ARGES

Atomic densities measured radially in metal halide lamps under microgravity conditions with emission and absorption spectroscopy

The Cyclopes were giant beings with a single, round eye in the middle of their foreheads. The first generation consisted of three brothers, Brontes (thunderer), Steropes (flasher), and Arges (brightener), who came from the union of Gaia (earth) and Uranus (sky).
<table>
<thead>
<tr>
<th>Participants</th>
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<tbody>
<tr>
<td><strong>TUE (EPG)</strong></td>
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<tr>
<td>Gerrit Kroesen, Mark Bax, Danny van den Akker, Guido Schiffelers, Pim Kemps, Frank van den Hout, Winfred Stoffels, Joost van der Mullen, Xiao-Yan Zhu, Loek Baede, Charlotte Groothuis, Anette Sezin</td>
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<td><strong>TUE (GTD and BLN)</strong></td>
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<td>Peer Brinkgreve, Erwin Dekkers, Jovita Moerel, Rob de Kluijver, Hans Wijtvliet, Ruud de Regt, Fred van Nijmweegen, Roel Smeets, Gerard Harkema, Klaas Kopinga, Paul Beijer</td>
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<td><strong>Philips (CDL)</strong></td>
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<td>Marco Haverlag, Rob Keijser, Jos Eijsermans, Jacques Claassens, Paul Huijbregts, Wally Dekkers, Jacques Heuts, Jan Peeraer, John Etman, Joop Geijtenbeek, Folke Nörttemann, Cees Reynhout, Bruno Smets</td>
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<tr>
<td>Dutch Space: Ron Huijser, Eric Boom, Geert Brouwer</td>
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<td>Kayser-Threde: Roland Seurig, Andreas Kellig</td>
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<td>Verhaert: Piet Rosiers</td>
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HID (High Intensity Discharge) lamps
Burner geometries used

- Buba (quartz): CDM-TD 150 W
- Burner:
  - Quartz for spectrometry
  - DGA for helical instabilities
Motivation

Scientific issues related to applicability:
- axial and radial de-mixing *(Plasimo modelling)*
- helical instabilities (see next slide)

Gravity (convection) messes things up!
- convective cells
- gravitational de-mixing
- channel arcing
Helical instabilities in metal halide lamps
Scientific methods

- High-resolution ($\Delta \lambda < 0.02$ nm) emission spectroscopy, radially resolved
- Spatio-temporally resolved laser-diode absorption spectroscopy
- Colour camera observation of helical instabilities
- Several lamps can be used in a caroussel
High-resolution emission spectroscopy

- Echelle grating in 38th order, Littrow mount
- Zone selection with interference filters
- Home built system
- 2-D CCD camera (spectrum on one axis, lateral dimension on the other axis)
- No moving parts
- Intensity regulation with camera shutter
- Physical principle
- Example image
- Spectrometer design
Example of a spectrum to be measured
Dy (10 mg, 150W)

Intensity [cnts]
- 2 wheels, mounted on concentric axes
- Each wheel has 5 filter spots, of which one is empty
- Both wheels are driven by Maltese Cross transmissions

Filter wheel with Maltese Cross transmission
Laser diode absorption spectroscopy

- Expand laser beam to irradiate full lamp diameter
- Parallel detection of 31 lateral positions using photo diode array, integrated with pre-amplifiers and multiplexer on one circuit board
- Scan piezo at ca. 100 Hz (full line profile)
- With 32 diodes: 4 times per second full matrix determination (line profile and lateral profile)
Dysprosium absorption under 1G, 0 G and 2G conditions
Colour camera observation

• Needed for overall inspection of lamp and for detection of instabilities
• Web-cam specs are sufficient
• Optics is fixed: one lens and neutral density filter
• Camera is stripped to stamp size PCB
Colour Camera Observation

09/07/2003  Gerrit Kroesen
Lamp mounting and movement

• 20 lamps mounted in caroussel
• All three diagnostics can be performed on the same measurement spot
• Lateral precision: 50 microns
Lamp caroussel in operation
Maltese Cross transmission of lamp caroussel

Elastic hinges give “play” in transmission
Maltese Cross transmission of lamp caroussel: how it works
Optics mounting frame as used in 34th ESA PFC
Optics mounting frame with minimised weight: first concept
Heat removal

Duct to base plate

Laser diode to base plate

Webcam

Lamp to duct

Base plate to air
Experiment manufacture

- Philips (lamps & Ballasts) and TUE (rest)
- Triple containment (Hg and Kr$^{85}$)
- Support: Dutch Space, Kayser-Threde
- Scientific collaboration: IHED (Moscow)
Experiment: Status Quo

- Has flown in 34\textsuperscript{th} ESA PFC
- Everything works (in principle: see “lessons learned”)
- Construction now optimised for reliability
Parabolic Flights
Training of Andre Kuipers
Marco at work
34th ESA PFC: Emission spectroscopy

![Graph showing emission spectroscopy data]

- 3354, 0.95g
- 3358, 1.06g
- 3405, 1.78g
- 3409, 1.74g
- 3412, 1.77g
- 3416, 1.72g
- 3420, 1.44g
5 mg Hg

$\epsilon / \epsilon_{\text{max}}$

$r$ (mm)

-4 -3 -2 -1 0 1 2 3 4

90W 2g

90W 0g
34th ESA PFC: Laser diode absorption

Absorption profile through an entire parabola
Power series, always taken at end of microgravity period
High aspect ratio lamps
Lessons learned from 34th ESA PFC

- New DGA lamps are needed
- Experimental protocol needs adjustment:
  - emission shutter times or averaging
  - elimination of laser diode absorption (reduces weight, risk, power and astronaut time requirements) for ISS, retained for parabolic flights
Lessons learned from 34\textsuperscript{th} ESA PFC (ctd.)

- Heat household is now OK
- Reliability and reproducibility is now OK
- System can be dismounted and mounted, will run in 1 h
- More internal EMC-shielding is required: ignition voltage pulse of lamp has a tendency to (inductively) blow up laser diode electronics and reboot computers
- Andre Kuipers has had preliminary training in Bordeaux, but more is required
Temperature Development

Temperature in aircraft

09/07/2003  Gerrit Kroesen
09/07/2003
MSG

- MSG (Microgravity Science Glovebox): the “home” of Arges in the ISS
- ESA-owned, sitting in USA Destiny lab
- Built by Astrium (D) and Bradford Engineering (NL)
All switches need protection  

Cold plate: heat removal
Video drawer for downlink

Philips TL lamps??
MSG accommodation
Parts List

<table>
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<th>POS.</th>
<th>BENAMING</th>
<th>AANT</th>
<th>TEK.NR.</th>
<th>MATERIAAL</th>
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Total setup: 9 parts
RS-ISS accommodation
Qualification steps

- Plan together with DS
- Vibration / environmental: Thales
- EMC: DARE
- Electronics: Netronics
- Containment levels: separate testing of each level (inner balloon, outer balloon, experiment container) under supervision of QA personnel of Philips, TUE, Dutch Space, ESA
ISS

- Development of Flight Model funded by Ministries of OC&W (200 kEuro -> TUE) and EZ (100 kEuro -> Fokker Space).
- Safety review: 14 August 2003 (with NASA!)
- ICR: 21 August 2003
- Qualification tests: 1 October 2003
- Acceptance testing: 1 November 2003
- Launch Progress: 31 January 2004
- Launch Soyuz with Kuipers: 23 April 2004
ISS

USS lab “Destiny”
Holds MSG
And Arges

Progress transport vehicle
Conclusion

We will make it!

If everybody works like HELL...

TUE and Philips alike