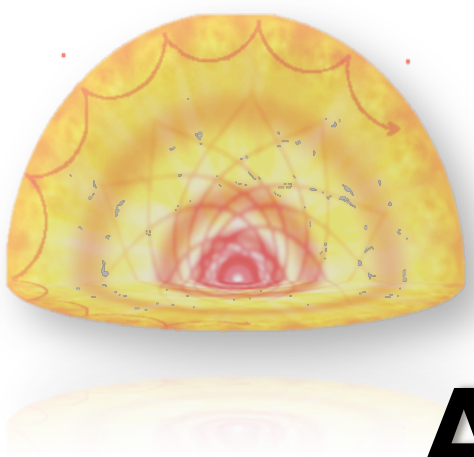
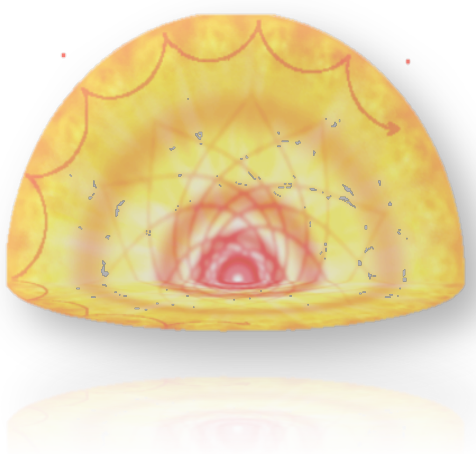


# Asterosismologia presente e futuro

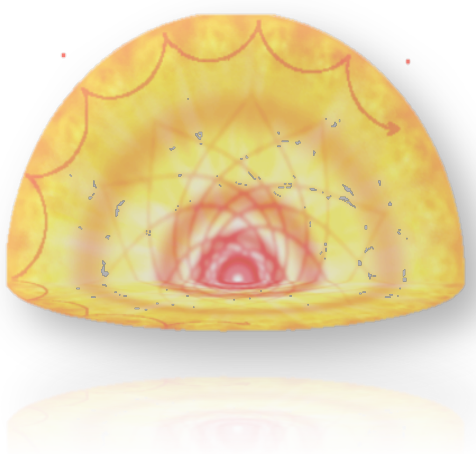
Studio
della struttura ed evoluzione delle stelle
per mezzo delle oscillazioni
osservate sulla superficie



# Asterosismologia

## In Italia

| Personale coinvolto nel 2010 (22) | Sedi INAF |
|---|---|
| **Cardini D., Di Mauro M. P.** | IAPS Roma |
| **D'Antona F., Maceroni C., Ventura** P. | Osservatorio Astronomico di Roma |
| **Bonanno** A., **Catanzaro** G., **Ventura R., Leone F., Paternò** L. | Osservatorio Astrofisico di Catania |
| **Poretti E.** , **Rainer** M., **Antonello E., Bossi** M.,**Mantegazza** L | Osservatorio Astronomico di Brera |
| **Marconi** M., **Ripepi** V. | Osservatorio Astronomico di Napoli |
| **Silvotti** R. | Osservatorio Astronomico di Torino |
| **Claudi** R., **Benatti** S. | Osservatorio Astronomico di Padova |
| **Degl'Innocenti S., Prada Moroni G.** | Università di Pisa |
| | |



# Asterosismologia

## In Italia

| Personale coinvolto nel 2016 (19) | Sedi INAF |
|---|---|
| **Di Mauro M. P.** | IAPS Roma |
| **D'Antona F., Maceroni C., Ventura** P. | Osservatorio Astronomico di Roma |
| **Bonanno** A., **Catanzaro** G., **Ventura R.,** | Osservatorio Astrofisico di Catania |
| **Poretti E.** , **Rainer** M., **Antonello E.,** | Osservatorio Astronomico di Brera |
| **Marconi** M., **Ripepi** V. | Osservatorio Astronomico di Napoli |
| **Silvotti** R. | Osservatorio Astronomico di Torino |
| **Claudi** R., **Benatti** S. **, L. Girardi** | Osservatorio Astronomico di Padova |
| **Degl'Innocenti S., Prada Moroni G.** | Università di Pisa |
| **Montalban J.** | Università di Padova |

# HELAS Community

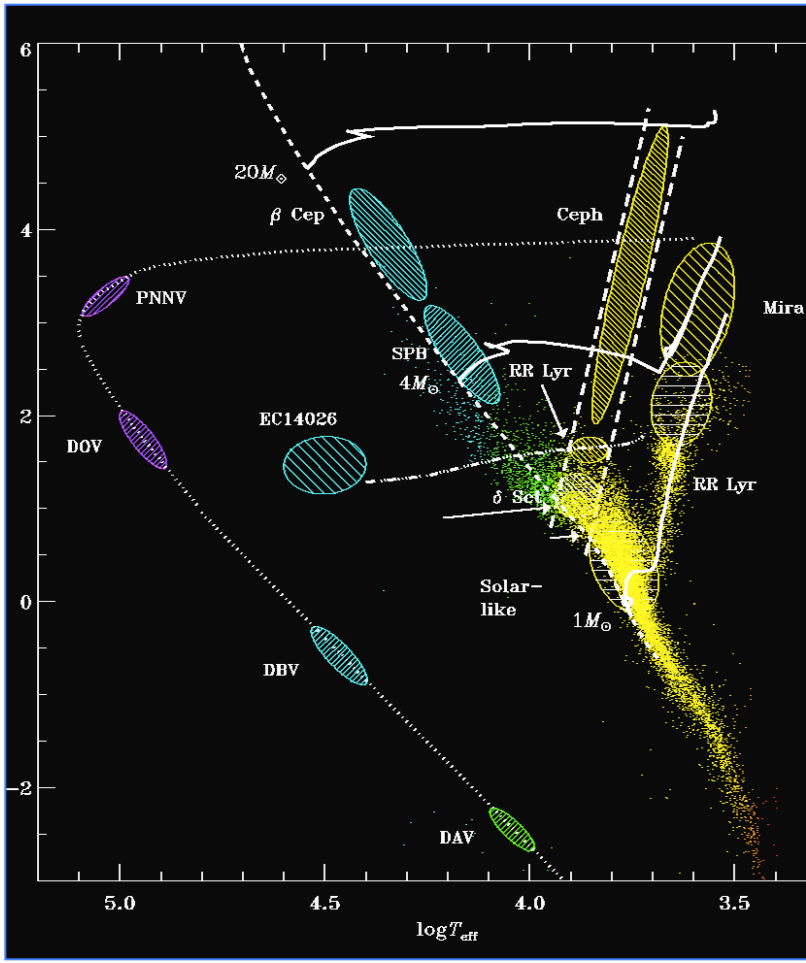
**300 scientists worldwide registered to participate in HELAS European Helio- and Asteroseismology network**

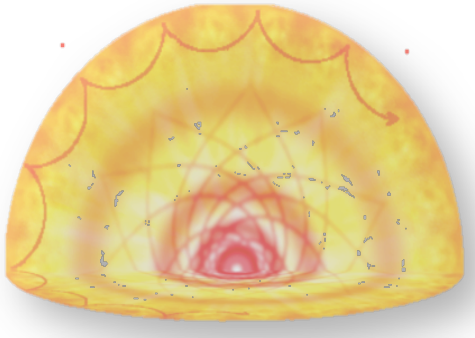

7% Italian community

# Pulsating stars

Italian community is expert of stellar oscillations detected over large part of the H-R diagram, in each stage of stellar evolutionary phase

| Type | Period | Excitation | Modes |
|---|---|---|---|
| roAp | 6-15 min | κ mechanism | p with high n , high l |
| SPB and γ Doradus | 10h-7 d | κ mechanism | g with high n low l |
| SdB | 100-400s 0.5-2h | κ mechanism | p and g |
| WD | 100-1000s | κ mechanism | g with low l high n |
| ELM WD | 20 min-2h | κ mechanism | g mode (may be also p) |
| δ Scuti | 1-3 h | κ and solar-type | p,g,mixed |
| β Cephei | 3-7 h | κ mechanism | p |
| Solar-type | 100s-2d | convection | p,mixed |

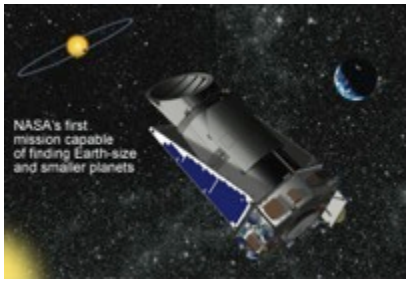




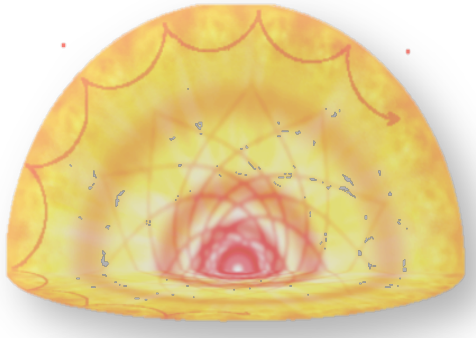
# Space photometry


**CO**nvection **RO**tation and planetary Transits

French leading, (2006-2012) various types of stars. **The satellite revealed that 50% stars are much more variable than thought**+239 planets




**KEPLER (NASA)** – search for extra-solar planetary systems, particularly Earth-like planets using transit technique. Continuous monitoring over 100,000 stars, with a 30-minute cadence. 512 stars observed with a 1-minute cadence. 2326 **planets discovered, asteroseismology of exo-planet hosts** (2009-2012)



# Space photometry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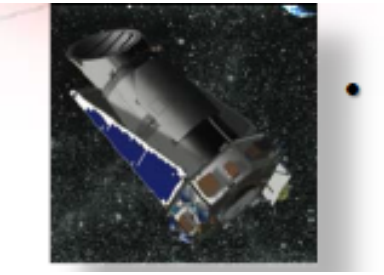
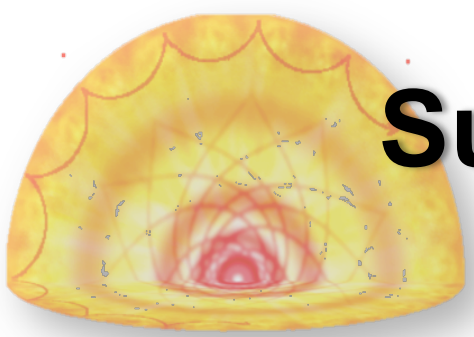


- **K-2 (Kepler 2) (NASA)**

**observe fields in the ecliptic plane for ~80 days/field**

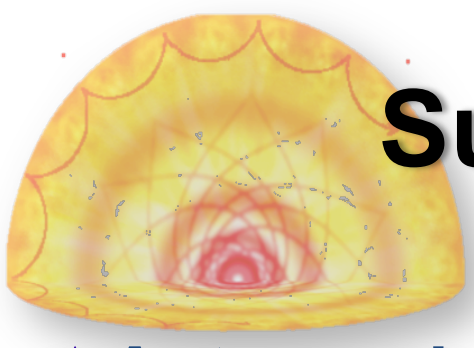
**Extended to 2018, 28345 long cadence targets and 138 short cadence targets**



# Successi dell'ultimo decennio

## ★Solar-like stars:

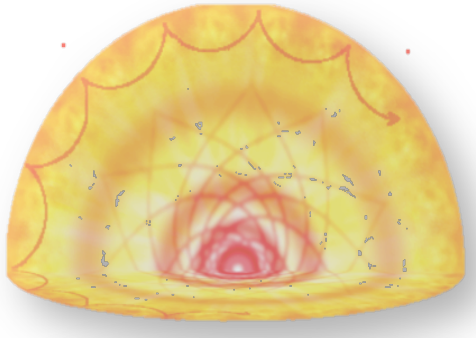
- **Existence of g and mixed modes**
- **Red giants:** Age (shell burning and He core burning phase) and internal rotation
- **Characterization:** Mass, Radius, Age of thousands of stars (scaling relations with Teff and L)➔characterization of exoplanets
- **Galactic archaeology: map of our galaxy** (see L. Girardi talk)
- **Other things that have turned out to be measurable** (core properties, CZ depth, overshooting)
- **Magnetic activity cycle** (faculae and spots variation)
- **Internal magnetic field** (some stars with suppressed dipolar modes)



# Successi dell'ultimo decennio

- **Asteroseismology of binary systems**
  1. better precision in determination of parameters, several binaries with red giants
  2. Strange behavior of oscillations in giants probably due to tidal effects
- **Gamma Doradus-delta Scuti stars**
  1. PMS-relation $\nu_{max}$ and age ➔age of associations
  2. MS-mixed behaviour (solar –like and high amplitude pulsators)
- **Discovery of Extremely Low Mass WD pulsators**

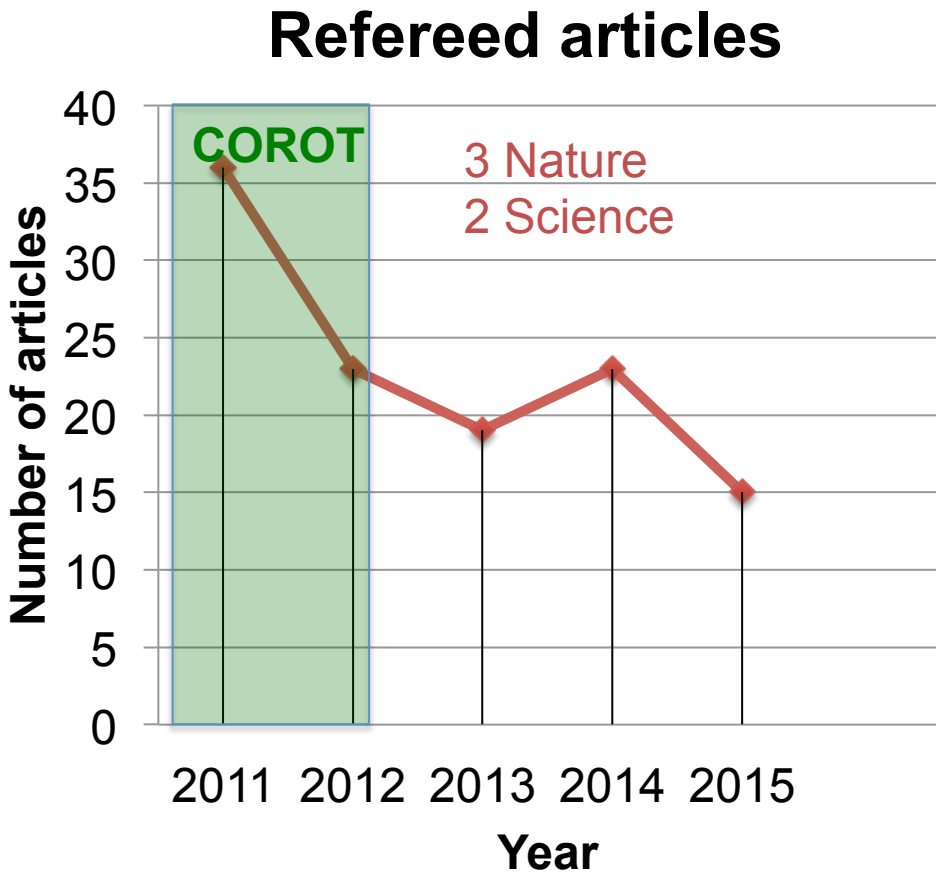
prolungamento fascia di instabilità delle ZZ Ceti (DAVs) (0.2M, nucleo solo He, in binary system) hanno modi g di periodo molto lungo



# Results

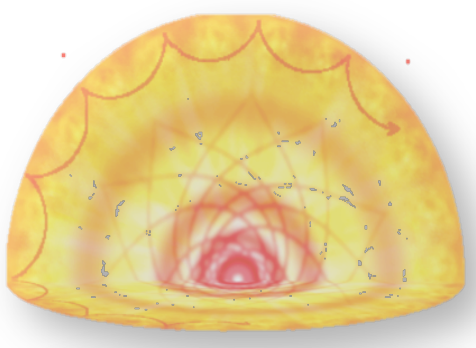
- **Leading presence in any international project**

- **Approved proposal**
  - **-Large Programme ESO** (HARPS 45 notti 2012/2013 per COROT targets)
  - **-HARPS–N (GAPS)**
  - **-Osservatorio di Loiano**
  - **-Osservatorio di Serra La Nave**




**Group visibility:**

**-www.iaps.inaf.it/asteroseismology/**

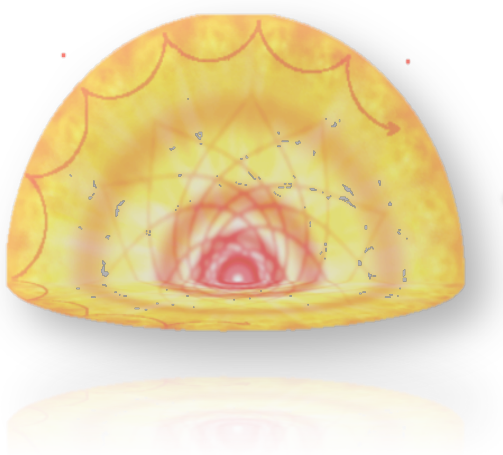


# Funding

## In the past

- **2015-2017:** PRIN INAF 2014, L. Girardi
- **2010-2017:** ASI PLATO 2.0 o n. I/044/10/0
- **2013-2017**: FP7 RESEARCH INFRASTRUCTURES 'SOLARNET'
- **2013-2016**: FP7-Cooperation-SPACE, SPACEINN Poretti E.

- **2006-2010:** FP6-InfrastructureCoordinationAction-'HELAS, M. P. Di Mauro
- **2007-2010:** ASI INAF su COROT
- **2011-2014:** PRIN INAF 2010 Poretti E.
- **2007-2009:** PRIN INAF 2006 Paternò L.
- **2004-2006**: PRIN MIUR 2004 Paternò L.
- **2002-2004:** COFIN- MIUR 2002 Paternò L.



# Funding

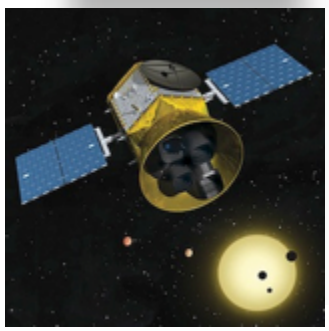
## In the future

**2016:** **H2020-HELAS Integrating activity** just submitted (Poretti E.)

# Science for the future

- **Stellar-Sun synergy** -Is the Sun peculiar or its properties are common?
- **Exoplanets characterization**
- **Map of our galaxy** (combining asteroseismic data with radial velocity and stellar position)
- **Understanding magnetic activity**
- **Convection (3D stellar models? )**
- **Low mass stars**
- **Massive stars of spectral type F and O**
  Fast rotators and g mode pulsators

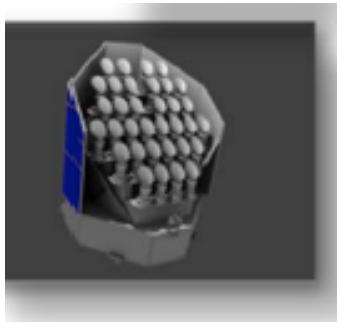
# The future perspectives



**TESS (NASA, launch 2017):** **scan the whole sky, ~1 month/field**
**~2% of sky at poles for 1 year**

It will discover thousands of planets around bright stars (cool dwarf of spectral type K and M), but blind to earth like size planets

**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



**PLATO 2.0** (ESA , launch 2024) to detect and characterize planets around **bright** solar-like stars . Seismology of 85000 stars → **Stellar radii and masses (~2%) and ages (~10% ).** Good also **for WD seismology** thanks to time resolution (see I. Pagano talk)- **Sinergies with GAIA results**