INAF ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS

Audizione RSN2-May 16th 2022

HELAS
The modern era of Asteroseismology

Main correlated **'schede progetto INAF'** are:

- Properties of stars with exoplanets (PI: K. Biazzo)
- PLATO - M3 ESA (PI: I. Pagano)
- Architecture and physical properties of planetary systems (PI: A. Sozzetti)
- Stellar activity and dynamo theory in the era of precision astrophysics (PI: A. Bonanno)
- Hot subdwarfs and white dwarfs: Pulsatons, Binaries and Planetary Systems (P.I.: R. Silvotti)

UNIVERSITÀ DI PISA

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

HELAS

In 2005 INAF was co-founder of
HELAS the European Helio- and Asteroseismology network

- **2006-2010**: FP6- Infrastructure Coordination Action - (PI: M. P. Di Mauro)
- **2013-2017**: FP7-Cooperation-SPACE-2012-1,SPACEINN (P.I. Ennio Poretti)

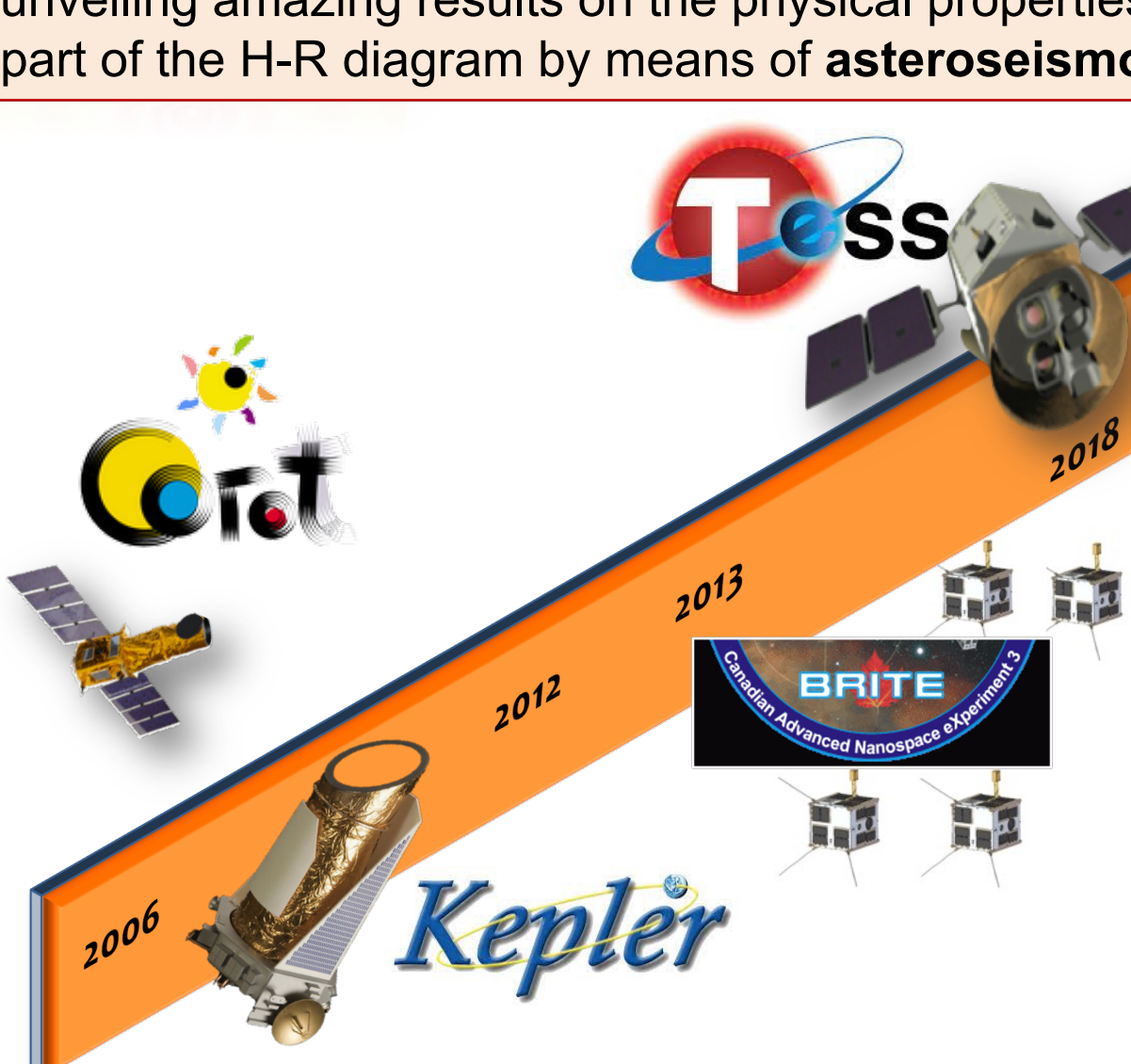
TEAM INAF 2022

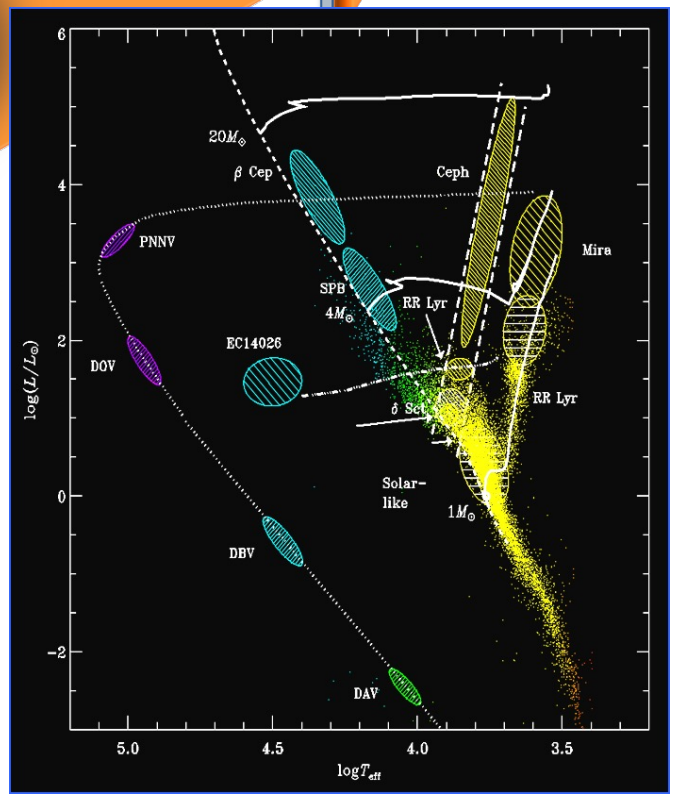
Institute	Personnel in the 2022 (21)
IAPS Roma	Di Mauro M. P., Maceroni C., Alberti T.
OA Abruzzo	Cassisi S.
OA Catania	Bonanno A, Catanzaro G., Corsaro E., Ventura R.
OA Brera	Poretti E. , Rainer M.
OA Capodimonte	Leccia S., Marconi M., Ripepi V.
OA Torino	Silvotti R.
OA Padova	Claudi R.
OA Palermo	Benatti S.
Università di Roma Tor Vergata	Berrilli F., Giovannelli L., Reda R.
Università di Bologna	Miglio A.
Università di Pisa	Degl'Innocenti S.

14 TI INAF + 1 TD INAF=
10 FTE accertate tra 2022-2024

The modern era of asteroseismology

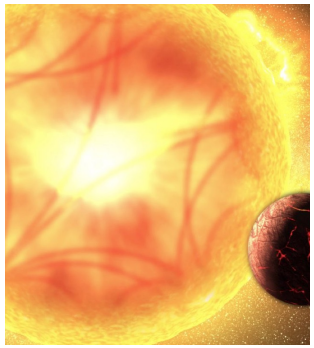
Space photometry has produced an extraordinary revolution in astrophysics, unveiling amazing results on the physical properties of the stars over a large part of the H-R diagram by means of **asteroseismology.**





Scientific results

Stellar pulsations opened a new window for investigating stellar structure and physics



- **Characterization of stars:** Accurate Mass, Radius, Age of thousands of stars ➔ characterization of exoplanets

Internal dynamics (in solar-like, WD and sDb), core properties, diffusion of elements, overshooting, new understanding of variation of masses for Cepheids and RRL, rotational syncronitazion of sDb in binaries

- **Galactic archaeology: map of our galaxy** and use of stars as fossils to reconstruct the chemo-dynamical history of the Galaxy

- **Study of the magnetic activity cycle, dynamo, convective properties**

Synergies and Expertises

Analysis of photometric data

Single stars, binary systems, planetary systems, field stars and clusters

- **Solar-like stars (stochastic pulsations)**
- **Delta Scuti, Gamma Doradus (self-excited)**
- **Classical pulsators**
- **Compact oscillators**

Characterization of stellar properties

Fast automated codes for extraction of oscillation parameters and analysis of the light curves

FAMED™ PIPELINE

Python and IDL codes for the extraction of oscillation mode parameters
https://github.com/EnricoCorsaro/FAMED

DIAMONDS™ BAYESIAN SOFTWARE

C++ code for the fitting of granulation activity and other non-oscillatory signal
https://github.com/EnricoCorsaro/Background

Stellar models by accurate and update evolutionary codes

BaSTI collaboration (a Bag of Stellar Tracks and Isochrones) are collected in http://basti-iac.oa-Abruzzo.inaf.it

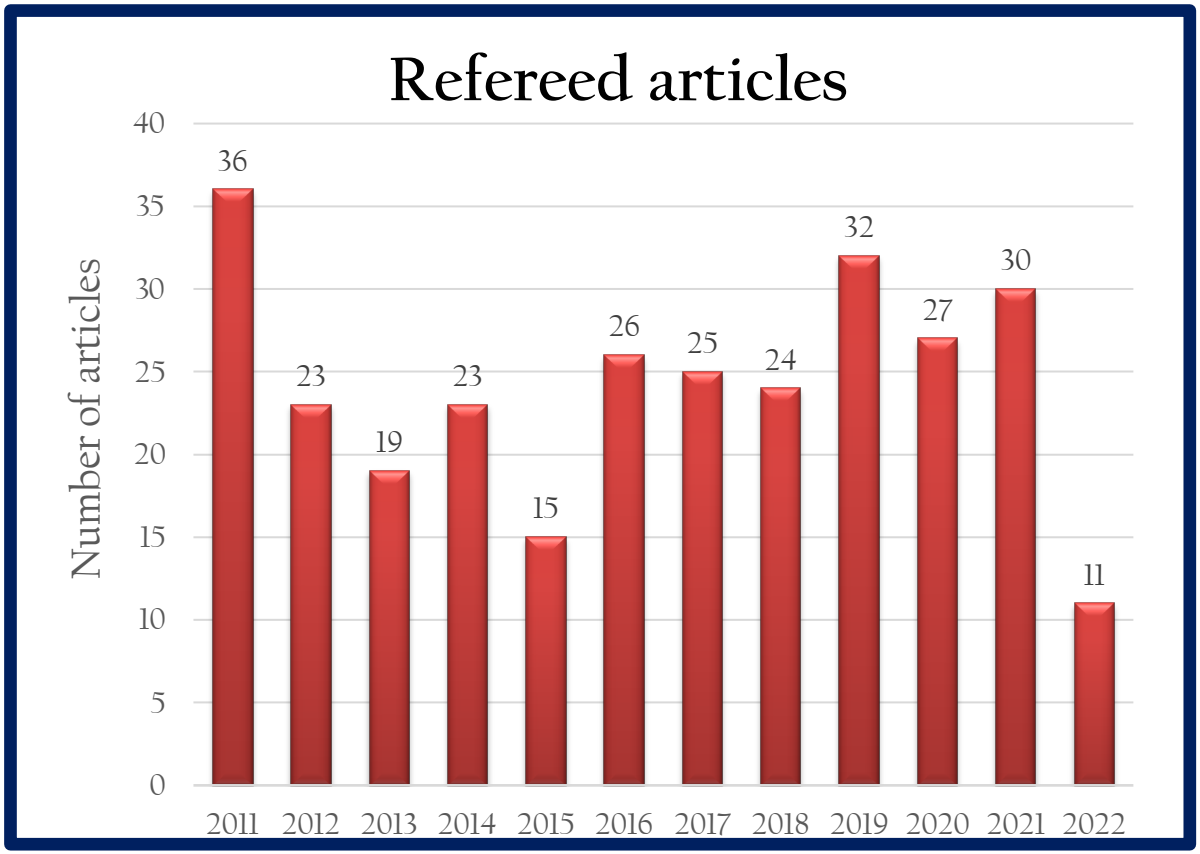
Pulsations models

Tools for interpretation of oscillation spectra (e.g. inversion codes)

Spectroscopic analysis of stellar atmospheres SISMA, LAMOST, APOGEE

Track records

- Group visibility: https://asteroseismology.iaps.inaf.it
- Stellar models: http://basti-iac.oa-Abruzzo.inaf.it
- Galactic archaeology: https://www.asterochronometry.eu



Statistics

Average ➡ 30 ref art/year
Invited talks ➡ 10/year
Review ➡Tot 50 since 2011

Collaborations

- University of Aarhus (DK)
- University of Birmingham
- IAC Tenerife
- University of Graz
- University of Warsaw
- University of Sydney
- CEA Saclay: Gif-sur-Yvette, Île-de-France, FR
- Observatoire de Paris
- Etc.…

Leadership

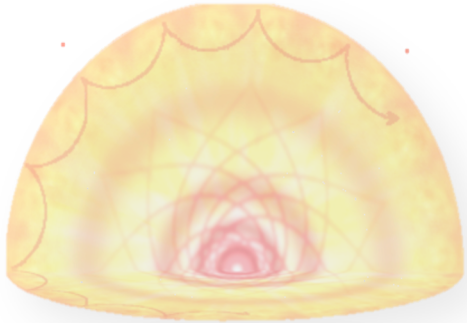
- **Leading presence in any international project**

- **Tens of approved observational proposals every year**
  - **KASOC (Kepler Asteroseismic science operation center)**
  - **TASOC (TESS Asteroseismic science operation center)https://tasoc.dk**

EU Horizon 2020 grants

- **ERC Consolidator Grant**: "Asterochronometry: Galactic archeology with high temporal resolution" Project ID: 772293, awarded **by A. Miglio**
- **Marie Sklodowska-Curie grant 'ASTROFIT'** agreement n. 664931, awarded by **E. Corsaro**

IAU **M. P. Di Mauro and M. Marconi elected members of Commision G4, Pulsating stars**



Future perspectives

PLATO 2.0 (ESA , launch 2026) to detect and characterize planets around **bright** solar-like stars . Seismology of 85000 stars → Stellar radii and masses (~2%) and ages (~10%).
PI of WPs of Stellar Science : S. Cassisi, A. Miglio

SONG (Stellar Oscillations Network Group) Danish initiative for a global network of small telescopes. At each site: 4 telescopes of 50cm diameter with highly efficient spectrograph. **CoPI: E. Corsaro**

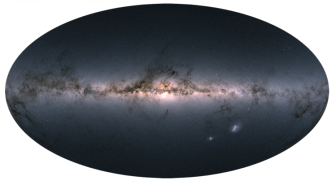
High-precision Asteroseismology in Dense stellar fields ESA Voyage 2050 Call, July 2022 deadline to submit Phase-2 proposal!
PI: A. Miglio, L. Girardi

Challenges for the future

✧Galactic archaelogy

combining asteroseismic data with radial velocity and stellar position

Gaia
astrometry



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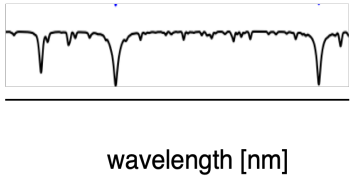
spectroscopy



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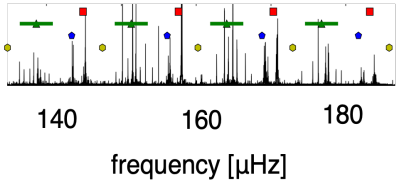
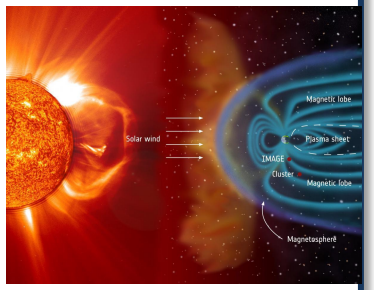
asteroseimology



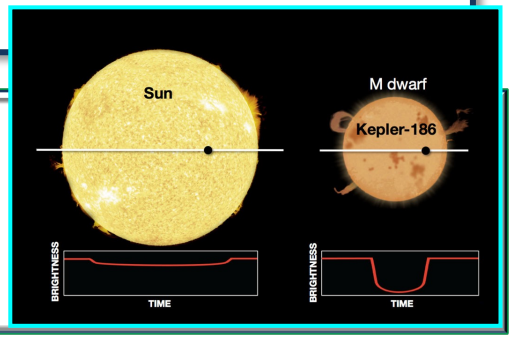
✧Exoplanets characterization, analysis of star-planet interaction and habitability

combining asteroseismology with space-weather techniques
analysis of the effect of the stellar magnetic activity on the exoplanets



✧ M dwarf stars very low-mass stars M≤0.5M$_\odot$

M dwarfs comprise ~70% of all stars in the Galaxy,
Oscillations have not yet been identified in these stars



Criticalities

Number of asteroseismologists	2005	2022
In the world	300	697
In Italy	26	21

Despite the plain international acknowledgment and the results obtained, financial support has not been assured for the period 2022-2024

PLATO 2.0 ESA ➡ launch 2026

plato

✧ We need to consolidate the consistency of the group

✧ High risk of loosing the reached and recognized expertise and experience

✧ Mantaining visibility