ULTRAVIOLET ASTRONOMY IN THE XXI CENTURY

e-Workshop 2020 – October 27-29

JcUVa

Feasibility study for the implementation of small-size astronomical UV telescopes

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5TH WORKSHOP OF THE NETWORK FOR ULTRAVIOLET ASTRONOMY

VIRTUAL MEETING OCTOBER 27th - 29th, 2020

FACE-TO-FACE MEETING VITORIA (SPAIN), OCTOBER 5th - 9th , 2021

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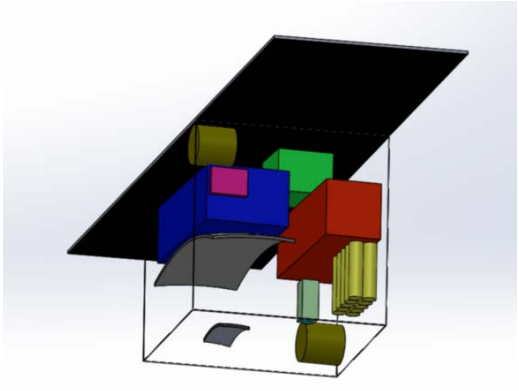


Proposed draft design of the 27U CubeSat with a 36 cm telescope

Motivation

1) Cover the niche of FUV instruments in upcoming years

2) Use small Earth Observation (EO) flown platforms and know-how to implement astronomical small satellites

3) Use new manufacturing techniques to achieve low mass and high efficiency UV telescopes

HyperScout. Hyperspectral imaginer (around 2 Kg and 10 W). Image source ESA.

Objectives

1) *36 cm aperture telescope* to be fit in a 27U CubeSat

   To study exoplanets in transit regime

   Target spectrum: 120-280 nm

2) Explore *new concepts*.

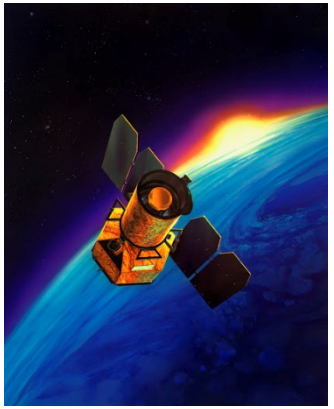
3) Be able to plan and launch missions in < 4 years

4) *Bring advances from EO, to astronomy*.

Current UV missions

Past or in process of decommissioning missions:

1) **Hubble Space Telescope (HST).**
   - STIS instrument (115-310 nm and R500-1000)
   - COS instrument (90-320 nm and R1500-24000)
   - Mission operative until mid-2020
2) **Space Shuttle UV** telescopes (90's).
   - UIT telescope had a 38 cm Cassegrain telescope (120-320 nm)
   - Other planed experiments were cancelled due to funding cuts
3) **GALEX**.
   - 50 cm Richey-Chrétien (280 Kg) at 135-280 nm with R100
   - Decommissioned 2013



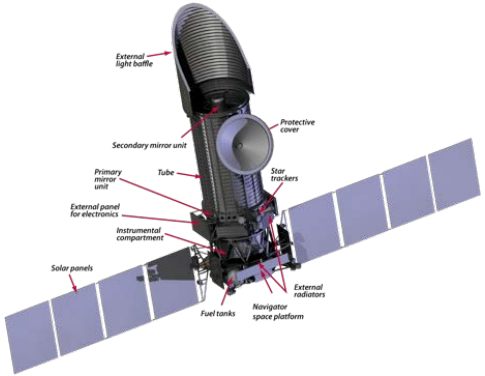
GALEX. Image source Caltec.edu[1]

1- http://www.galex.caltech.edu/media/glx2004-01r_img01.html

Current UV missions

Future planed missions:

1) **World Space Observatory (WSO)**.
   - Drafted in 1999 and to be launched in 2023.
   - Richey-Chrétien 135-315 nm and R1000-50000.
   - Spanish/Russian
2) **Cosmic Evolution Through Ultraviolet Spectroscopy (CETUS).**
   - 1.5 m telescope
   - 100-400 nm using three instruments
   - USA. To be launched 2025.
3) **LUVOIR…**



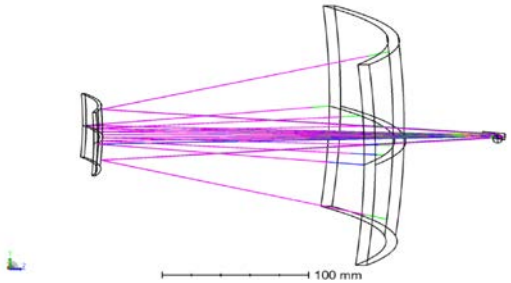
WSO. Image source www.wso-uv.es

--> Missions required & still require decades and cost billions <- -

What we propose…

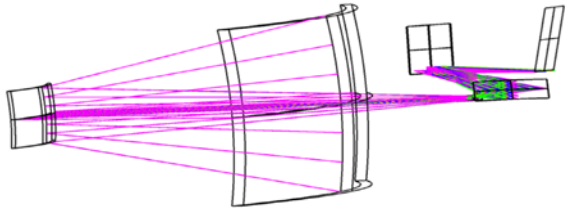
Modest Telescope and instrument

- 2-mirror Cassegrain with rectangular aperture
  - M1: concave radius 570 mm with 360x150 mm sizes
  - M2: convex radius 246 mm with a 120x48 mm sizes
  - Capture 10^{-3} to 10^{3} W/m^2/µm
  - Distinguish 1-10% of signal variation



Telescope design

- Spectrometer (UV: 120 to 280 nm)
  - Resolving power between 1000 and 10000
  - Minimum amount of surfaces (reflection)
  - Spherical grating embedded in a concave surface
  - Spectral resolution 0.5 to 1 nm



Telescope + spectrometer

Enhanced devices and new techniques

Detector:

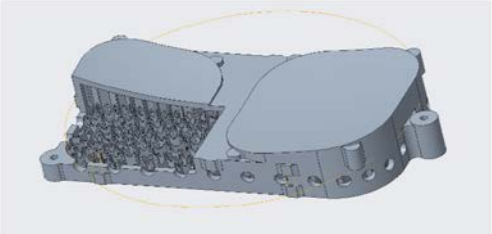
- Small Micro-channel plate detector (used also in the HST COS)

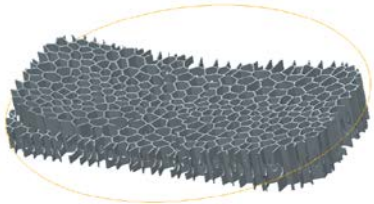
Manufacturing:

- New additive manufacturing techniques reduce mass up to 64% (AlSi, Scalmalloy)
- Magnetorheological Finishing (MRF) for polishing required quality

Required devices

- Solar panels, batteries, star trackers… based in available **COTS**[1]





Lightweight telescope mirrors using additive manufacturing. Source Fraunhofer IOF

1- Commercial off-the-shelf

Bottlenecks

- UV Coatings:

  ALD and PVD[1] techniques

  New Mg_2F, AlF_3 and LiF coatings provide UV efficiency up to 80%

  Planned for CETUS and WSO missions

- Pointing accuracy:

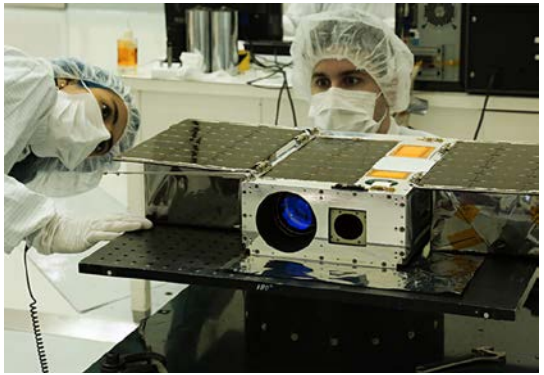
  Arcsec requirement for exoplanet observation

  ASTERIA demonstration facts:

  → 10 Kg CubeSat deployed 2017

  → 0.5 arcsec RMS over 20 min

  → Repeatability of 1 marcsec RMS orbit to orbit



ASTERIA technology demonstration CubeSAT. Source: JPL NASA[2]

1- Atomic Layer Deposition and Physical Vapor Deposition

2- https://www.jpl.nasa.gov/cubesat/missions/asteria.php

Satellite Budgets

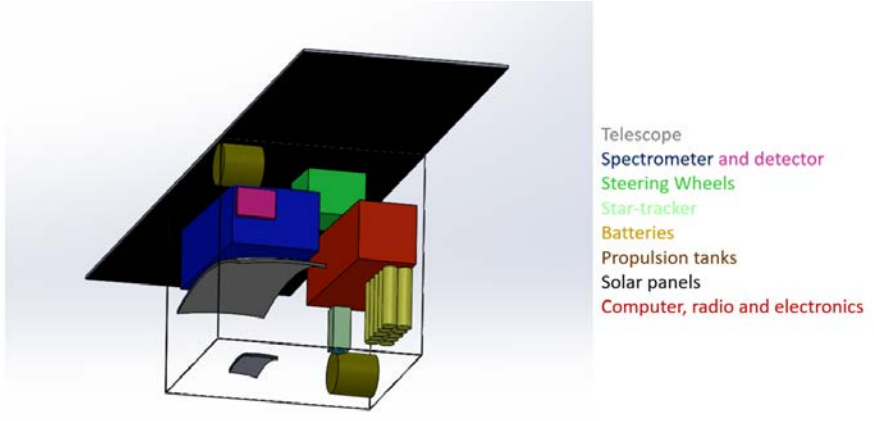
Baseline design thought to fit in a 27U CubeSat

Required devices:

- Satellite structure (harnesses, fasteners, mounting plates, etc.),
- Power supply (solar panels, batteries) and electronics,
- Position measurement (gyroscopes, start trackers, etc.) and position adjustment (reaction wheels, thruster etc.),
- Communication systems.

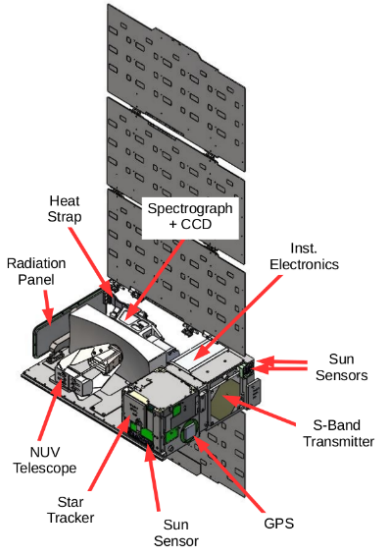
Target:

- Sat 54 Kg, 60 W and 34X35X36 cm^3
- Payload 25 Kg and 45 W



A smaller example in the roadmap…

- Similar concepts are being implemented. As the CUTE experiment for Colorado University[1,2]:
  - Colorado Ultraviolet Transit Experiment
  - 6U CubeSat
  - 250-330 nm R3000
  - 10 Kg
  - Cassegrain with M1 of 206 mm x 84 mm
  - To study exoplanet atmospheric mass loss and magnetic fields
  - 4 years mission to be launched… soon.



CUTE design. Source CUTE[1].

1- Arika Egan, et. al., SPIE, 2018. Doi: 10.1117/12.2309990
2- Brian T. Fleming, et. al., SPIE, 2018. Doi: 10.1117/1.JATIS.4.1.014004

Conclusions

- In the next years will
- Technology is mature cheap small platforms
  - FUV coatings av
  - Lightweight ma
  - Enhanced point
  - COTS
- Based in CubeSat plat 4 years

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Space telescopes through philanthropic support

Luca Maresi & Alessandro Zuccaro Marchi

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Metrics

Philanthropic donations are a significant contribution to the betterment of humankind, with a large percentage dedicated to science and education. Affordable small satellites may offer philanthropists the opportunity to give students and underprivileged communities access to small space telescopes.

But most important: **<u>What is the opinion of NUVA community?</u>**
Contact me for further discussions → pol.ribes@esa.int

Andromeda. Source: https://storymaps.arcgis.com/stories/83594c9838cb445ba8725115d6309e2e