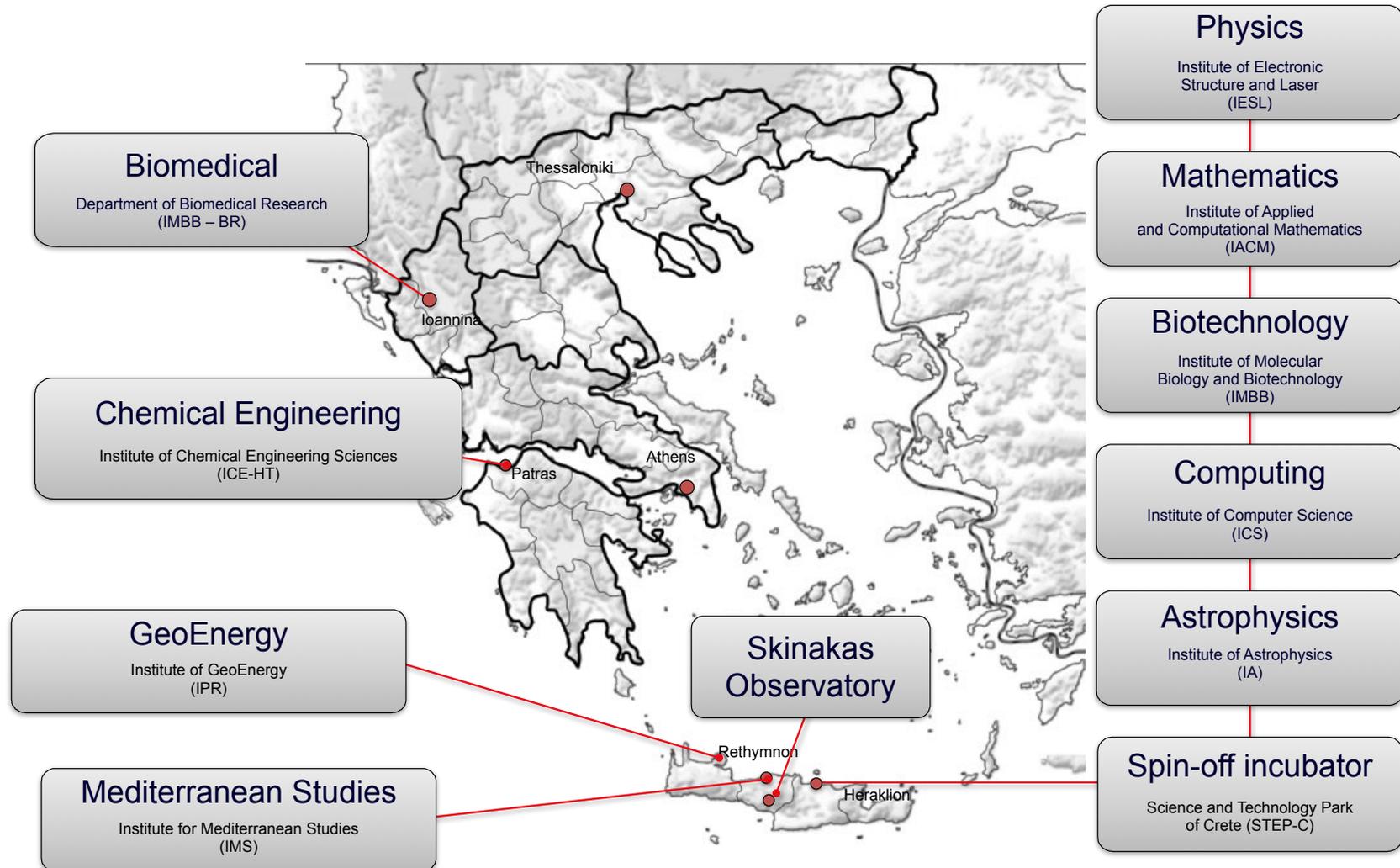

Space Related Research Groups



Wolf von Klitzing

The eight institutes of FORTH



Space Related Research Groups



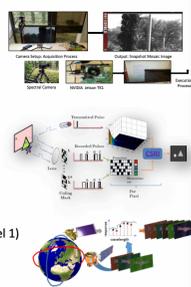
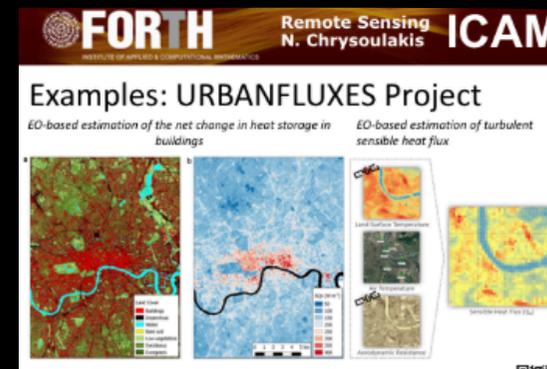
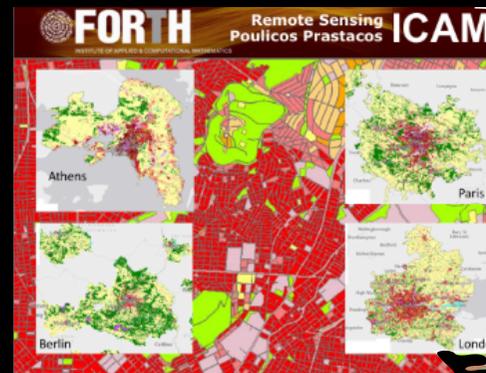
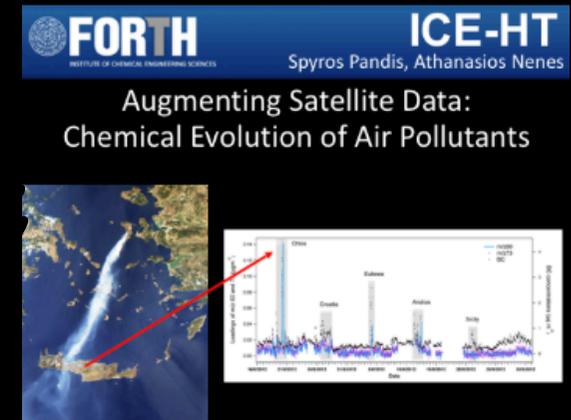
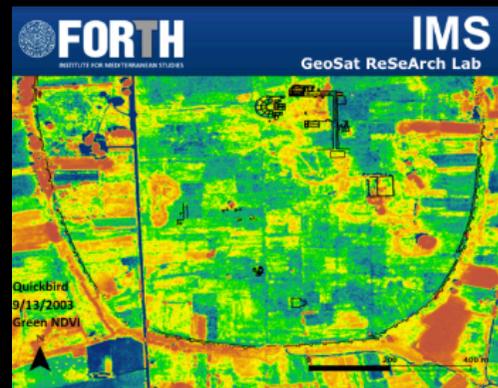
- **Data usage / augmentation**
- **Physical systems and simulation**

Wolf von Klitzing

Data Usage & Data Augmentation

FORTH INSTITUTE OF COMPUTER SCIENCE **ICS** Signal Processing Laboratory

- > **Multispectral Imaging**
Multispectral **video** processing & analysis
Low weight and size (cubesat-friendly)
Onboard data processing
- > **LIDAR**
Multiple depth encoding
Novel algorithmic framework
- > **Machine Learning in Big Data in EO**
Deep Learning framework
Automated land cover estimation (NASA MODIS)
Accurate Soil Estimation (NASA SMAP & ESA Sentinel 1)
Galaxy redshift estimation (ESA Euclid)
Spatio-spectral enhancement (Sentinel 2)

Data Usage & Data Augmentation



ICS
Signal Processing Laboratory

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Multispectral **video** processing & analysis

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➤ Machine Learning in Big Data in EO

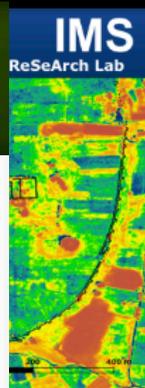
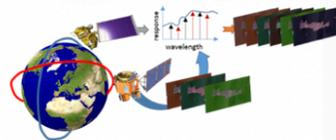
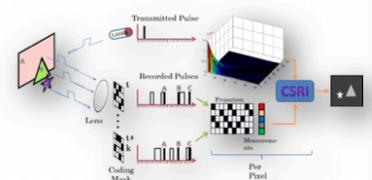
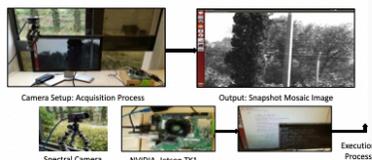
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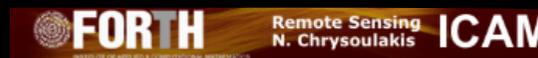
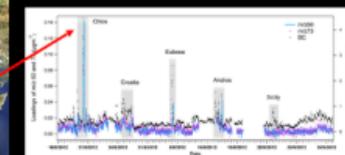
Spatio-spectral enhancement (Sentinel 2)



ICE-HT

Spyros Pandis, Athanasios Nenes

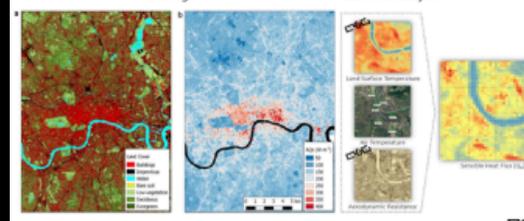
Augmenting Satellite Data:
Chemical Evolution of Air Pollutants



Examples: **URBANFLUXES** Project

EO-based estimation of the net change in heat storage in buildings

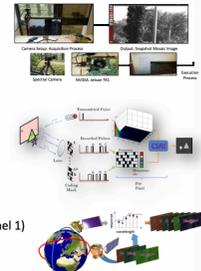
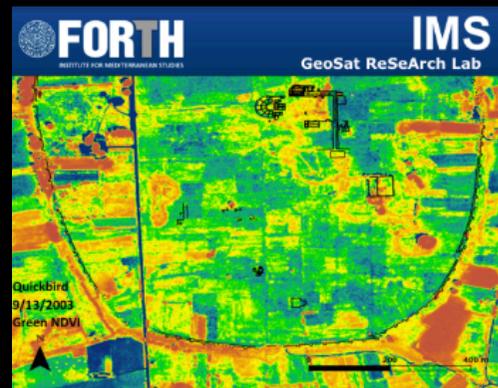
EO-based estimation of turbulent sensible heat flux



Data Usage & Data Augmentation

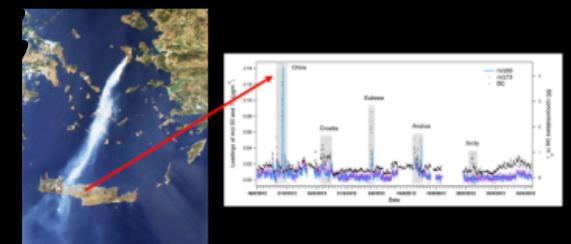
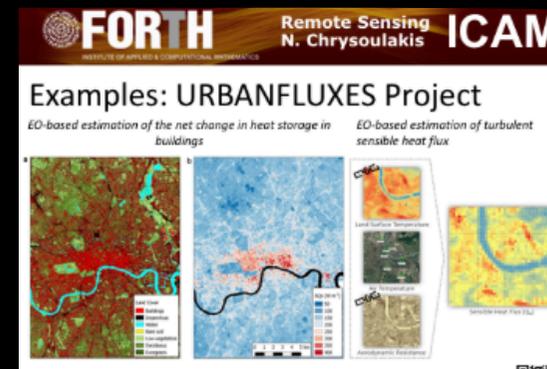
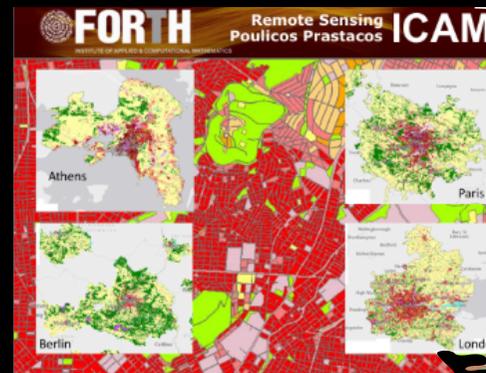
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FORTH INSTITUTE OF CHEMICAL ENGINEERING SCIENCES
ICE-HT Spyros Pandis, Athanasios Nenes

Augmenting Satellite Data:
 Chemical Evolution of Air Pollutants

Physical Systems (and simulations)

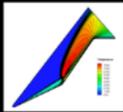
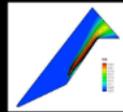
FORTH Fluid Dynamics **ICAM**
Yannis Papaharilaou

Chemically Reacting Flows

Multiphysics: DG Methodology for Hypersonic Reactive Flows (M=9)

Double cone model

Chief characteristic of re-entry aerodynamics is that the temperature of the flow is so great that the chemical bonds of the diatomic molecules of the air are broken in an endothermic reaction – *Thermal protection of space vehicles*


Temperature for non-reactive double cone simulation

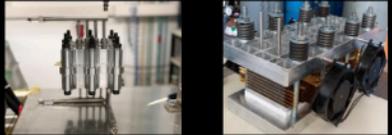
Molecular oxygen mass fraction

ScramJet intake shock reflection (M=3)

FORTH **ICE-HT**
Patras

Electrochemical Power Generation, Energy storage and life-support technologies.

Contact Persons: Stylianos Neophytides, Maria Daletou, Dimitris Niakolas



Development of a closed loop Regenerative HT-PEM Fuel Cell System

FORTH **IESF**
Wolf von Klitzing

Matter-Wave Interferometry and Space Optics

Matter-Wave Interferometry

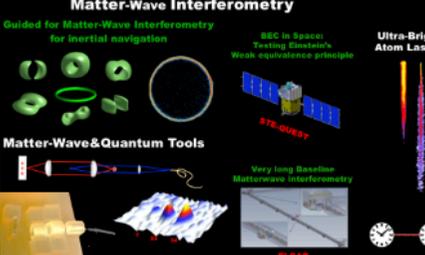
Guided for Matter-Wave Interferometry for inertial navigation

BEC in Space: Feshbach Resonance Weak equivalence principle

Ultra-Bright Atom Lasers

Matter-Wave & Quantum Tools

Very long Baseline Matterwave Interferometry



FORTH **ICS**
Dimitris Tsakiris

Vision and Robotics Laboratory

- Planetary/Lunar Robotic Exploration
 - Robotic locomotion and manipulation for RE of unstructured environments.
 - Bio-inspired compliant-body amphibious crawlers & aquatic swimmers.
 - Control for functional materials and compliant structures.
 - Sensor-based motion planning and control. Visual perception.

Related ESA Programmes: TRP, PRODEX, MREP.



FORTH amphibious ped-undulatory robot at the Planetary Analog Terrain facility, Aberystwyth University, UK

FORTH **AI**
Skinakas Observatory

FOUNDATION FOR RESEARCH & TECHNOLOGY - HELLAS UNIVERSITY OF CRETE

MAX PLANCK INSTITUTE for EXTRATERRESTRIAL PHYSICS

SKINAKAS OBSERVATORY



ESA: Space Object Tracking ?

FORTH **AI**
Kostas Tassis **PASIPHAE**

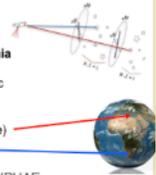
Aim:

- Measure stellar optical polarizations using innovative state-of-the-art optopolarimeters
- Combine with stellar distances measured by Gaia
- Map the 3D structure of Galactic magnetic field
- Aid in foreground removal in maps of the cosmic microwave background.

Location: Skinakas Observatory (FORTH/U Crete) + Sutherland (South Africa)

Direct Relation to ESA missions:

- provide a complementary, unique value added dataset to Gaia's measurements for over 10⁶ stars
- enhance the scientific exploitation of Planck mission (B-mode science)



FORTH **IESL**
Photonic- and Meta-materials

Metamaterials: Structured materials with unique, controllable properties (e.g. negative or giant or near zero refractive index, permittivity, permeability, chirality, ...)

ESA useful properties and applications:

- Backwards phase advance and sub-wavelength operation
- Component miniaturization
- Unusual and "arbitrary" wave steering and shaping
- Communication applications
- Zero-reflection & Perfect Absorption
- EM shielding, controlled impedance in antennas, filtering
- Ultra-strong Chirality
- Polarization modulators and filters, polarization isolators



FORTH **IESL**
Microelectronics

<p>Material Development</p> <p>III-V Semiconductors (MBE)</p> <p>SiC (MOCVD)</p> <p>2D materials (CVD)</p>	<p>Device & Circuit Fabrication</p> <p>20nm minimum feature with 30kV</p> <p>Max. wafer size 4inch</p> <p>Sputtering (oxides)</p>	<p>Material evaluation</p> <p>HR-XRD</p> <p>FE-SEM</p> <p>AFM</p> <p>PL, μPL, Hall</p>	<p>Device & Circuit assessment</p> <p>I-V, Rf, C-V, L-I</p>
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2 Class 1000 clean rooms (200m²), 2 Class 10000 clean rooms (80m²)



FORTH **IESL**
Laser Based Fabrication of Biomimetic Functional Surfaces

Functionalized surfaces

Chemical: patterned superhydrophilic, superhydrophobic and omniphobic surfaces

Optical: wideband optical absorbers/emitters, antireflection

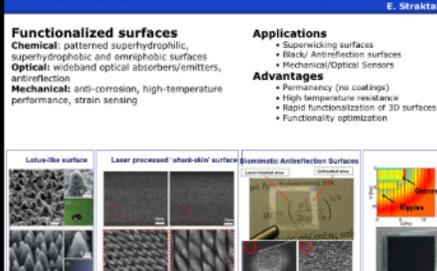
Mechanical: anti-corrosion, high-temperature performance, strain sensing

Applications

- Superwetting surfaces
- Black/Antireflection surfaces
- Mechanical/Optical Sensors

Advantages

- Permanency (no coatings)
- High temperature resistance
- Rapid functionalization of 3D surfaces
- Functionality optimization



FORTH **IMBB**
INSTITUTE OF MOLECULAR BIOLOGY & BIOTECHNOLOGY

- C. Elegans research (Prof. Nektarios Tavernarakis: <http://www.elegans.gr>)
- Relevant ESA Projects:
 - Establishing Molecular Mechanisms of and Countermeasures to Muscle Decline in Space
- ESA Programmes:
 - TRP
 - CTP
 - PRODEX

RIGHT NOW on the Space Station

Freeze-dried OP50 GOES TO SPACE



Physical Systems (and simulators)

FORTH Fluid Dynamics ICAM
Yannis Papaharilaou

FORTH ICE-HT Patras
Electrical Power Generation, Energy and life-support technologies.
Contact Persons: Stylianos Neophytides, Maria Daletou, Dimitris Niakolas

Closed loop Regenerative HT-PEM Fuel Cell System

FORTH IES
INSTITUTE OF ELECTRONIC STRUCTURE AND LASER
Wolf von Klitzing Matter-Wave Interferometry and Space Optics

Matter-Wave Interferometry

Guided for Matter-Wave Interferometry for inertial navigation

BEC in Space: Testing Einstein's Weak equivalence principle

Ultra-Bright Atom Lasers

Matter-Wave & Quantum Tools

Very long Baseline Matterwave interferometry

OBST

ELGAR

SAGE

AI
Kostas Tassis PASIPHAE

polarizations using art optopolarimeters
distances measured by Gaia
Galactic magnetic field
real in maps of the cosmic

Observatory (FORTH/U Crete)

missions:
ry, unique value added dataset to Gaia's
10⁶ stars
xploitation of Planck mission (B-mode science)

IMBB
MOLECULAR BIOLOGY & BIOTECHNOLOGY

(Prof. Nektarios Tavernarakis: <http://www.elegans.gr>)

IS:
molecular Mechanisms of and
to Muscle Decline in Space

RIGHT NOW on the Space Station

freezed OP50
GOES TO SPACE
LabTIE

FORTH INSTITUTE OF ELECTRONIC STRUCTURE

Metamaterials: Structure controllable properties
(e.g. negative or giant permittivity, permeability)

ESA useful properties and

- Backwards phase advance
- Component miniaturization
- Unusual and "arbitrary" wave Communication applications
- Zero-reflection & Perfect Absorption
- EM shielding, controlled impedance
- Ultra-strong Chirality
- Polarization modulators and filters





GW-Detection using Photon and Atom Optics



Wolf von Klitzing
Dimitris Papazoglou
Konstantinos Makris
Giorgos Vasilakis
Giannis Drougakis



Vinay Pareek
Vishnupriya Puthiya Veetil
Vidhu Catherine Antony
Apostolis Brimis
Pandora Examilioti
Mary Georgousi



NanoLace

Marie Curie-Excellence
MatterWaves



MatterWave

Marie Curie-Excellence
MatterWaves





GW-Detection using Photon and Atom Optics



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MatterWaves



Space Optics Group



FORTH

INSTITUTE OF ELECTRONIC STRUCTURE AND LASER

CRETAN**MATTER**WAVES
www.bec.gr



Wolf von Klitzing,
group leader



Dimitris Papazoglou,
PI Optics



Giannis Drougakis
Post Doc / Engineer

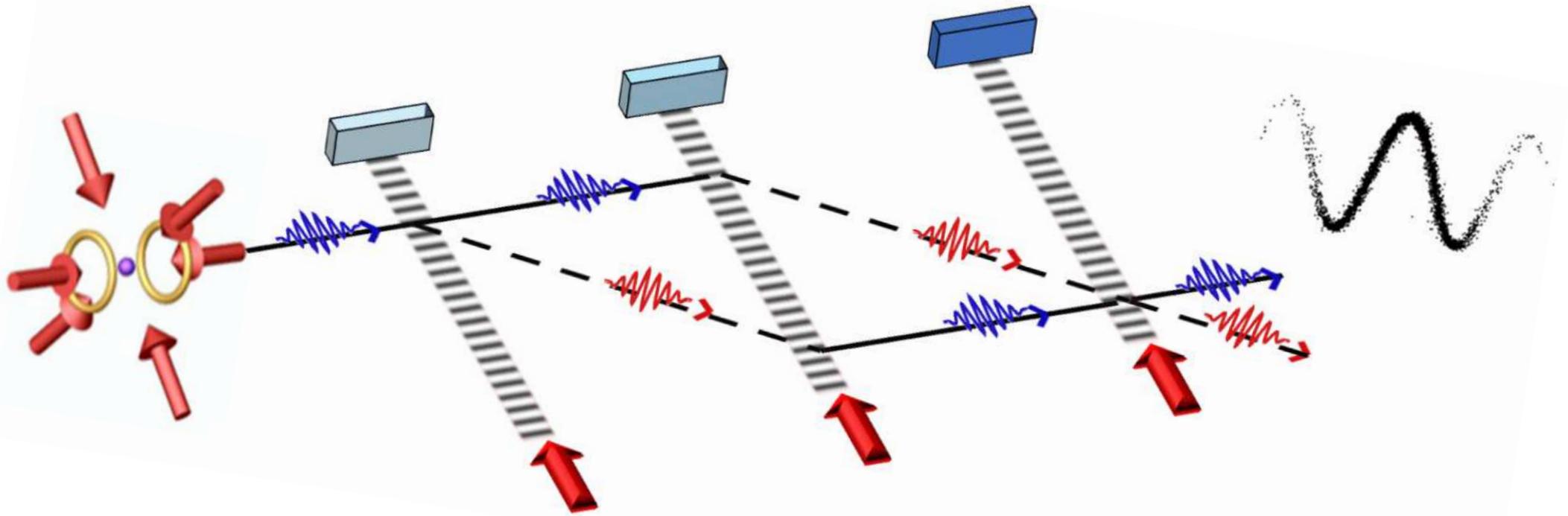


Pandora Examilioti,
PhD Student



Mary Georgousi,
MSci Student

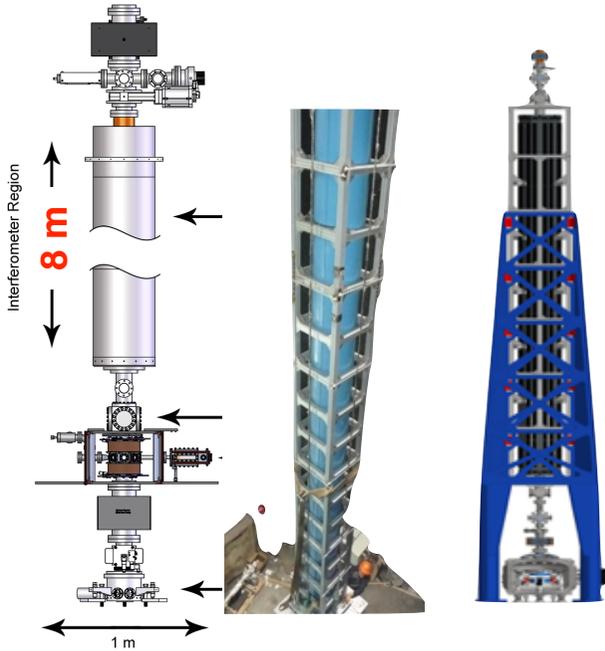
Matter-Waves



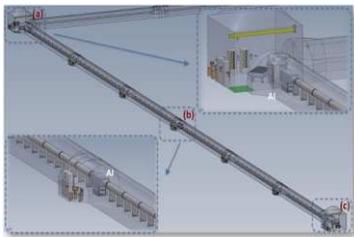
Matter-Wave Interferometry



Large Tubes

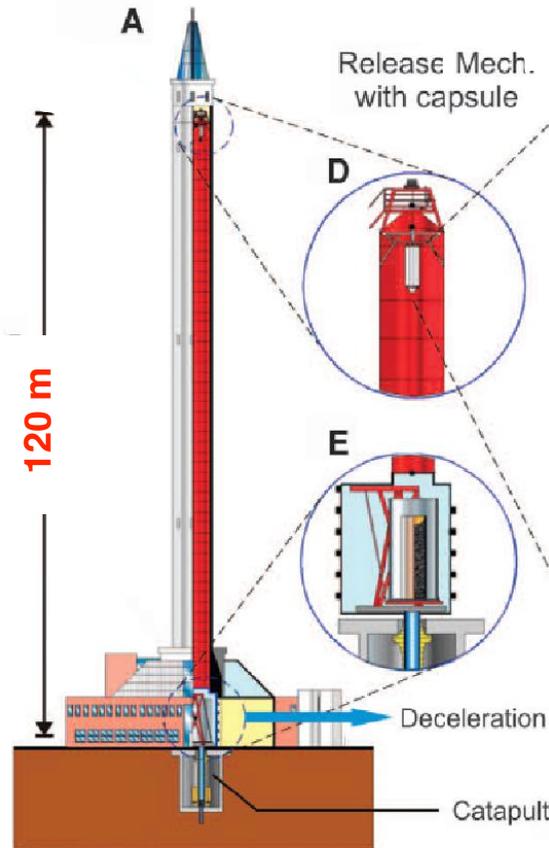


Stanford / Wuhan / Hannover



ELGAR

Free Fall ZARM drop Tower



Space

NASA
CAL



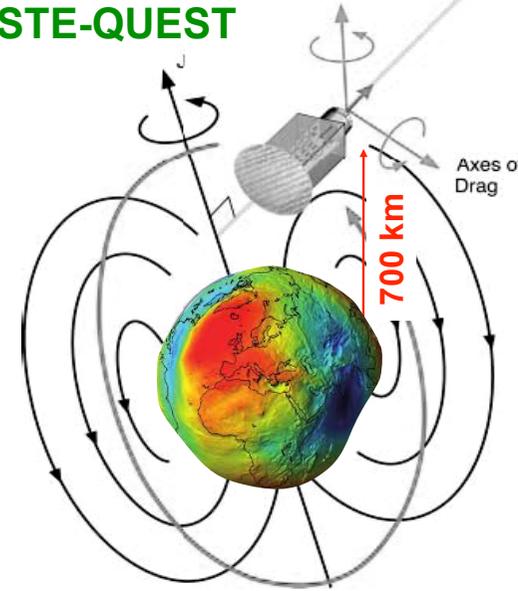
ESA
C-COOL



muQuans



AEDGE
STE-QUEST



Parabolic
Flights

Matter-Wave Interferometry



Large Tubes

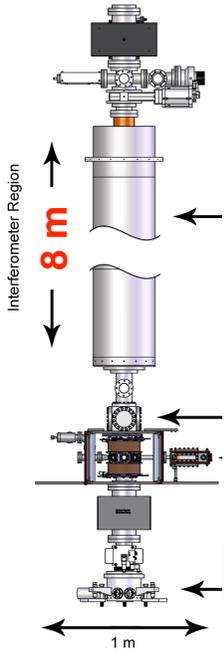
Free Fall

Space

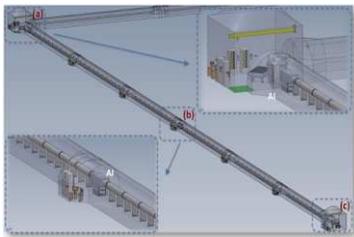
AEDGE

Atom Interferometric

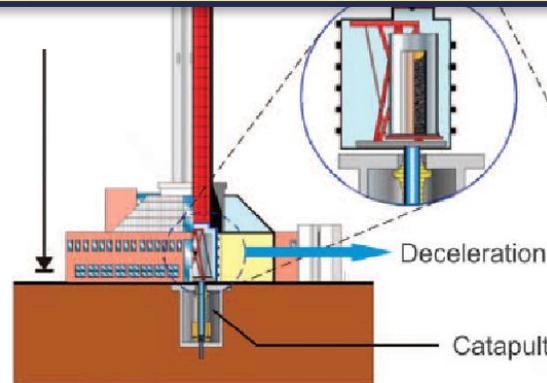
- Constraints on Dark Matter
- Limits on chameleon fields
- Confirmation of Einstein's Equivalence Principle
- Precision measurements of the fine-structure Const.
- Gravitational Waves (?)



Stanford / Wuhan / Hannover



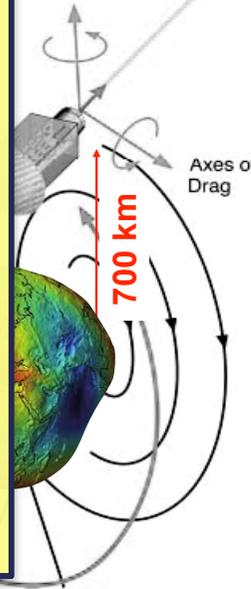
ELGAR



Google: "AEDGE quantum" (or DOI: 10.1140/epjqt/s40507-020-0080-0)



Parabolic Flights



Waves at IESL-FORTH and Beyond

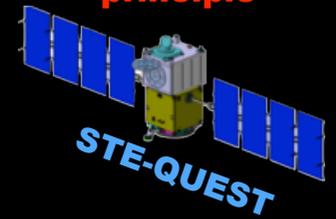
Guided Matter-Wave Interferometry

Space Clocks:
SAGE



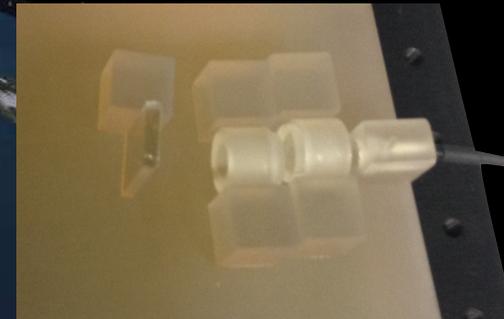
STE-QUEST

BEC in Space:
Testing Einstein's
Weak equivalence
principle

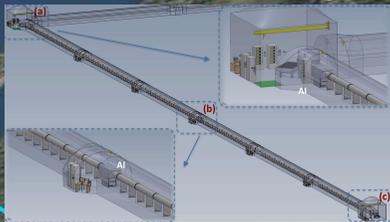


AEDGE

Atom Space
Technologies:
OBST 1 & 2



Very long Baseline
Matterwave interferometry



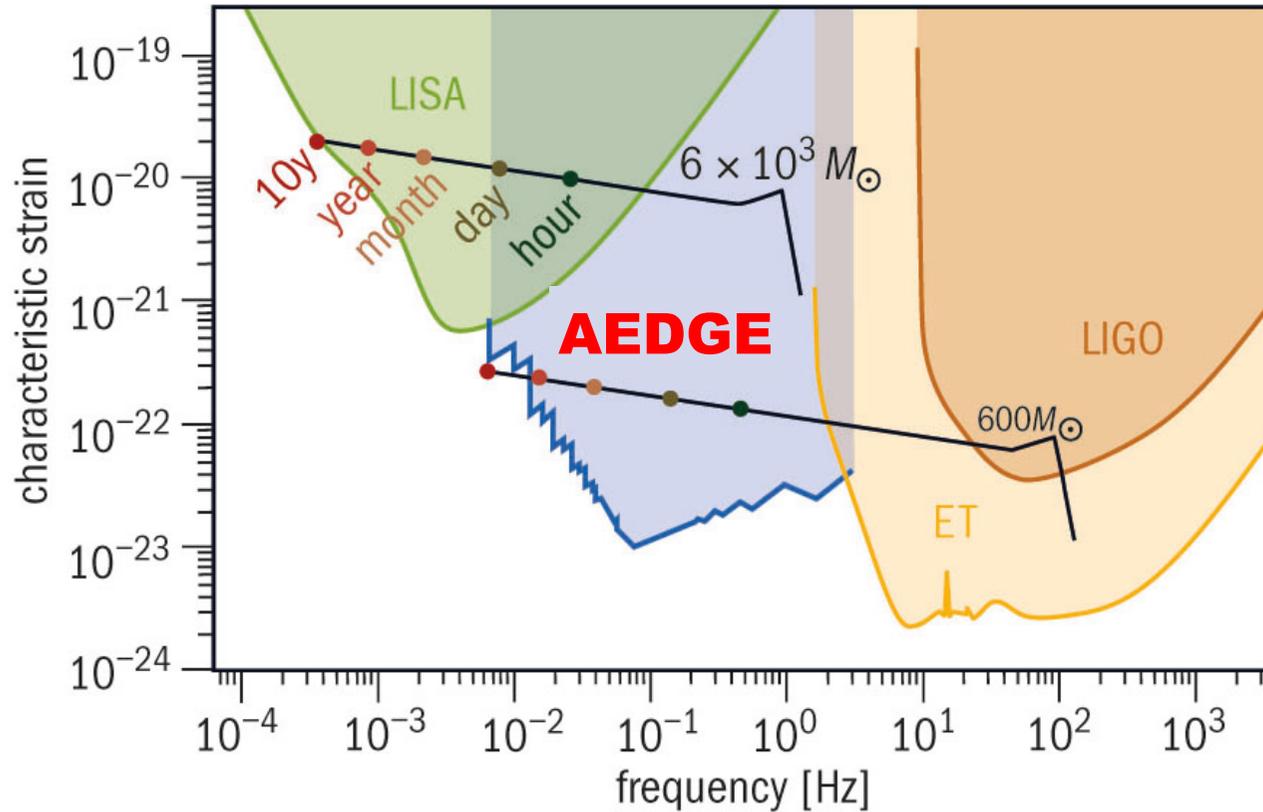
ELGAR



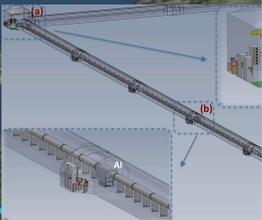
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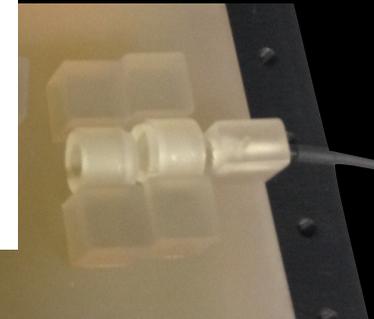


ELGAR

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Technologies:
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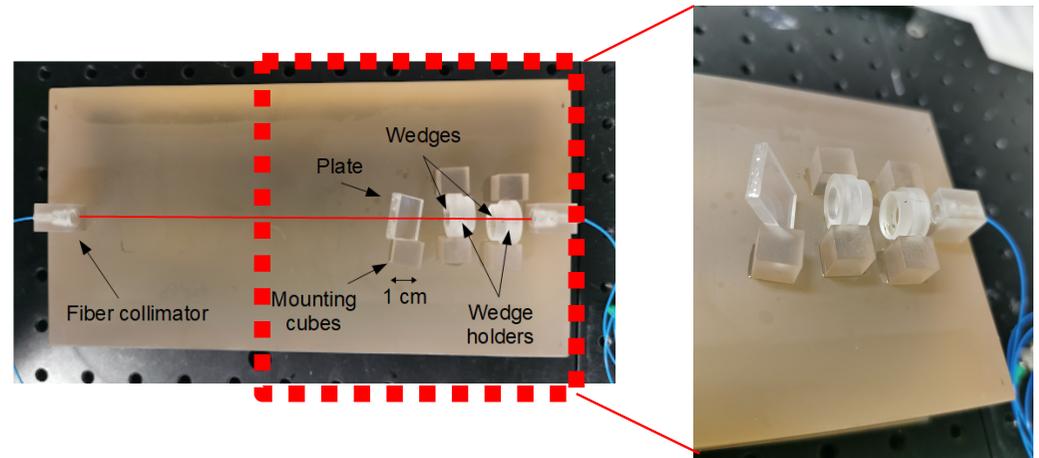
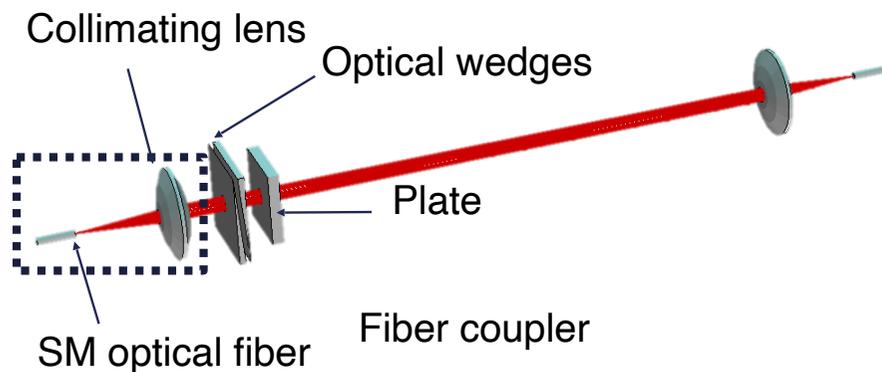


Optical Beam Steering Technology (OBST)

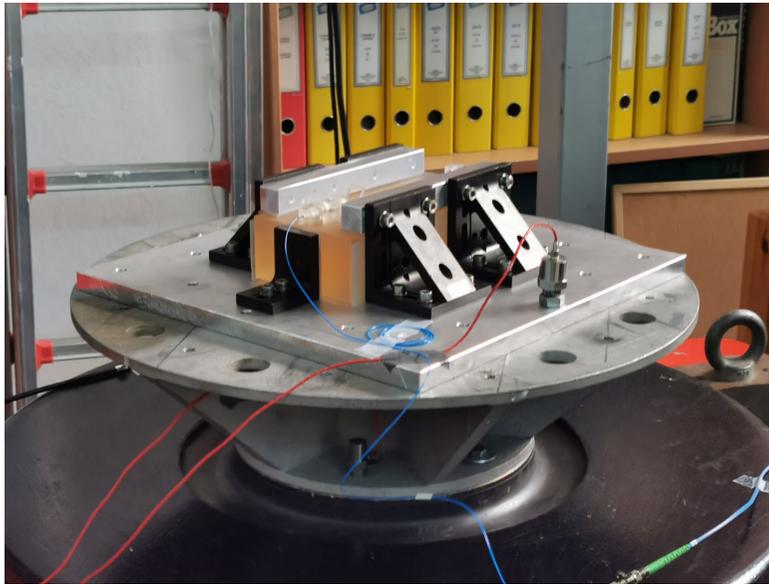


- Nearly monolithic design of components
- **Simple, fast and low-cost** manufacturing using COTS components (Assembly with standard laboratory equipment)
- **Extreme Stability:** Fluctuations : $0.1\%_{\text{RMS}}$ in 5 Days
Even under Temperature variations, shocks and vibrations Fluctuations $< 1\%$
- **Coupling Efficiency 94%**

Fiber- free space-fiber optical link using a pair of optical wedges and a plate to perform the fine steering of the beam

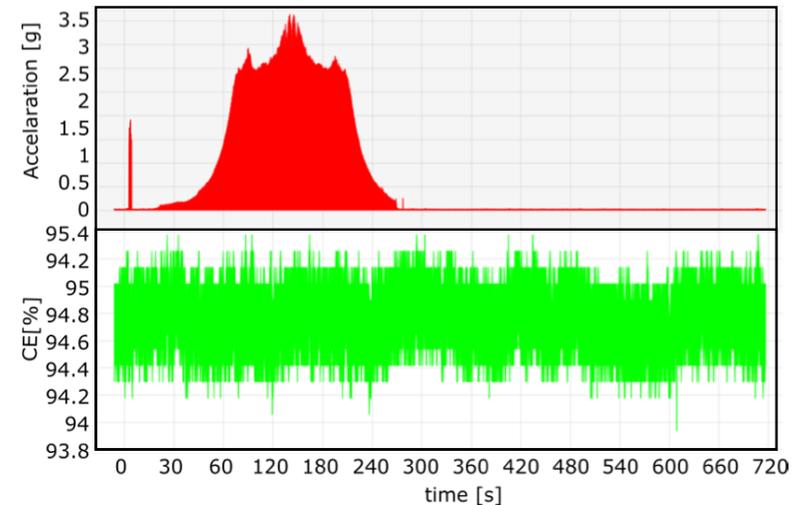


OBST stability under Launch Conditions



Vibration Tested according to the standards:

EN 60068-2-6:2008 (IC 60068-2-6:2007),
EN 60068-2-64:2008 (IC 60068-2-64:2008),
ISO 20780:2018.



Results

- Sine sweep, 3.5 g, 5 → 100 → 5 Hz
RMS fluctuations of CE = **0.15%**
- Max 8.3g RMS at a random spectrum between 20 – 2000 Hz
RMS fluctuations of CE = **0.28%**
- Shock tested at 89.4g for 1ms

OBST 4 LISA ?

