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GOME-1 Calibration Lamp Anomaly Investigation

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1. INTRODUCTION

The GOME (Global Ozone Monitoring Experiment) instrument on-board ERS-2 is equipped with a hollow cathode gas discharge lamp (Pt/Cr/Ne) for in-orbit wavelength calibration.

Since the start of GOME nominal operations on 20/07/1995 until 06/09/2001, wavelength calibration measurements were performed during one orbit per day. The original daily calibration timeline contained 2 lamp calibration sequences (with a typical duration of 117 seconds each) and a solar calibration sequence (with a typical duration of 238 seconds).

In addition the calibration lamp is used during a monthly calibration sequence that lasts for 5 orbits and is usually performed on the 28th of each month (e.g. diffuser characterization, see technical note *[1]*). The first monthly calibration was performed on 28/07/1995. (during one orbit of a monthly calibration sequence the lamp is used for a cumulative duration of 2000 seconds).

The power supply of the lamp is activated by the DDHU and is current stabilised. After lamp ignition, the power supply regulates the lamp current to ~10 mA, which corresponds to a voltage of ~198 V.

On day 10/11/1997 a first GOME *Lamp Failure* was noticed (see also table 1 where all GOME Lamp Failures are listed). A lamp calibration is considered to have failed when the voltage of the calibration lamp has not reached its nominal value of ~198 V within the start up period of ~12 seconds. Typically the voltage reached during the erroneous lamp calibrations was only ~160 V. The operation of the calibration lamp is then automatically aborted, and the "Lamp Failure" flag is set.

To reduce the time the calibration lamp is used -and hence the risk of too much wear and tear- the daily calibration timeline was modified on day 02/04/1998. Since then the daily calibration timeline was performed with only one calibration lamp sequence (~117 seconds) and one solar calibration sequence (~238 seconds). The operation of 5 monthly calibration orbits each 28^{th} day of a month remained as before.

However, at the end of August/beginning of September 2001, nearly every day a Lamp Failure occurred (last successful lamp calibration of that sequence was performed on day 03/09/2001) and as a consequence the daily calibration timeline has been changed again on 06/09/2001. Since then only solar measurements are performed during the daily calibration timeline. The calibration lamp is used only during the 5 orbits of the monthly calibration and during a special calibration timeline (TST44) with warm detectors that is only used in case of a long instrument switch-off . In this case, two sequences of 117 seconds each are performed). Statistically such events occur about 6 times a year.

During recent Lamp Failures starting with day 28/08/2001 a different behavior in the lamp voltage performance has been noticed. In these recent erroneous cases the lamp voltage reaches a value of e.g. ~197 V and decreases afterwards slowly down to typically ~182 V. Subsequent lamp calibration sequences in the months after September 2001 have been successful.

This technical note characterizes the erroneous behavior of the GOME calibration lamp during recent calibration sequences.

2. DATA SET USED FOR THIS ANALYSIS

For the analysis following orbits out of a monthly calibration sequence were used:

- Orbit 21022, day 28/04/1999 as nominal case
- Orbit 33233, day 28/08/2001 containing data from a calibration where a lamp failure occurred

3. DATA ANALYSIS

3.1 Temporal Behaviour

3.1.1 LAMP VOLTAGE

Figure 1 shows the comparison of the voltage of the calibration lamp during a nominal operation (April 1999) with an erroneous lamp calibration sequence observed in August 2001. The Lamp Failure flag was set after product (data record) ~2600, the calibration data records before can be used for the analysis of the calibration lamp problem.

Three calibration lamp sequences with anomalous behaviour have been performed during the analysed orbit in August.

The comparison with the nominal case in 1999 shows that for the first sequence, immediately after ignition the lamp performance is nominal in both cases. In contrast to earlier anomalies, the nominal voltage of 198 Volt is actually reached at product 800 of the anomalous sequence. This corresponds to 45 seconds after ignition. The data from August 2001 subsequently show three steep decreases in voltage, the first two followed by a recovery, the last one ending with the end of the first calibration sequence at product 1170. After each recovery, the voltage drops to a value equal to the last values prior to that recovery.

The second anomalous sequence also starts with nominal voltage increase which is interrupted after 60 products by a steep decrease to 192 Volts, which is equal to the last anomalous values of the first sequence. In this sequence, no recovery is observed. In stead the voltage continues to decrease to 182 Volts.

The third anomalous sequence starts off at this same value of 182 Volts. This value is so far below the nominal value that the on-board software considers this calibration lamp ignition to have failed. The lamp is switched off after 10 seconds and the lamp failure flag is set.

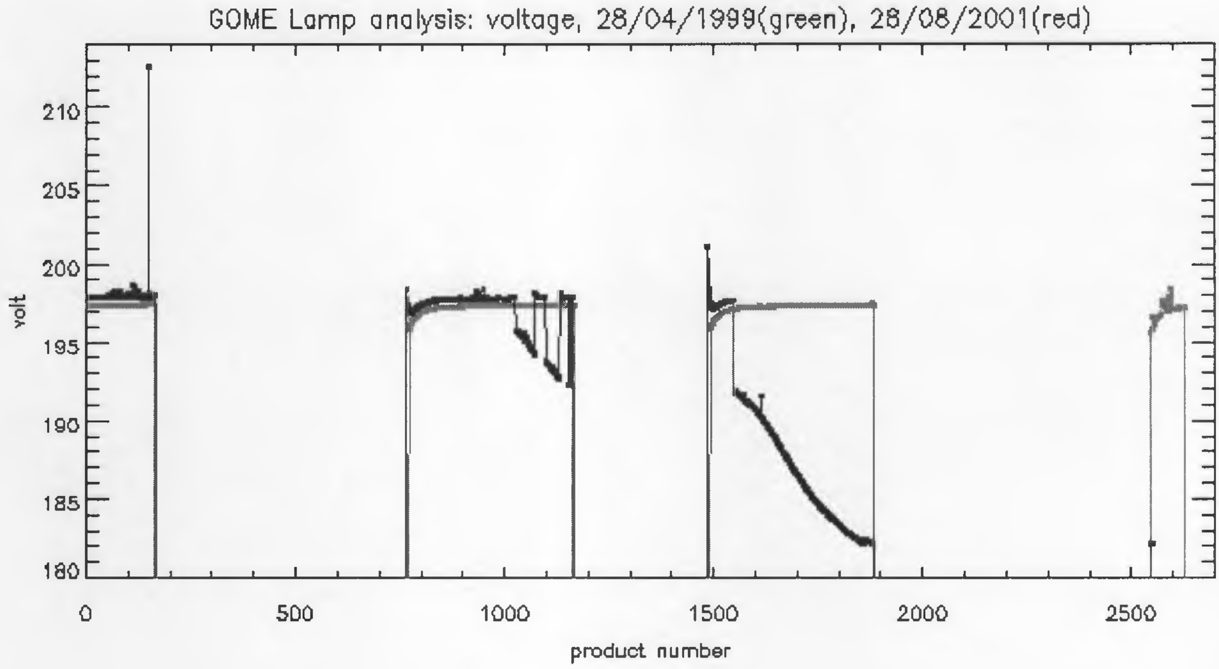

Figure 1: Comparison of Voltage. Nominal case plotted in green, data with lamp failure in red

3.1.2 LAMP CURRENT

During the anomalous voltage reduction intervals, the current stabilisation of the lamp remains effective and with few exceptions the current remains constant.

Prior to the first complete sequence visible in figure 2, the last part of a nominal sequence is visible in which a strong current spike is present that corresponds to a voltage spike.

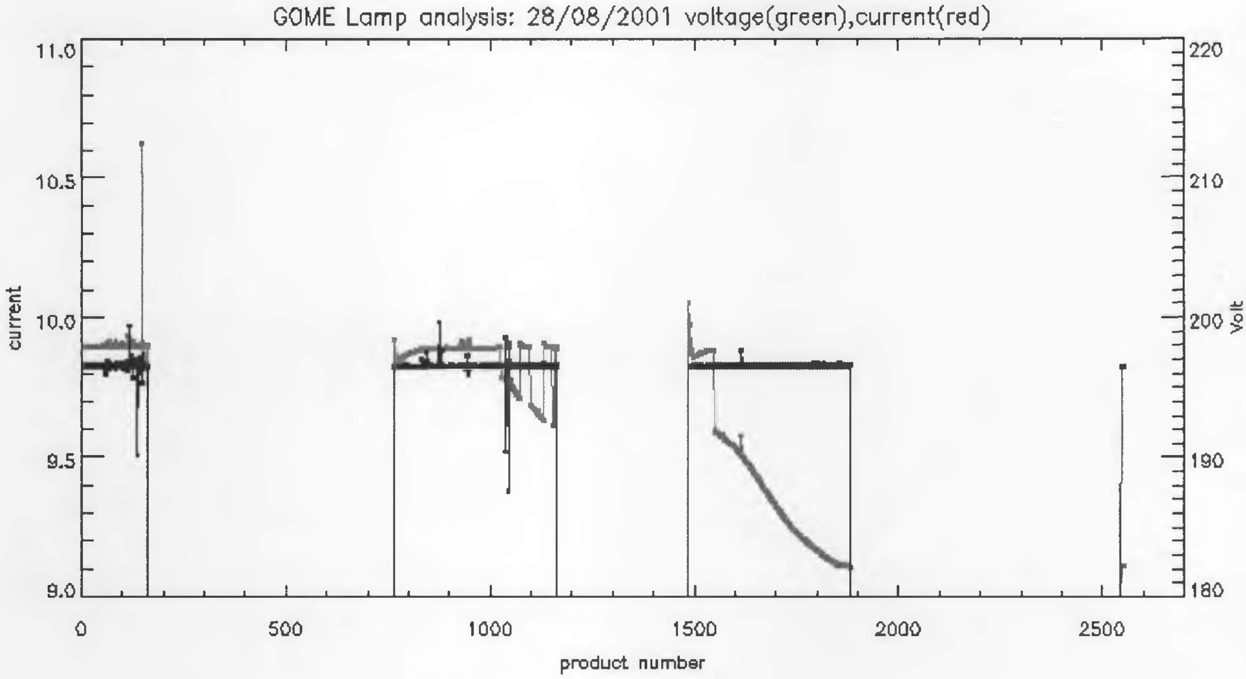

Figure 2: voltage and current in comparison (28/08/2001)

3.1.3 INTENSITY OF EMISSION LINES

In order to further characterize the anomalous events, the intensity of the lamp emission lines is analysed.

For the analysis one emission line per element is used. The intensity of the center pixel, where the readout is maximal, is in first approximation taken to be proportional to the intensity of the emission line. The following three emission lines have been used for this analysis

- Pt at 265 nm (pixel 503, channel 1)
- Cr at 425 nm (pixel 146, channel 3)
- Ne at 540 nm (pixel 694, channel 3)

The calibration unit temperature shows repetitive behavior in all cases, increasing gradually with time during all the intervals with lamp current, and decreasing whenever current is negligible. As a consequence, no significant differences in spectral calibration are observed between the nominal and anomalous case, and the simplified line centre selection method can be considered adequate. The intensities are corrected for leakage current, but no absolute radiance calibration is performed.

From Figures 3-5 the behaviour of the emission lines from the different elements of the hollow cathode gas discharge lamp can be seen. Cr, Pt and Ne decrease all steadily in intensity and at the same time the lamp voltage decreases to ~182 V.

Comparing the intensities of the different emission lines (Figures 3-5), it results that the intensities of Pt and Cr of dataset year 1999 are higher than the ones of August 2001. However for the intensity of the Ne emission line it is the contrary. This difference is consistent with the study results of TPD that show that metal line intensities degrade faster than Ne line intensities (see study TPD *[2]*).

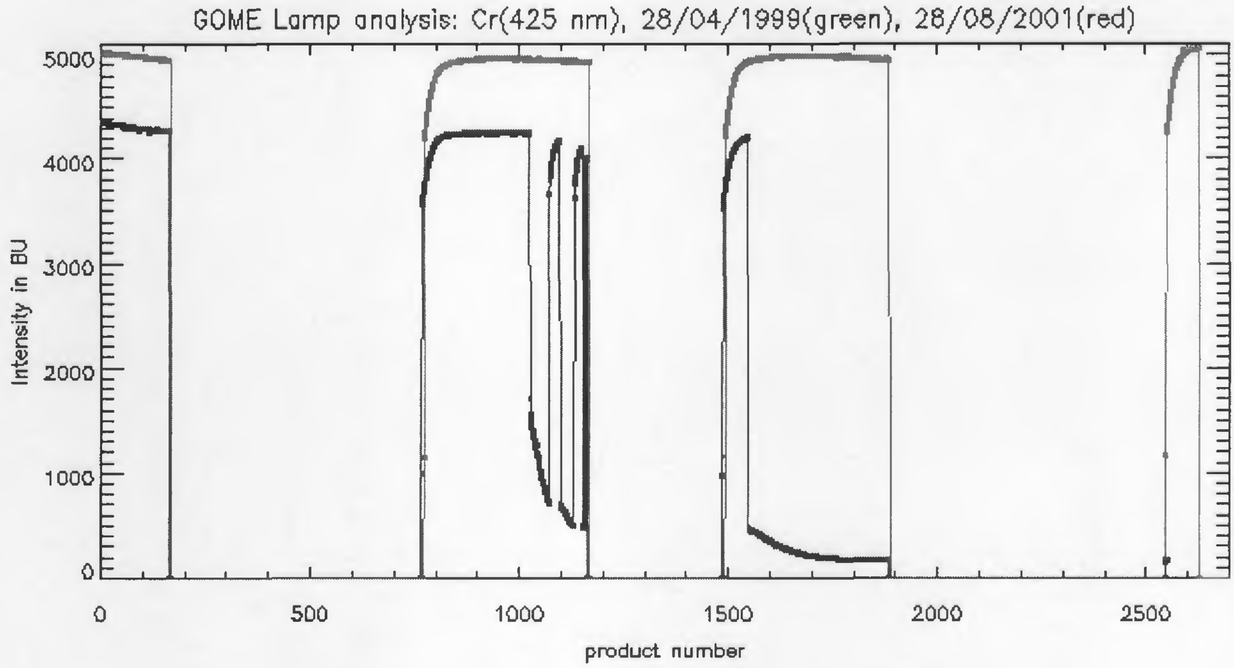

Figure 3: Intensity of Cr emission line (green nominal case, red data with lamp failure)

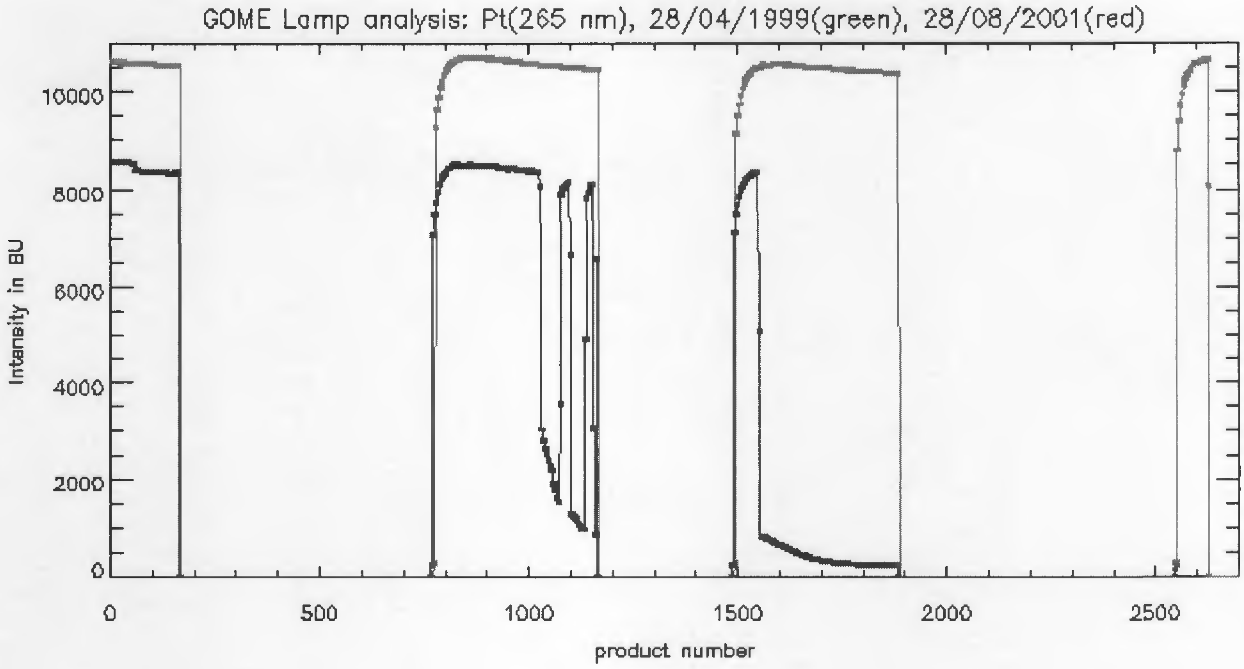

Figure 4: Intensity of Pt emission line (green nominal case, red data with lamp failure)

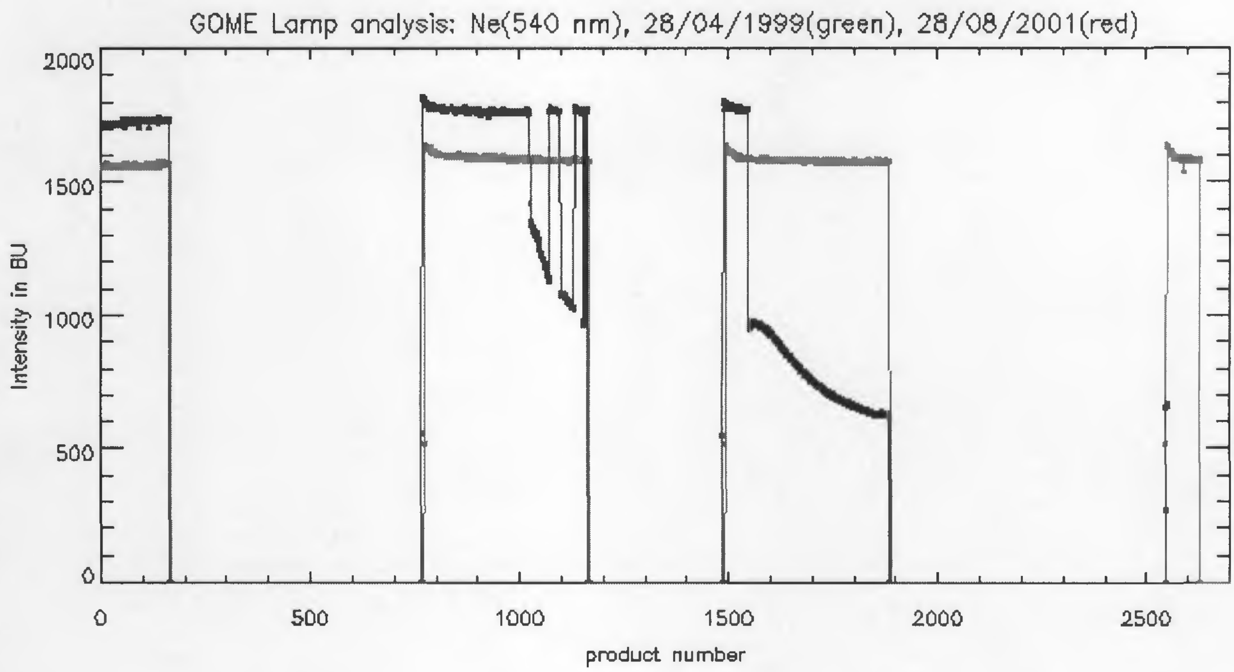

Figure 5: Intensity of Ne emission line (green nominal case, red data with lamp failure)

3.2 Correlations

To further characterise the differences between the anomalous sequence and the nominal case, relations between selected parameters are investigated.

3.2.1 CURRENT VS. RESISTENCE

During the anomalous voltage reduction intervals, the current stabilisation of the lamp remains effective and with few exceptions the current remains constant. Only during the nominal part of the sequence is the characteristic 'negative resistance' behaviour present: slight increases in current that occur within the margins of the current stabilisation process are the consequences of excessive voltage correction, immediately resulting in reduction of resistance as additional electrons are liberated.

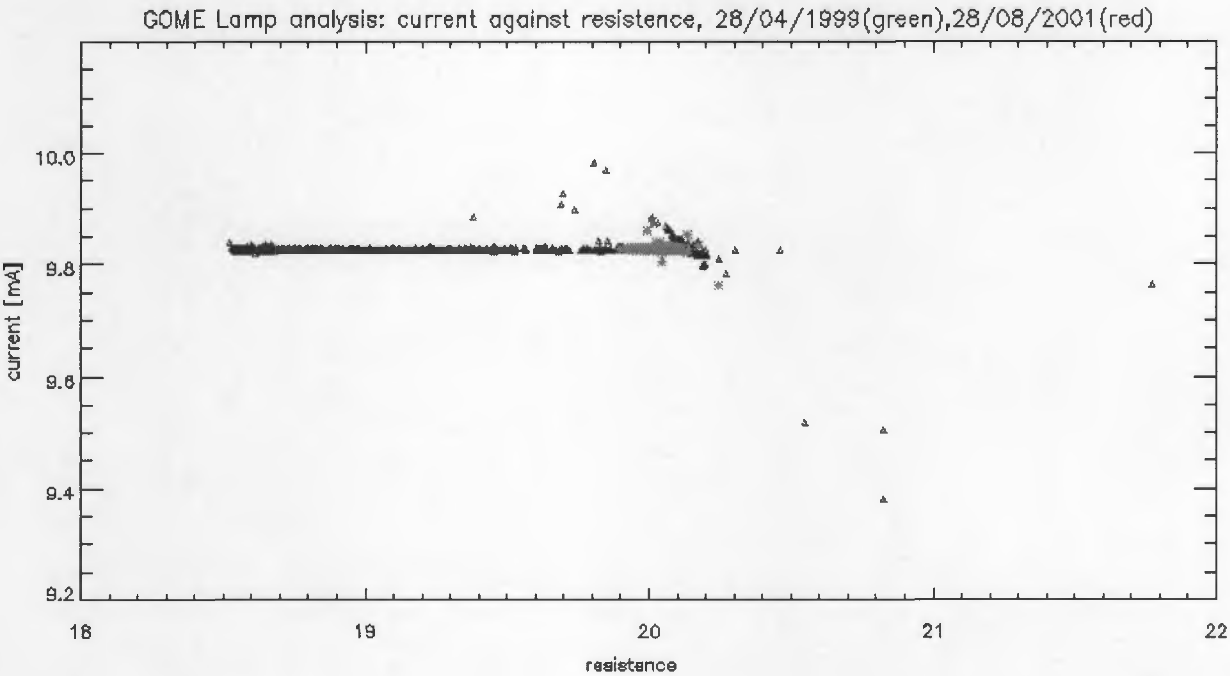

Figure 6: current versus resistence

3.2.2 INTENSITIES VS. VOLTAGE

For the metal emission lines, the voltage cycles to stabilize the current can be observed at high voltage, but only in the nominal case does the intensity increase linearly with voltage

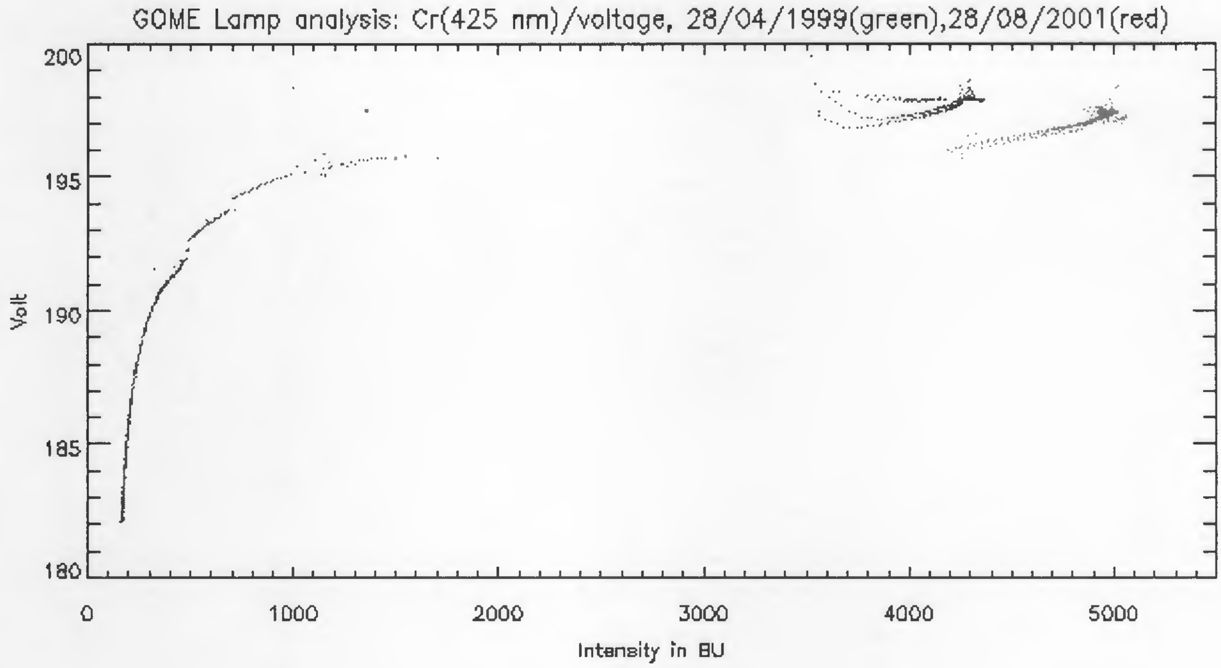

Figure 7: Intensity of Cr emission line in relation to lamp voltage (nominal case plotted in green; anomalous data plotted red)

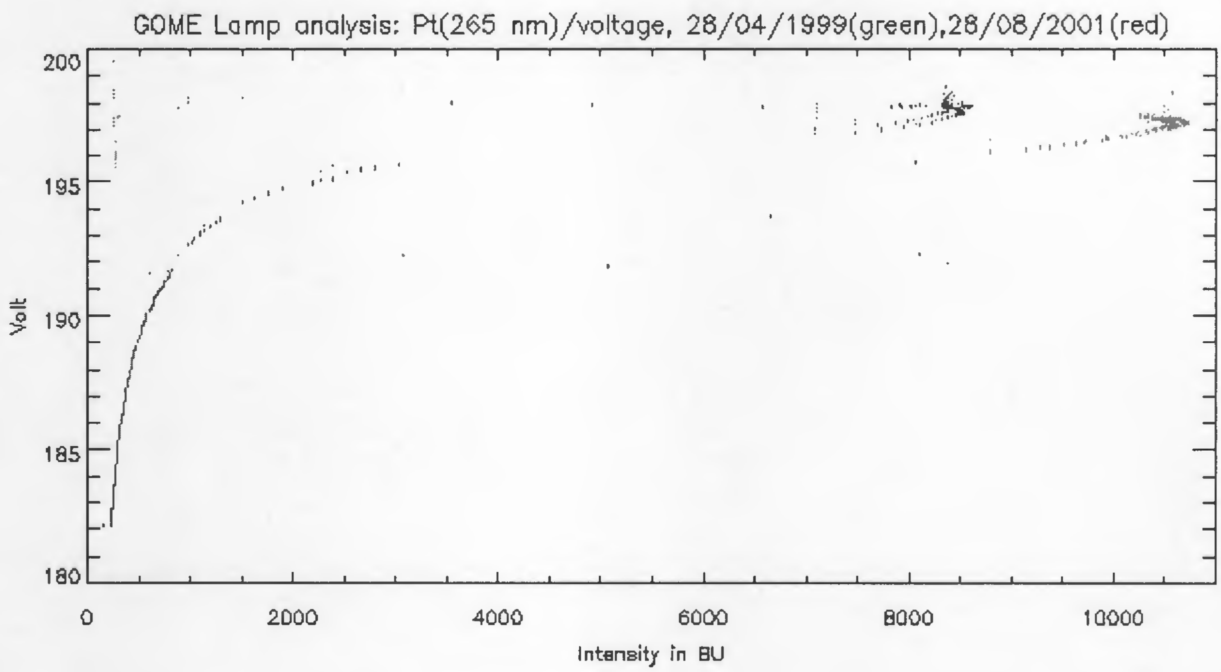

Figure 8: Intensity of Pt emission line in relation to lamp voltage (nominal case plotted in green; anomalous data plotted red)

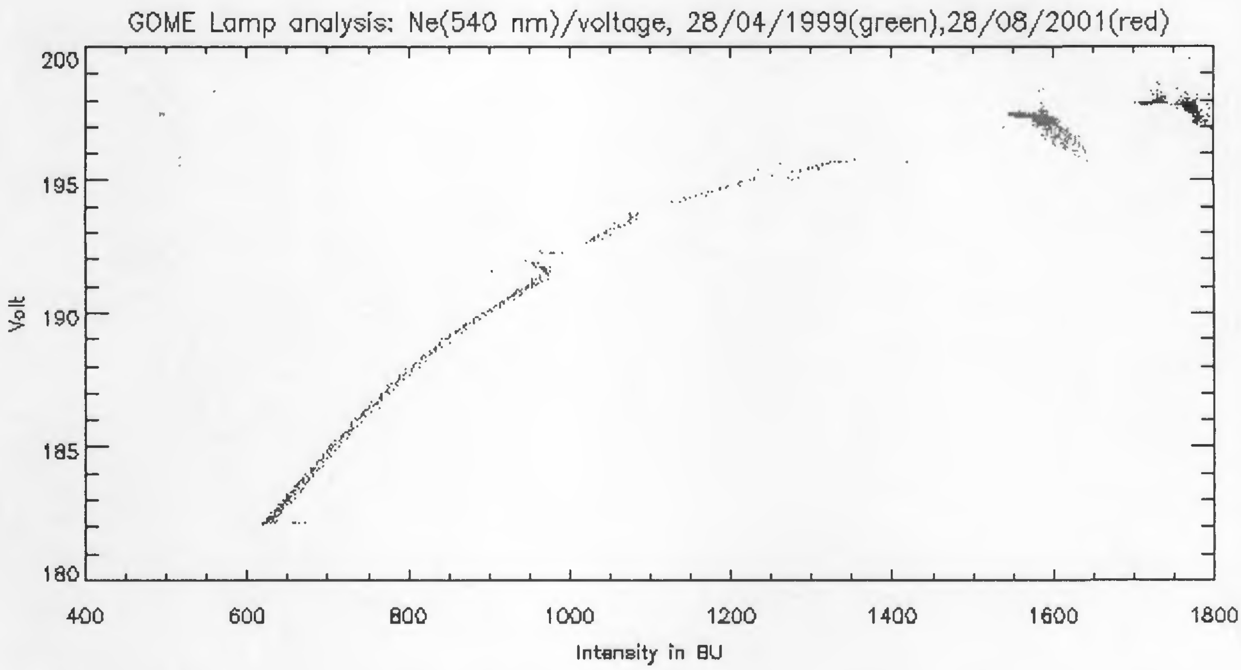

Figure 9: Intensity of Ne emission line in relation to lamp voltage (nominal case plotted in green; anomalous data plotted red)

3.2.3 INTENSITY RATIOS OF EMISSION LINES

The ratio of the line intensities show two features:

- A gradual deviation of the ratio of the anomalous calibration compared to the nominal case. This is an indication of thermal effects: in the anomalous case the decrease of voltage causes reduction of temperature and the emission line ratio will change since the lines have different wavelengths
- Unexplained peaks in the ratio occur at the onset of anomalies

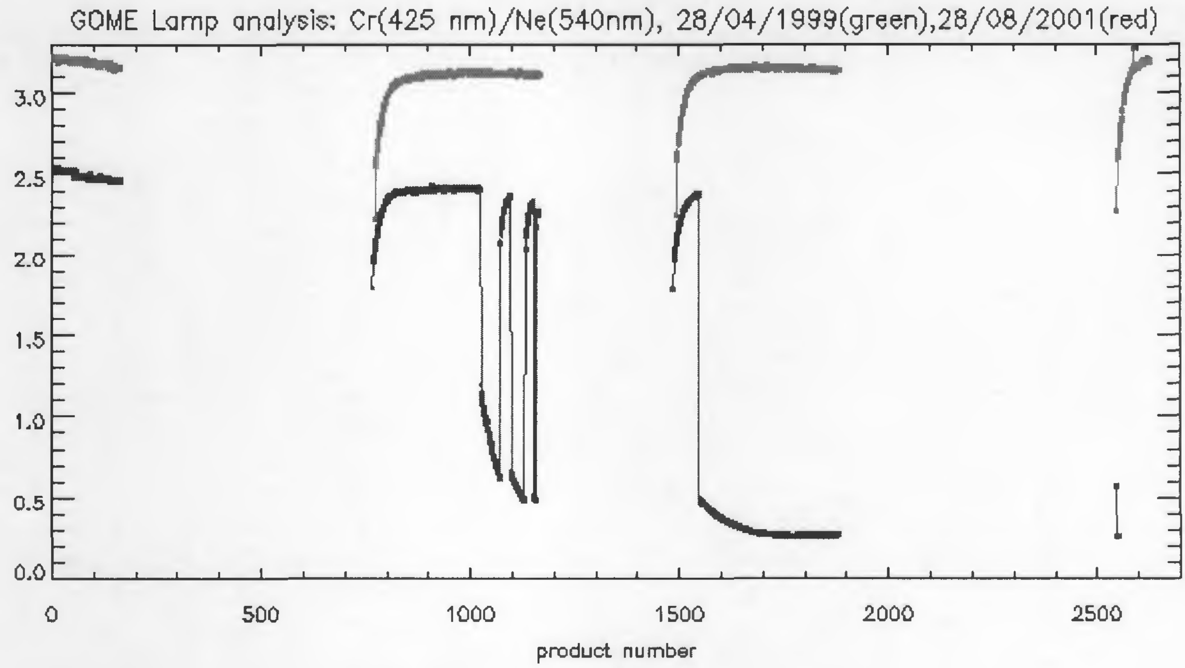

Figure 10: Intensity of Cr emission line divided by intensity of Ne emission line

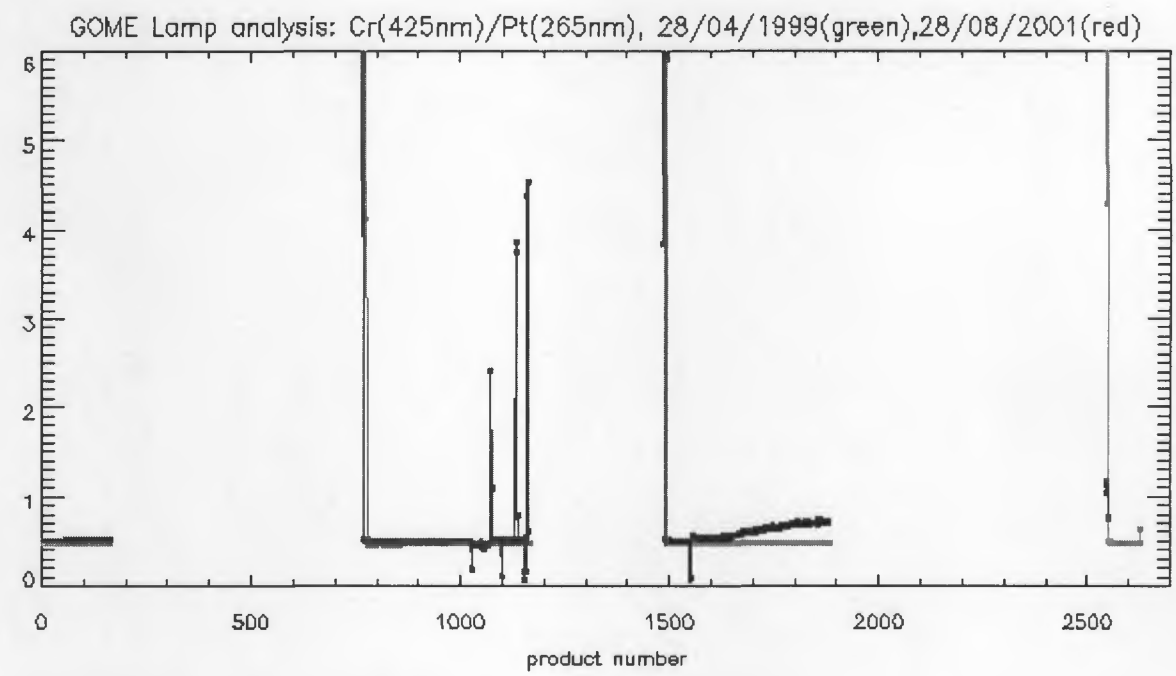

Figure 11: Intensity of Cr emission line divided by intensity of Pt emission line

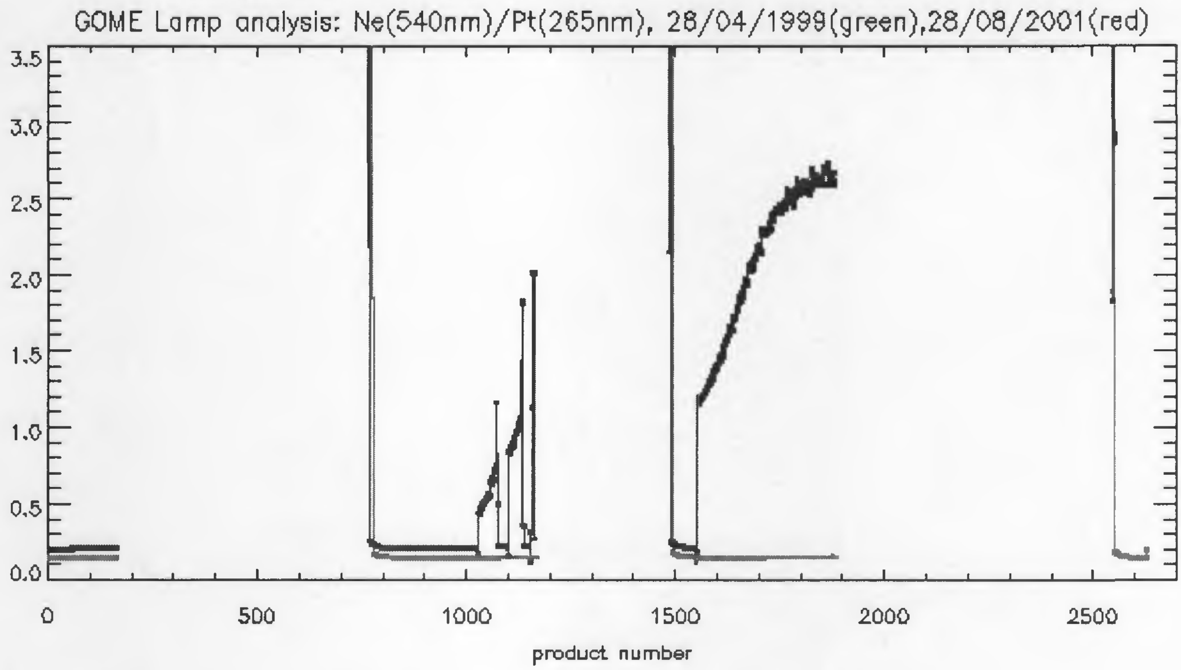

Figure 12: Intensity of Ne emission line divided by intensity of Pt emission line

4 CONCLUSIONS

The anomalous calibration investigated has been characterised by analysis of the GOME level 0 products. The characterisation shows a bi-modal behaviour of the lamp, switching back and forth between nominal behaviour, alternated by anomalous behaviour in repetition. The subsequent intervals of anomalous behaviour show a common trend where each anomalous interval starts with values and gradients similar to those found at the end of the previous anomalous interval.
The onset of the anomalous behaviour is gradual and no cause could be identified. The only remarkable event before the onset of the anomaly is a strong current spike during the last nominal calibration before the anomalies. Note that calibrations in recent months have not resulted in similar anomalies.

5 OPERATIONAL CONSEQUENCES

As a first consequence the GOME operations have been changed to avoid daily use of the calibration lamp since day 06/09/2001. Since that day, the lamp is only switched on for the monthly calibration orbits.

The GOME data processor at D-PAF DLR has been modified accordingly. Its algorithm has been changed to derive wavelength calibration information by fitting solar Fraunhofer features in the spectra.

6 REFERENCES

[1]: Long Term Monitoring of GOME Diffuser Reflectivity and Dark Signal Analysis- A. Dehn ERSE-SPPA-EOAD-TN-01-0006 Issue 1.0 2001

[2]: Lifetime test results of Pt/Cr/Ne lamp TPD, ER-TR-TPD-GO-0001, 20 December 1991

Table 1: History of GOME Lamp Failures (days of occurrences)

1997	1998	1999	2000	2001
10/11	26/01	04/01	26/04	06/03
06/12	06/03	23/02	28/04	07/03
	14/07	28/05	29/04	13/03
	10/08	28/05	09/05	20/03
	23/12	29/05	09/06	29/03
	28/12	26/07	24/07	06/05
		14/11	30/08	20/05
		19/12	31/08	26/05
			01/09	10/06
			01/10	25/06
			12/10	12/07
			18/10	28/07
			29/12	04/08
				07/08
				28/08
				29/08
				30/08
				01/09
				02/09
				03/09