HyperGES: The ESA Large Diameter Centrifuge (LDC)

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Background & Motivation

• **HyperGES = Hypergravity Experiment Series**
• The motivation is to make hypergravity environment accessible to countries which do not possess the access to such facilities
• Agreement to collaborate established with a MoU signed 10/2018
• First selection in **2019**
• Second AO in **2022**
• Finally three teams form AO 2019 and AO 2022 were selected and await implementation in September - December 2023

• **Opportunity for (young) professionals to:**
  - build up experience in space / science field
  - experience an international research setting / collaboration
  - exposed to space – related project management / requirements
  - .......

* THE EUROPEAN SPACE AGENCY
1st Round Awardee: Mahidol University, Thailand: Team leader: Dr Tatpong Tulyananda.

Study the effect of hypergravity on watermeal, the smallest and fastest-growing flowering plant on Earth.

2nd Round Awardee: Universidad Católica Boliviana "San Pablo": Team leader Dr. Georgina Aurelia Chávez Lizárraga

Study, in real time, the effect of hypergravity on erythrocyte membrane and its index of osmotic fragility in order to have a possible explanation of space anemia.

2nd Round Awardee: Macau University of Science and Technology: Team leader: Marta Filipa Simões

Expose several fungi species to hypergravity and study their morphology, genetic stability and metabolism but also the fungal dimorphism and possible relation towards pathogenic transitions during several generations.
ESA-Technology Center ESTEC, Noordwijk, NL

the ‘Center of Gravity’
Schematic presentation of potential experiment opportunities compared to 'classic' experiment setups. Novel space station facilities as well as ground simulations and centrifuges may be applied to study the role of weight (accelerations) on various living and non-living samples.
Large Diameter Centrifuge

- Regular hypergravity research
- Launch simulations
- Parabolic Flight hyper-g phase exploration
- …etc.

Gravity Continuum

The ‘Reduced Gravity Paradigm’ (RGP)

Centrifuges general topics / background / references:
doi:10.3389/fspas.2016.00021
TEC-MMG Lis Lab @ ESA-ESTEC
Life- and Physical Science Instrumentation Laboratory (LIS)

meeting room

clean room

(flow.) mic.s

plant chamber

flow benches

FFC furnace

Melissa ISRU/FFC

MidICAR

RPMs

+ other ESTEC labs !!

workbench

LC/MS

e.g. autoclaves

clinostats

LDC

meeting room

cleanroom

life sciences lab

‘wet’ analysis lab

support lab

‘gravity’ lab

Link: ESA TEC-MMG lab

Furnace

Link: ESA TEC-MMG lab

The beauty inside out
LDC Main Properties

diameter : ~ 8 meter
arms : 4

g levels : various (8 locations / arm)

exp. Volume: 7 ‘gondolas’; 6 rotating (60×60×80 cm)
center gondola: control / g-sensitive materials

g vector : swing-out: 

payload : 80 kg per gondola (total 210 kg incl. gondola)
g load : 20×g fully loaded

motor : 22 kW (Siemens)

for HyperGES : max 2 weeks use of LDC
LDC Start-up & Profiles

Immediate spin up to 20 g and spin down to 1 with fully loaded LDC (6 gondola’s).

~60 sec

~55 sec

Simulated Soyuz launch

- Data taken from file: Test_1C_09_00_12_08.csv
- Test done with fully loaded (6 gondola’s) LDC
- g sampling frequency: 1 Hz

~120 sec

~15 sec
Scaling effects:
- $g = N$
- Length: $1/N$
- Time: $1/N^2$
- Mass: $1/N^3$
Some Experiment Configurations

- Impact (Glasgow, UK)
- Crab/Neurovestibular (Aberdeen, UK)
- Mass & Heat Transfer (Thessaloniki, GR)
- Planetary/Glacier (Amsterdam, NL)

5 camera’s

Bubble Generation (Thessaloniki, GR)

Fluorescence Mics (Liege, BE)
Some peer reviewed papers from previous LDC studies (non-exhaustive list) on general, cell biology, animal physiology, fluid physics, plasma physics, geology/planetary, technology, material sciences and other topics: see in LDC user Manual; LINK

**Centrifuges** general topics / background
- doi:10.3389/fspas.2016.00021
- DOI 10.1007/s12217-015-9462-9

**Fluid physics**
- doi:10.1007/s12217-016-9531-8
- DOI: doi.org/10.1016/j.ijmultiphaseflow.2019.03.029.
- https://doi.org/10.1016/j.fbp.2017.02.001
- https://doi.org/10.1103/PhysRevE.91.053009
- DOI: 10.1209/0295-5075/110/24001
- DOI: 10.1007/s10035-013-0403-2
- http://dx.doi.org/10.1016/j.ijheatmasstransfer.2018.05.151
- https://doi.org/10.1007/s12217-016-9531-8
- http://dx.doi.org/10.1016/j.ijmultiphaseflow.2019.03.029.
- https://doi.org/10.1016/j.expthermflusci.2015.01.011
- https://doi.org/10.1007/s12217-012-9323-8

**Cell biology:**
- doi: 10.1002/jbm.a.37215
- doi: 10.1016/j.bjp.2021.01.021
- https://doi.org/10.1016/j.bjp.2019.03.038
- doi: 10.1089/scd.2017.0206
- doi:10.2147/JOJ.S76329
- DOI: 10.1371/journal.pone.0144269.
- DOI: 10.1089/ten.tea.2012.0267

**Material sciences**
- DOI: https://doi.org/10.1016/j.ijheatmasstransfer.2018.05.151

**Plasma physics**
- doi:10.1088/0963-0252/24/7/022002
- http://dx.doi.org/10.1016/j.materresbull.2014.03.013
- DOI: 10.1140/epjd/e2013-40408-7

**Plant biology**
- https://doi.org/10.1007/s12217-016-9531-8
- http://dx.doi.org/10.3389/fspas.2016.00002
- doi:10.1038/rep07730
- http://dx.doi.org/10.1155/2014/964203
- doi:10.1371/journal.pone.0058246
- doi:10.1007/s12217-012-9301-1

**Animal physiology**
- doi:10.1302/2046-3758.102.BJR-2020-0239.R1
- doi: 10.1089/jphysci.2018.0231
- DOI: 10.1371/journal.pone.0058246
- https://doi.org/10.3390/ijms20030720
- DOI: 10.1140/epjd/e2013-40408-7

**Geology/planetary**
- doi:10.1098/rspa.2016.0673

**Technology**
- doi:10.1016/j.bjp.2021.01.021
- DOI: 10.1002/adv.21937
Any question / remarks regarding LDC ?!
Don’t wait asking !!

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TEC-MMG LIS Lab web URL: https://technology.esa.int/lab/life-support-physical-sciences-instrumentation-laboratory

Other general webinar info
SELGRA webinar: Gravity-related research instrumentation applications in life and physical sciences
https://www.youtube.com/watch?v=jejiXx0Zt-4

UNOOSA webinar: Introduction to Hypergravity/Microgravity: https://youtu.be/AjmR0syOc-Y?list=PLaOqa4cng0GGgCeqlAw0bWTPAdBzHICx&t=1263 /
UNOOSA webinar series: https://www.unoosa.org/oosa/en/ourwork/access2space4all/HMTrack_Webinars.html#Tag6

ESA Petri website: https://www.esa.int/Education/PETRI_programme/PETRI_What_is_it