Upcoming LYRA Science Data Products

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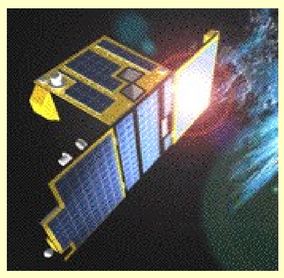
Abstract

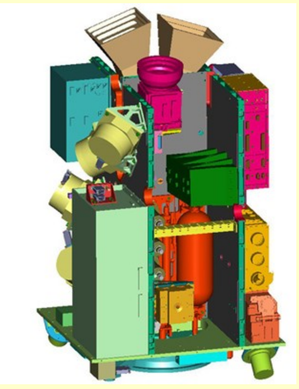
The satellite PROBA2, built in Belgium and to be launched next year, is an ESA micro-mission for the purpose of demonstrating new technologies. It will carry the radiometer LYRA that will measure the solar flux in four selected UV passbands chosen for their relevance to aeronomy, space weather and solar physics. Irradiances will be observed in high temporal resolution. Integration time can take values between 10 s and 0.01 s. - The poster shows the data that can be expected from LYRA. Simulations were performed using data from instruments already in space. The current state of the pre-flight calibration is demonstrated, and the planned LYRA data products are explained

PROBA2 – the PRoject for On-Board Autonomy



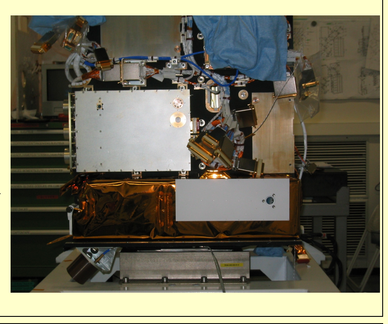
PROBA2, currently under development and due for launch in the second quarter of 2009, is the second in ESA's series of small, low-cost satellites that are being used to validate new spacecraft technologies while also carrying scientific instruments.

LYRA will monitor four bands in a very wide ultraviolet spectrum, while the neighbouring UV imager SWAP will make measurements of the solar corona in a narrower band. Both experiments are collaborations between the Royal Observatory of Belgium, the Centre Spatiale de Liege, Belgium, and the Max Planck Institute for Solar System Research, Germany. In addition, LYRA collaborates with IMO/IMOMEC in Belgium, the Belgian Institute for Space Aeronomy, and the World Radiation Centre in Davos, Switzerland (PMOD/WRC), which played a key role in the design and construction.

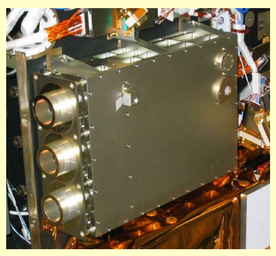


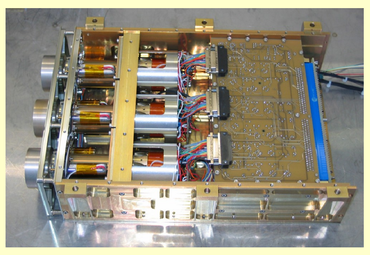
<= LYRA =>

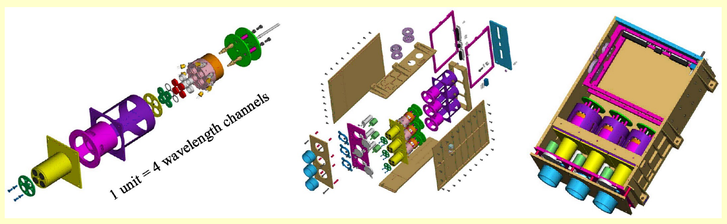
<= SWAP =>



LYRA – the Large Yield RAdiometer on PROBA2







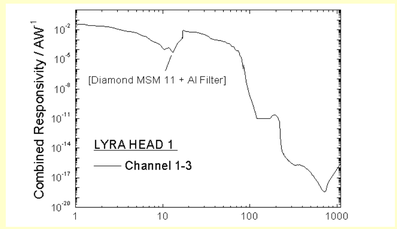
LYRA consists of three redundant (similar, but not identical) heads with four channels each. The instrument's four channels are labeled
(1) the H I 121.6 nm Lyman-alpha line,
(2) the 200-220 nm Herzberg continuum range,
(3) the 17-80 nm Aluminium filter range including the He II 30.4 nm line,
(4) the 1-20 nm Zirconium filter range, where solar variability is highest
cf. J.-F Hochedez et al. (2006).

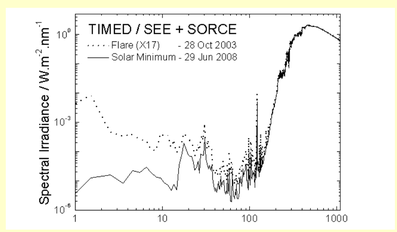
As shown in the figure above, the optical path of a LYRA channel consists of a view-limiting aperture, a precision aperture, an optical filter and the detector.

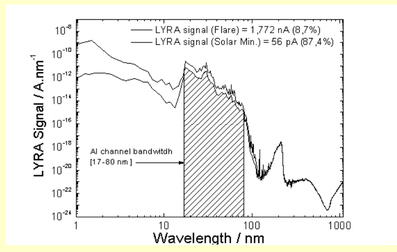
The scientific goal of LYRA is to improve the absolute accuracy of solar irradiance measurements, hence the need for sub-system and system calibrations, on ground and in flight, as described below. Additionally, data from channels 1 and 2 will be used for Earth atmospheric models, data from channels 3 and 4 - in close collaboration with SWAP - will be used to observe flares.

For further details, please see the presentation "**LYRA, expected performance and usage within SOTERIA**" by T. Dudok de Wit and M. Dominique in the PROBA2 splinter session of ESWW5, scheduled for Tuesday 14:40 - 15:05.

Pre-flight calibration with the LYRA Radiometric Model







Figures left: Examples for LYRA radiometric model simulations.

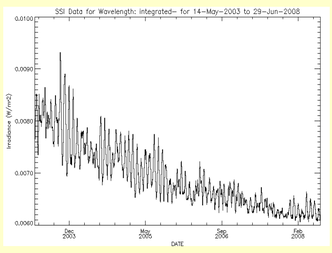
From top to bottom: Responsivity curve of Channel 1-3 (MSM detector + Al filter), two solar sample spectra (high-flux spectrum from 2003 and solar minimum spectrum from 2008), and the product of both. The integral of the last curve estimates the total output signal of the LYRA channel, when multiplied with the area of the 3-mm-diameter precision aperture. (from: A. BenMoussa et al., 2009, in prep)

Table below: Expected LYRA total output signals, with purities, and corresponding expected solar signals.

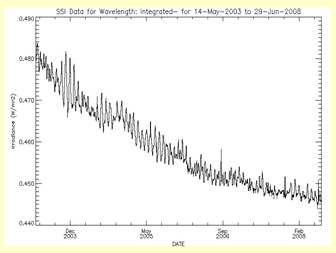
The "minimum" and "maximum" signals correspond to the sample spectra mentioned above, i.e., June 2008 and October 2003.

ch.#	filter	detector	LYRA signal range (and purity) min	max / nA	solar signal range min	max / Wm^{-2}
Head 1						
1-1	*Lyman XN*	*MSM12*	0.289 (25.5%)	0.346 (32.5%)	0.0061	0.0093
1-2	*Herzberg*	*PIN10*	10.918 (83.7%)	11.710 (83.8%)	0.4454	0.4764
1-3	*Aluminium*	*MSM11*	0.056 (87.4%)	1.772 (8.7%)	0.0017	0.0057
1-4	*Zr(300nm)*	*AXUV20D*	0.085 (97.7%)	3.704 (99.9%)	0.0007	0.0133
Head 2						
2-1	*Lyman XN*	*MSM21*	0.101 (25.3%)	0.121 (32.3%)	0.0061	0.0093
2-2	*Herzberg*	*PIN11*	11.690 (83.8%)	12.512 (83.9%)	0.4454	0.4764
2-3	*Aluminium*	*MSM15*	0.048 (88.6%)	1.370 (9.7%)	0.0017	0.0057
2-4	*Zr(150nm)*	*MSM19*	0.012 (96.9%)	0.583 (99.9%)	0.0007	0.0133
Head3						
3-1	*Lyman N+XN*	*AXUV20A*	0.269 (32.6%)	0.317 (42.2%)	0.0061	0.0093
3-2	*Herzberg*	*PIN12*	9.389 (83.5%)	10.055 (83.6%)	0.4454	0.4764
3-3	*Aluminium*	*AXUV20B*	0.926 (92.1%)	14.037 (19.7%)	0.0017	0.0057
3-4	*Zr(300nm)*	*AXUV20C*	0.088 (95.7%)	3.766 (99.9%)	0.0007	0.0133

Had LYRA flown during the last five years ...



LYRA 121.6 nm
Lyman-alpha channel (1)
(data simulated according to daily averages from SORCE)



LYRA 200-220 nm
Herzberg channel (2)
(data simulated according to daily averages from SORCE)

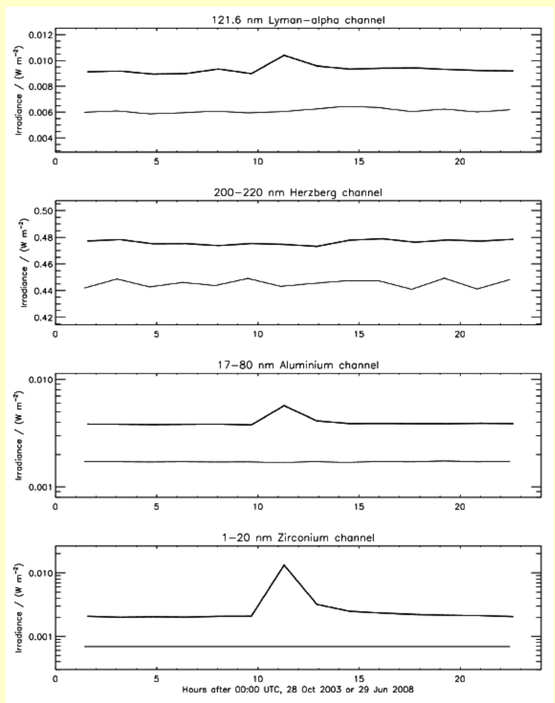
LYRA 17-80 nm
Aluminium channel (3)
(data simulated according to approx. hourly observations from TIMED/SEE)

LYRA 1-20 nm
Zirconium channel (4)
(data simulated according to approx. hourly observations from TIMED/SEE)

SORCE and TIMED/SEE are solar instruments that have been in space for more than five years. Their spectra are available for the public:
http://lasp.colorado.edu/sorce/sorce_data_access/
http://lasp.colorado.edu/see/see_data.html
(The overall trend is caused by the solar cycle, not instrument degradation.)

These spectra are used here to demonstrate what can be expected from the four LYRA channels after the launch of PROBA2: Measurements of long-term effects due to the solar cycle, effects due to solar rotation (like influences from active regions or coronal holes), and short-term effects from events like flares.

Had LYRA flown on 28 Oct 2003 (or on 29 Jun 2008) ...



The daily time series above are based on data – simulated in parts – observed by SORCE and TIMED/SEE, including one X17 flare from October 2003 (thicker line) and solar minimum data from June 2008. Since the mentioned instruments are constructed for different purposes – namely, to observe wide intervals in 1 nm spectral resolution - they have a temporal resolution worse than 1 hour. LYRA's cadence, on the other hand, will be in the order of fraction of a second. TIMED/SEE and SORCE miss many flares due to their lack of temporal coverage.

Cross-calibrations are planned with TIMED/SEE, SORCE, SWAP/PROBA2, SUMER/SOHO, and probably with GOES, SEM/SOHO, EIT/SOHO, and EVE/SDO.

After the launch of PROBA2, expected in 2009, ...

During observations, either one or two LYRA heads can be read out and transmitted simultaneously. In addition to the observing head(s), an integration time (0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10 s) is commanded. Telemetry thus consists of four or eight simultaneous time series, plus housekeeping.

To be scientifically suitable for the user, data have to be converted – at the least - to frequencies and enhanced by housekeeping data, like dark currents, electronics parameters, temperature, pointing, expected degradation etc.: values that may be default in near real-time, but refined at later, more experienced stages. These uncalibrated frequencies plus metadata constitute level 1; "**Lev1**" data are for publication, as are the following levels. Lev1 data will be useful rather for users with a certain technical understanding of the instrument.

All levels are subject to change, thus it is necessary to keep track of release time and version. All public data will be available as **FITS** files.

The standard LYRA data product will be level 2: "**Lev2**" data will be solar irradiance time series in physical units (W/m²), in full temporal resolution, and radiometrically calibrated. "**Lev3**" data will then be temporally aggregated to one-minute averages. Further data products, e.g. daily graphic overviews like the figure above, may also be available on the LYRA website.

... please visit us at http://lyra.oma.be/

Daily files available on LYRA website in near real-time:

level	temporal resolution	units	radiometr. calibrated	access	format
1	as commanded	kHz	no	on demand	FITS
2	as commanded	W/m²	yes	provided	FITS
3	one minute	W/m²	yes	provided	FITS
4	one minute	W/m²	yes	provided	graphic

References

J.-F. Hochedez et al.: LYRA, a solar UV radiometer on PROBA2. Adv Space Res 37 (2006) 303-312

A. BenMoussa et al.: Pre-flight calibration of LYRA, the solar VUV radiometer on board PROBA2. (2009, in prep)