“New Space” for Astronomy and Astrophysics

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The development of space instrumentation under the CubeSat standard has launched a “New Space” era in which missions develop much faster and at considerably lower cost than traditional space exploration. Vastly used for communications and EO science, CubeSats also have incoming possibilities for Astrophysics research, with the potential to be a complement (spatial, temporal or spectral) for large ground and space observing facilities. Recent missions taking CubeSat technology to the Moon, Mars and minor bodies in the Solar System are a good proof of this. Carrying out such projects in close collaboration with research institutions and companies is the main goal of IACTEC-Space, a long-term space program from the Instituto de Astrofísica de Canarias (IAC) with the aim of developing high-performance instrumentation on board small satellites.

IACTEC-Space Team

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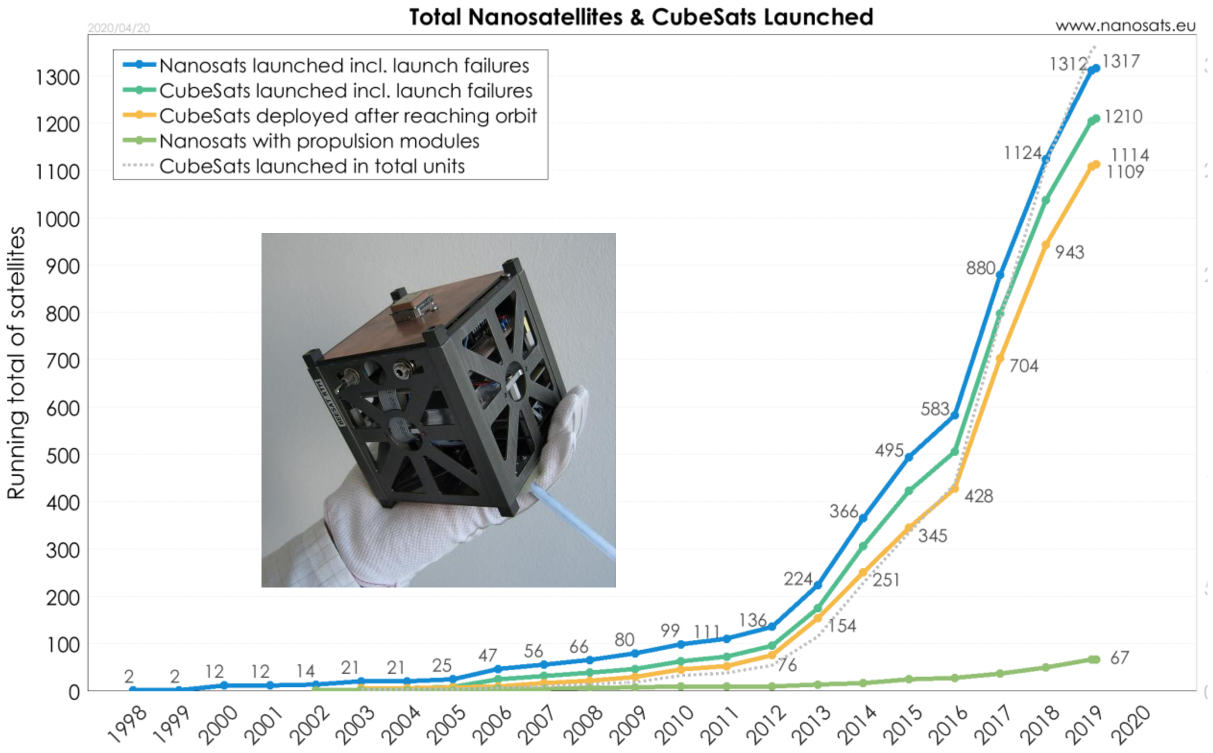
1. Context: "New Space" and the CubeSat standard

CubeSats are standardized Smallsats in modular 10x10x10 cm units (1U, 3U, 6U, 12U…)

- low cost (1 ESA M-class mission ≈ 10 x 12U CubeSats), short built times, COTS components available
- frequent launch opportunities as secondary payloads
- over 1700 Smallsats (1300 CubeSats) launched! (Starlink… ☹)



… could CubeSats be "astronomers friends"?

- observing during periods and at λ's inaccesible from ground (low energy gamma, X-rays, UV, IR, radio gaps)
- low cost → small collaborations → no telescope time allocation
- CubeSat constellations → flexibility and high FoV to respond to transient events (GRBs, supernovae, GW counterparts)
- calibrators for ground observatories; auxiliary missions / subsystem demonstrators for larger missions

… but with some technological challenges to face

- high resolution only achievable with complex deployable systems
- pointing stability
- propulsion and communications in deep space missions
- achieve high-performance following the small SWaP-C concept

1. Context: CubeSat Astronomy is a reality! Some examples

IACTEC Space · Cabildo de Tenerife · Gobierno de Canarias · MEDI · FDCAN Fondo de Desarrollo de Canarias · Gobierno de España, Ministerio de Ciencia e Innovación · Unión Europea

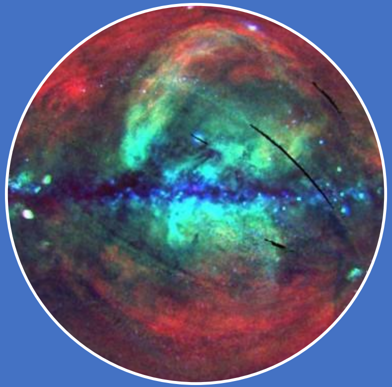
Detection of GRBs as GW counterparts:

BurstCube (NASA, 2021?)

- goal: 10 x 6U for full-sky coverage

CAMELOT (Japan-EU, ?)

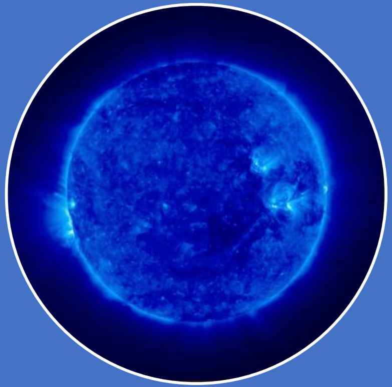
- 9 x 3U; 10’ localisation accuracy



HaloSat

(Univ. Iowa + NASA, 2018)

- map soft X-ray oxigen lines to constrain hot gas in Milky Way (“missing baryon problem” in Cosmology)



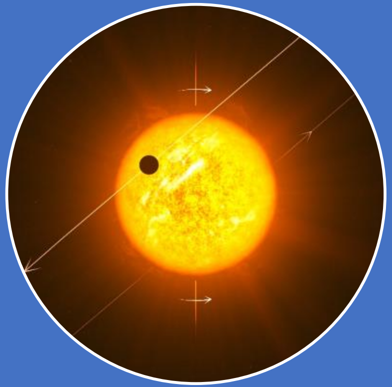
CUTE

(Univ. Colorado + NASA, 2021?)

- transit spectroscopy of hot Jupiters

SPARCS (NASA, 2021?)

- variability of low mass stars (stellar models for exoplanets)



BRITE (Canada-EU, 2013-14)

- 5 x 4U nanosats
- variability of bright stars + long-term photometry

ASTERIA (JPL, 2017)

- pointing repeatability and stability < 0.5” RMS ~ 20 min for exoplanet transits

GAMMA — **X-RAY** — **UV** — **VISIBLE**

DEEP SPACE

MarCO (NASA/JPL, 2018)

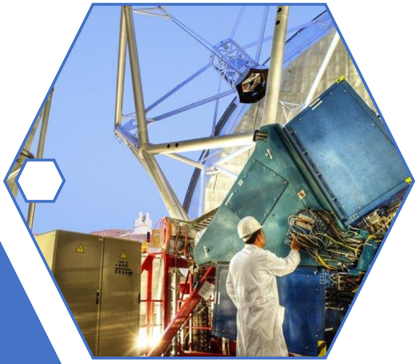
- communications relay for InSight mission on Mars

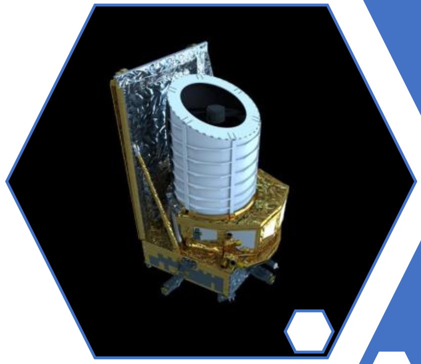
NEAScout (NASA, 2020?)

- close flyby of a near-earth asteroid using a solar sail (86 m2 inside 6U)

2. Description of the project

The IAC has years of expertise in design and development of astronomical instrumentation, for example:





VIS + IR

GTC (OSIRIS, EMIR, FRIDA)

VLT (EXPRESSO)

ELT (HARMONI, CODEX)

OTHERS

CTA

EST

NRT

QUIJOTE

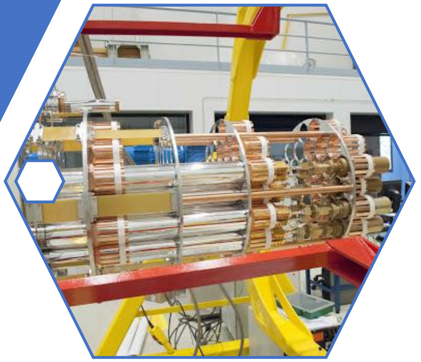
SPACE

HERSCHEL (PACS, SPIRE)

PLANCK (LFI)

EUCLID (NISP)

SOHO (GOLF)



IACTEC – Space main goals:

- Take profit of IAC expertise in order to train a multidisciplinary team with the capability of developing compact payloads for small satellites
- Create a business network on the Space Sector in the Canary Islands

See talk by I. Bustamante!

3. A science case related to IAC observatories

- The IAC observatory at La Palma will host the northern **Cherenkov Telescope Array (CTA)**
- A **CubeSat constellation** could be an **immediate alert system of GRBs** for this and other ground observatories worldwide, with **almost full-sky FoV** and **precise location of source by triangulation.** Current gamma ray satellites are working beyond its lifetime
- 9 x 3U CubeSats ~ **5M €** (Fermi telescope ~ 690 M USD)
- Several formation-flying CubeSats could also **complement observations of gamma-ray sources** (blazars…) in multi-wavelength, follow-up mode

4. Future prospects

On the Verge of an Astronomy CubeSat Revolution

Evgenya L. Shkolnik

CubeSat Astronomical Telescopes and Research in the 2020s

White Paper submitted to the National Academies Astro 2020 Decadal Study, July 10, 2019

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