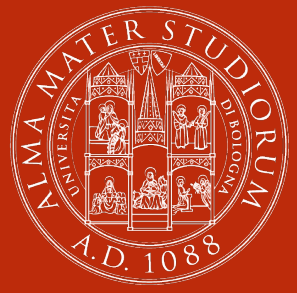
Astronomical Instrumentation Master Theses



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

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2023/2024

Dipartimento di Fisica e Astronomia

Astronomical Instrumentation Intro

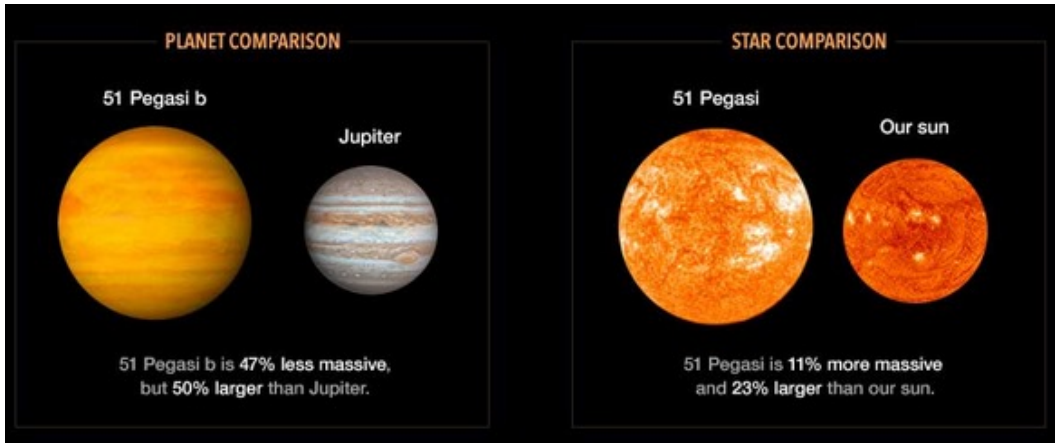
1. The «Navile» campus
    1. Unique concentration of astrophysical research: theory, observations and *instruments development*
    2. **UniBo/DIFA** Astrophysics section of the Deptarment of Physics and Astronomy
    3. **INAF-OAS** Observatory for Space Astrophysics
    4. **INAF-IRA** Institute for Radioastronomy
    5. **CTA-HQ** headquarters of the Cerenkov Telescope Array

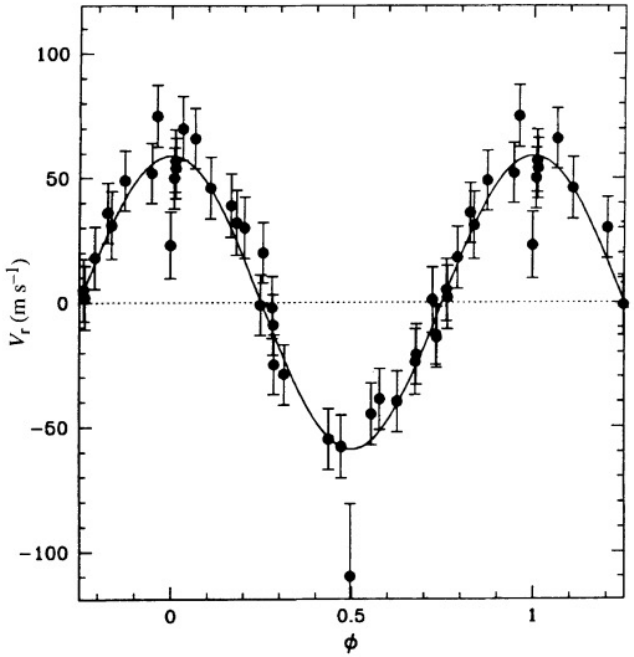
2. All areas of astrophysics research are represented, in a multiband approach

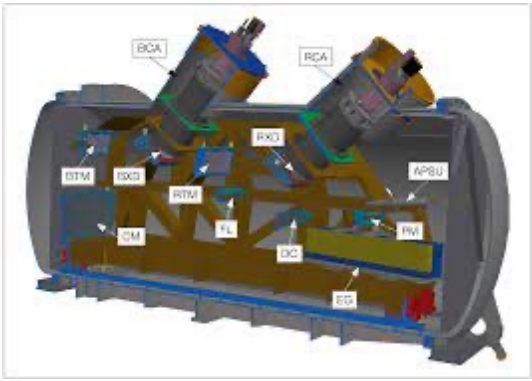
3. Astrophysics is a science which heavily depends on our ability to make precise measurements of the astronomical phenomena
    1. All major knowledge breakthroughs in astronomy are associated with the development of more advanced instrumentation or novel ways to use instrumentation to achieve a quantitative improvement of observations
    2. Obvious example: Galileo's telescope

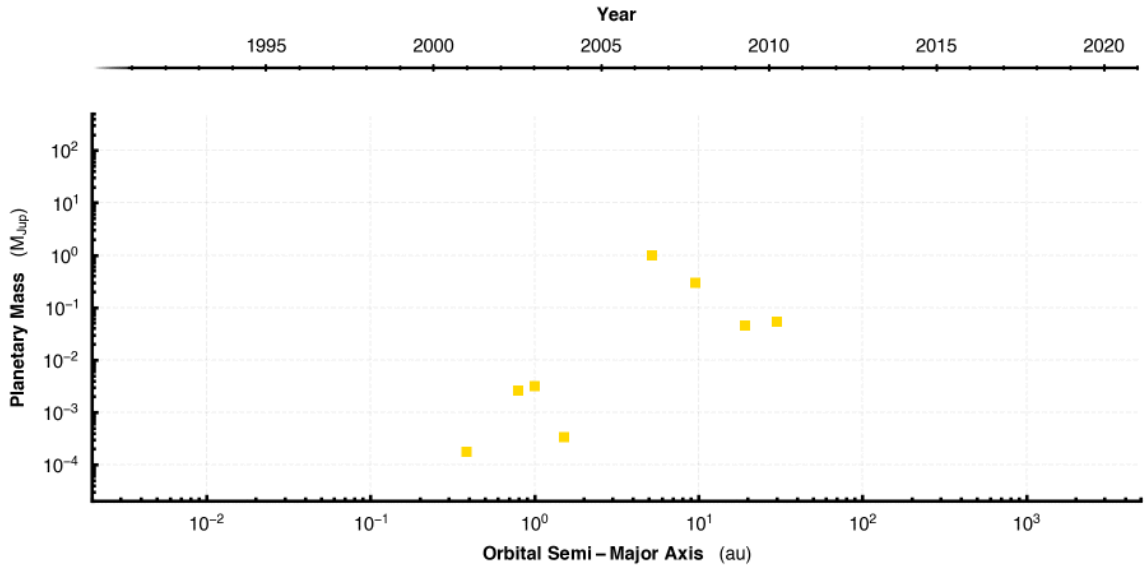
Some modern examples

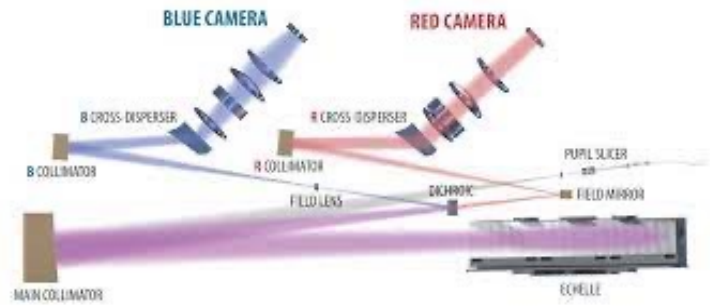
The discovery of Exoplanets
(Mayor e Queloz Nobel prize 2019)





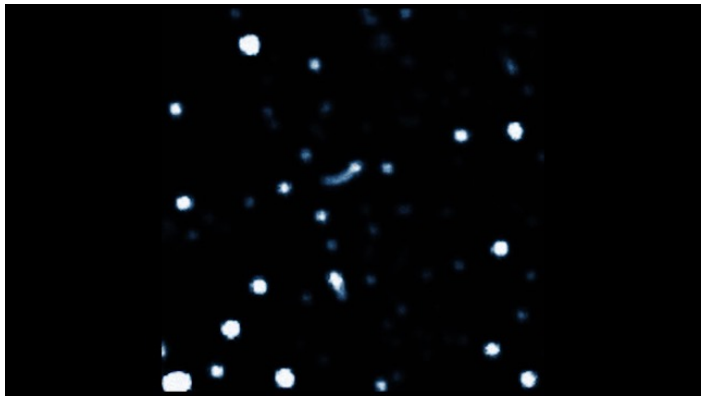


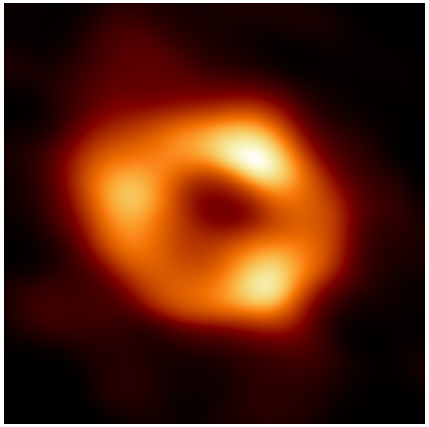


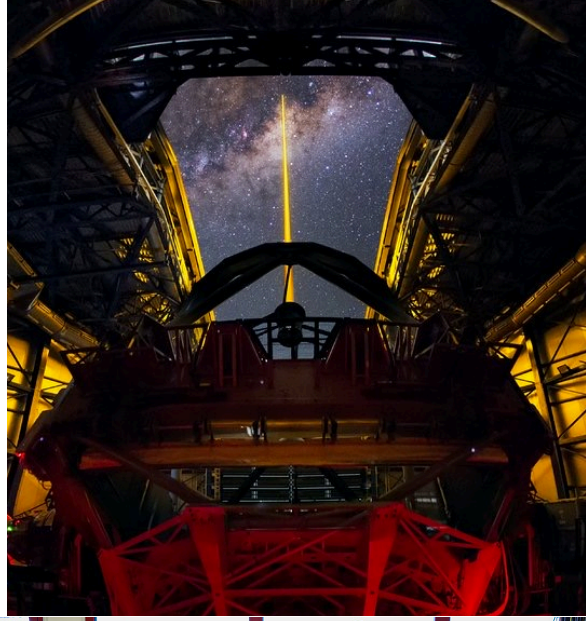


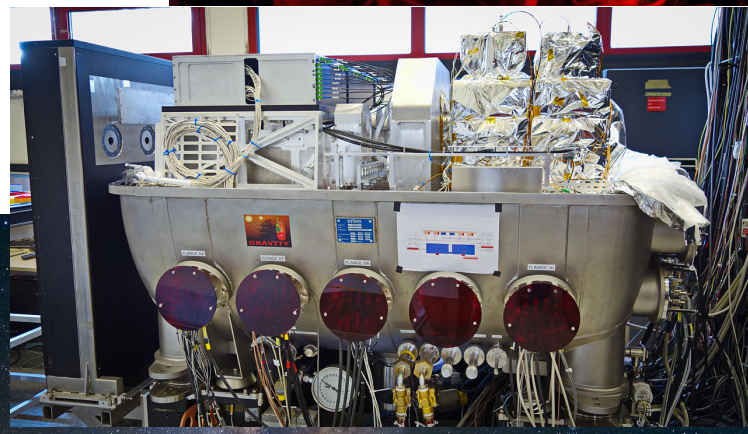
Some modern examples

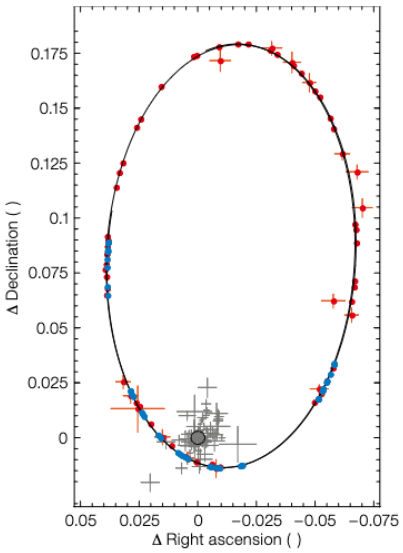
Supermassive Black Hole at the centre of the Galaxy (Genzel & Ghez Nobel prize 2020)

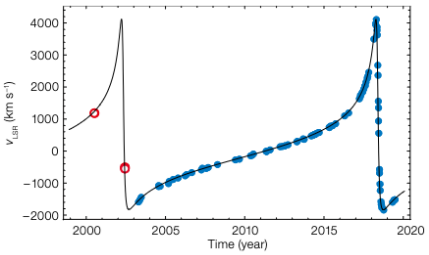


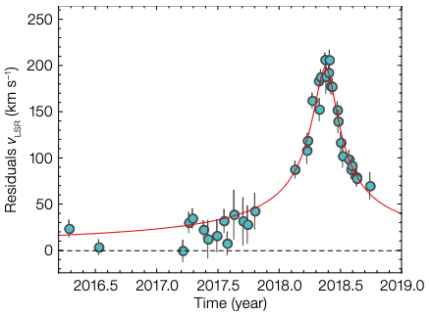












Astronomical Instrumentation Theses Topics

1. Instrumentation related theses in Bologna
    1. Microwave technologies – INAF-OAS/DIFA LTA/Cryowaves
        1. Villa, Cuttaia, Morgante, Terenzi => Next slides
    2. Radioastronomy technologies – INAF-IRA (from Medicina to SKA)
        1. Monari, Naldi, Pucillo
    3. High Energy Technologies – INAF-OAS HEA payload construction
        1. Amati, Campana, Virgili => Next slides
    4. Cerenkov Telescope Array – CTA-HQ telescopes, detectors, strategies
        1. Zanin => See dedicated presentation
    5. Adaptive Optics for Large Telescopes – INAF-OAS/DIFA LTA/Morfeo
        1. Rodeghiero => See dedicated presentation

2. INAF-OAS and INAF-IRA are major players in:
    1. Development of satellite payloads for high energy and microwave astrophysics
    2. Advanced astronomical instrumentation for ELT
    3. ALMA receiver development
    4. SKA and other cm and long wavelength radio observatories
    5. Standing collaboration with INAF-Merate on technology development

THESES and beyond
(specific arguments depend on period and project status)

- **Work in CRYOWAVES projects both with hardware and software modelling**
  - **LSPE-STRIP**
    - system testing (execution, setup, procedures, analysis codes)
    - Telescope modelling (i.e. alignment, thermo-elastic deformations, beam simulations)
    - Telescope Assembly Integration and Verification (AIV)
    - Calibrator assembly and testing
    - Thermal model of STRIP and of the Calibrator of STRIP
  - **SOLARIS development and implementation**
    - receiver design and component optimization
    - Receiver prototype integration and observations with Milano Telescope and/or Testa Grigia Telescope (Valle d'Aosta)
    - Design of the receiver and telescope optimisation for Antartica (Mario Zucchelli base and Dome-C)
  - **ARIEL**
    - Simulations/experimental characterization of the Big cryofacility for ARIEL telescope's mirrors
  - **THESEUS - IRT (InfraRed-Telescope)**
    - Modelling and simulation of the thermal behaviour of the telescope assembly for the IRT
  - **ALMA**
    - Concept and feasibility studies of microwave and cryogenics facilities for testing ALMA receiver components
    - Characterization at microwaves and mm-waves of materials and components for future ALMA upgrades

Possible exam topics

Soft / hard X-ray detectors

– **Interaction of radiation with matter**: photoelectric, Compton effects and pair production;

– **Scintillator** crystals: materials, main properties, use in astrophysics experiments. Photomultipliers;

– **Solid-state detectors**: basic principles. Comparison between ideal and real detectors ;

– **Silicon Drift Detectors**: main principles and use in present and future astrophysics experiments. The *siswich* principle.

– The **THESEUS** mission: science objectives and innovative technologies;

– Detection of Gamma-Ray Bursts (GRBs) with the **HERMES** constellation;

X-ray telescopes

– **Imaging techniques for X-ray astrophysics**: spatial modulation with coded masks;

– **Grazing incidence** for X-ray astronomy: Wolter I telescopes for X-ray astrophysics in the last century;

– Methods for making X-ray **mirrors** and supermirrors;

– **Lobster eye** telescopes: basic principles;

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