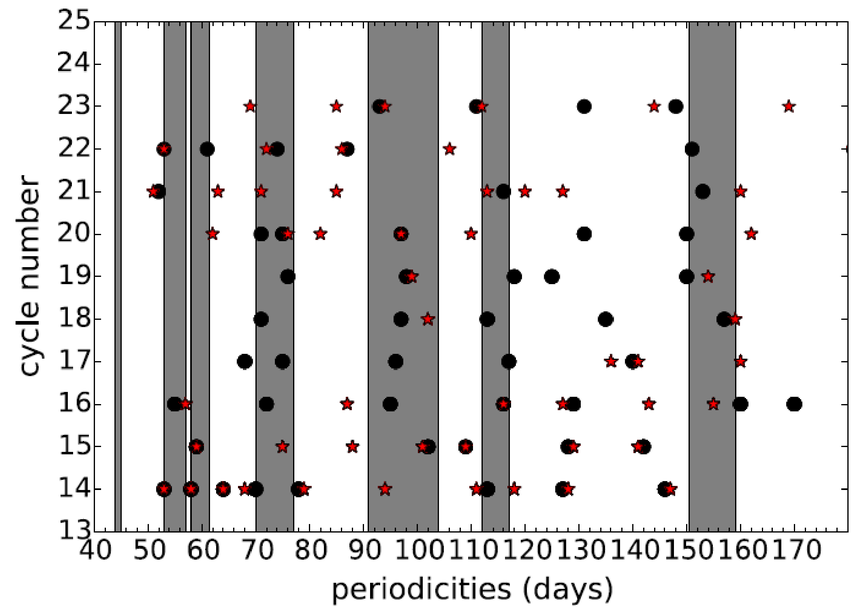


Figure 2 Periodicities of Table 1 obtained from the Lomb–Scargle periodograms (red triangles) and from the wavelet transform (blue stars) in the LYRA zirconium and aluminum datasets, the sunspot number, the F10.7 radio flux, the X-ray flare index, and the sunspot area. The shaded areas provide an estimate of the variation of all periodicities within the time series.

The peaks at 28 and 150(the Rieger periodicity) days are well known. We highlight the peridiodicities at 60 and 100 days.

Spectrum content for sunspot index and sunspot area over the last ten solar cycles

The sunspot number (black) and the sunspot area (red) periodicities for the cycles 14 to 23. The dark gray areas reproduce the variability of the periodicities.



The **periodicities** that have been shown **for a partial cycle** on the left panel can be **generalized here over 10 cycles.** The same conclusion applies for the sunspot index/sunspot area. The amplitude of the peaks between 120 and 155 days vary from one solar cycle to the next. We will perform this analyze.

Conclusion

- We analyzed the spectral content of two of the LYRA channels (the aluminum and zirconium channels)
- We compared the LYRA periodicities obtained to other solar indices representing the solar activity: the sunspots index, the 10.7 radio flux, the number of X-Ray flare events and the sunspot area.
- LYRA spectra exhibit a similar behavior as the other ones. Such a good correlation reinforces the validity of our LYRA data.
- The spectrum in itself is interesting due the universality shown.
- Some periodicities are well described in the literature, like the 28 and 160-day periods, but other periodicities are still debated. The fact that they can be clearly identified in our data is an argument in favor of their existence.
- The periodicities at 60 and 100 days are visible in the various datasets.