haydn

high-precision asteroseismology in dense stellar fields

Andrea Miglio, Léo Girardi
on behalf of the core proposing team

European Research Council
Established by the European Commission

ASTERO CHRONOMETRY

UNIVERSITY OF BIRMINGHAM | SCHOOL OF PHYSICS AND ASTRONOMY

INAF
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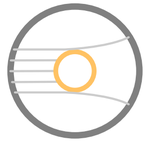
HAYDN: THE CONTEXT

- stars are formidable physics laboratories
- our understanding of stellar structure and evolution underpins most of astrophysics

however

high-precision tests of stellar models limited, until…



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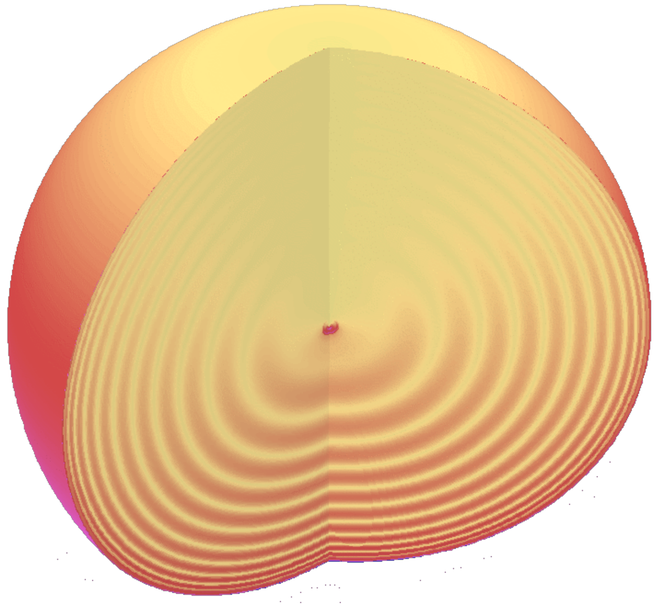


however

high-precision tests of stellar models limited, until…

the "space photometry revolution”

CoRoT, *Kepler*-K2, TESS

⇩

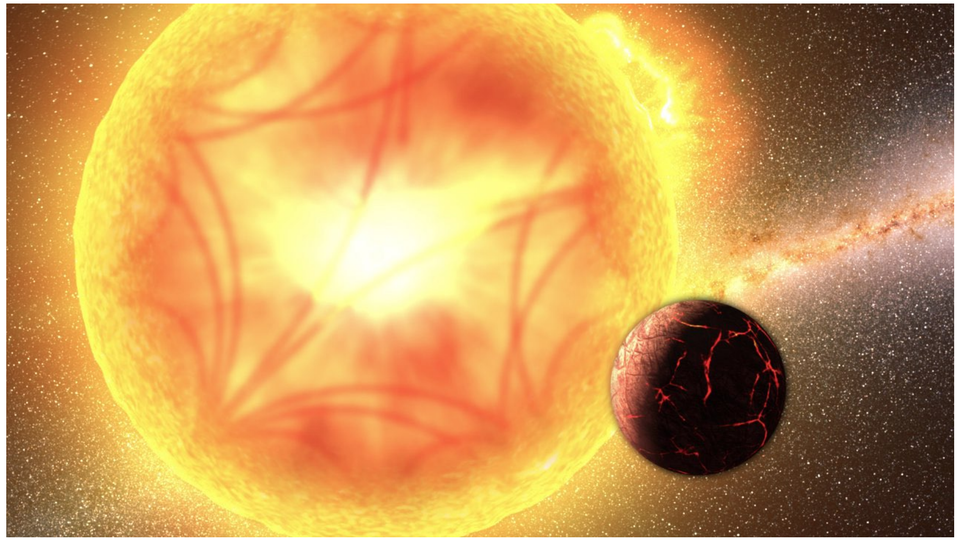
global, resonant oscillations detected in tens of thousands stars in the Milky Way

HAYDN: THE CONTEXT

the space photometry revolution: discovering the potential of asteroseismology

A. precise, accurate stellar properties (e.g. radius, mass, age)

- characterise exoplanetary systems



Credit: Gabriel Perez Diaz/Instituto de Astrofisica de Canarias

plato

M3 mission of ESA's Cosmic Vision

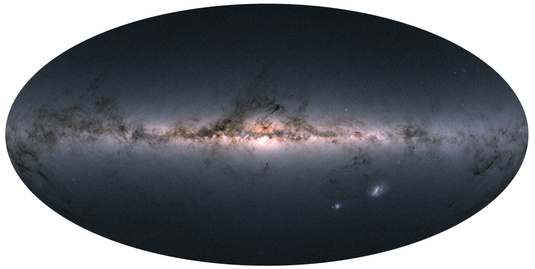
HAYDN: THE CONTEXT

the space photometry revolution: discovering the potential of asteroseismology

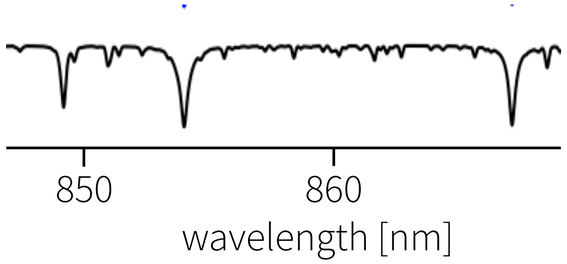
A. precise, accurate stellar properties (e.g. radius, mass, age to ~10%)

- use stars as fossils to reconstruct the assembly and chemo-dynamical history of the Galaxy

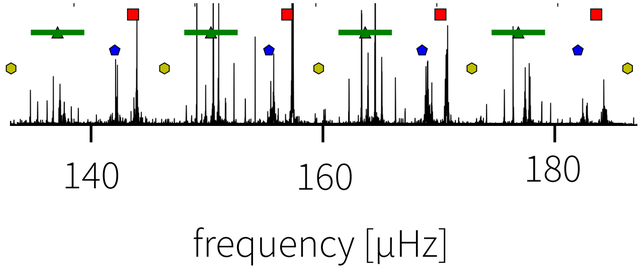
Gaia astrometry



spectroscopy



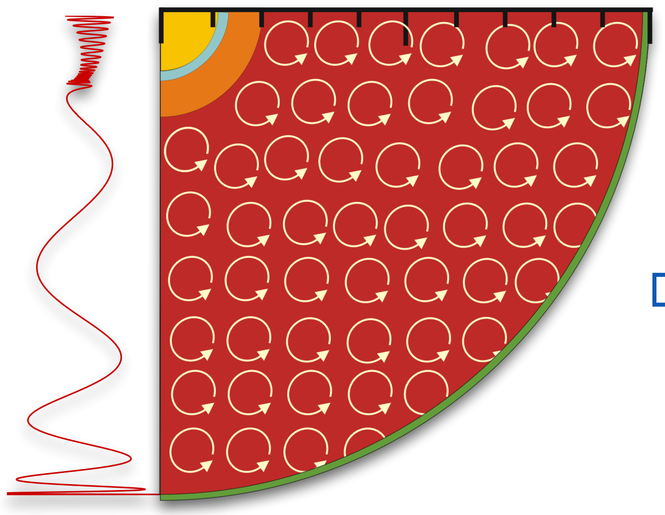
asteroseimology



HAYDN: THE CONTEXT

the space photometry revolution: discovering the potential of asteroseismology

B. high-precision stellar physics



e.g.

- chemical composition gradients
- density stratification
- internal rotational profile

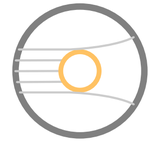
stellar interiors and their evolution accessible to our investigations

HAYDN: THE CONTEXT

- CoRoT, *Kepler*-K2 — have demonstrated the potential of asteroseismology (in clusters)
- TESS
- PLATO

— observational strategy not optimised for stellar / galactic science

designed primarily for planet searches: wide field, bright targets, large pixel sizes



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observational strategy not optimised for stellar / galactic science

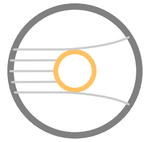
designed primarily for planet searches: **wide field**, **bright targets**, **large pixel sizes**

overcoming these limitations i.e.

obtaining *Kepler*-like observations in crowded stellar fields

⇩

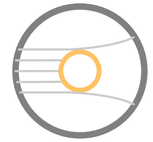
breakthroughs in stellar and Galactic science



HAYDN: SCIENCE GOALS

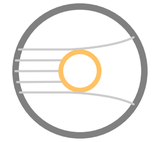
- having now a better understanding of the strengths and limitations of asteroseismology, we can propose a mission design that will lead to breakthroughs in three broad areas:

SG1	high-precision stellar astrophysics, especially in the metal poor regime
SG2	evolution and formation of stellar clusters
SG3	assembly history and chemical evolution of the Milky Way's bulge and few nearby dwarf galaxies.



HAYDN: SCIENCE GOALS

SG1 high-precision stellar astrophysics: need to perform tests in **controlled environments**, i.e. stellar open and globular clusters



HAYDN: SCIENCE GOALS

SG1 high-precision stellar astrophysics: need to perform tests in **controlled environments**, i.e. stellar open and globular clusters

- Transport of chemical elements in the stellar interior
- Core rotation and transport of angular momentum
- Mass loss on the RGB
- Occurrence of mergers / products of binary evolution
- Tests of fundamental physics

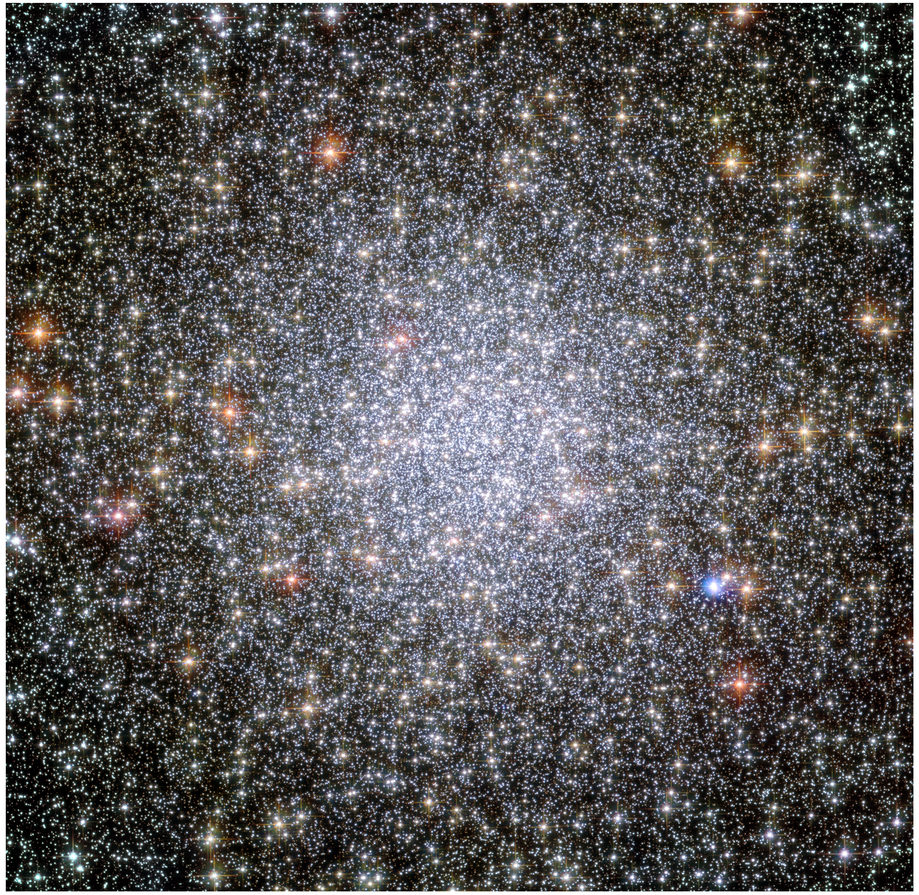
⇨ high-precision tests of stellar models, especially in the metal-poor regime (early Universe)

HAYDN: SCIENCE GOALS

SG2 evolution, formation and dynamics of stellar clusters

- Globular clusters formation from absolute ages
- Origin of multiple populations
- Measuring helium content in GCs with asteroseismology
- Redistribution of angular momentum from inclination of stellar spin axes

47 Tuc



NASA, ESA, and the Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration
Acknowledgment: J. Mack (STScI) and G. Piotto (University of Padova, Italy)

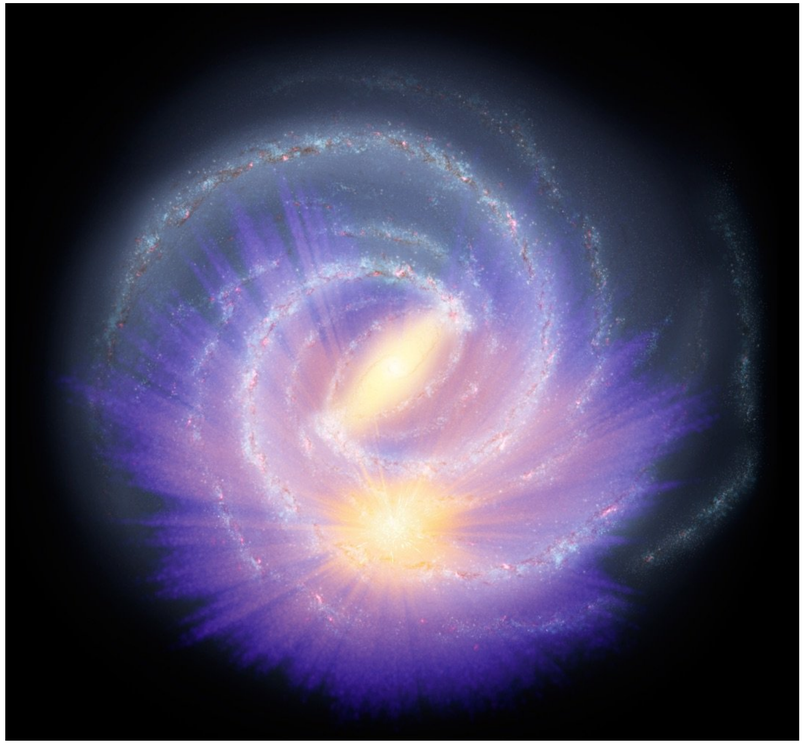
HAYDN: SCIENCE GOALS

SG3 assembly history and chemical evolution of the Milky Way's bulge and few nearby dwarf galaxies.

- key yet complex component: disentangle the composite bulge population and its formation history

- reconstruct star formation history of Sgr dSph and its interaction with the Milky Way

Gaia-based distances for ~200 million stars (Anders et al. 2019)



Credit: Data: ESA/Gaia/DPAC, A. Khalatyan(AIP) & StarHorse team;
Galaxy map: NASA/JPL-Caltech/R. Hurt (SSC/Caltech)

HAYDN: SCIENCE GOALS

complementary science

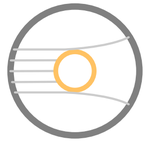
e.g.

- stellar activity
- exoplanets in clusters
- binaries
- microlensing events

HAYDN: MISSION PROFILE

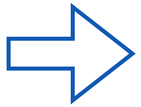
- suitable set of potential targets

Object name	d [kpc]	$m_{\mathrm{V,\,RC/HB}}$	[Fe/H]	Age [Gyr]	ang. size
NGC 104 (47 Tuc)	4	14	-0.8	13	$31'$
NGC 6121 (M4)	2.2	13	-1.5	12.2	$26'$
NGC 6397	2.4	BHB	-1.8	13.4	$32'$
NGC 2682 (M67)	0.9	10.5	0.0	4.5	$30'$
NGC 5139 (ω Cen)	4.9	14	broad	broad	$36'$
Bulge	6–10	$I > 14$	broad	broad	wide
Sgr dSph	25	18–20	broad	broad	$450' \times 216'$



HAYDN: MISSION PROFILE

- use the knowledge from previous/ongoing missions to translate

science requirements  possible mission profile

Mosser et al. 2019

HAYDN: MISSION PROFILE

- use the knowledge from previous/ongoing missions to translate

science requirements ⇨ possible mission profile

Mosser et al. 2019

- high-precision asteroseismic data define:

photometric noise

frequency resolution

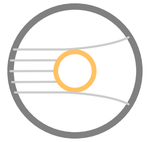
⇨

small field of view (< 1deg)

sub-arcsec pixel size

diameter of the collecting area (D)

duration of the observations (T)



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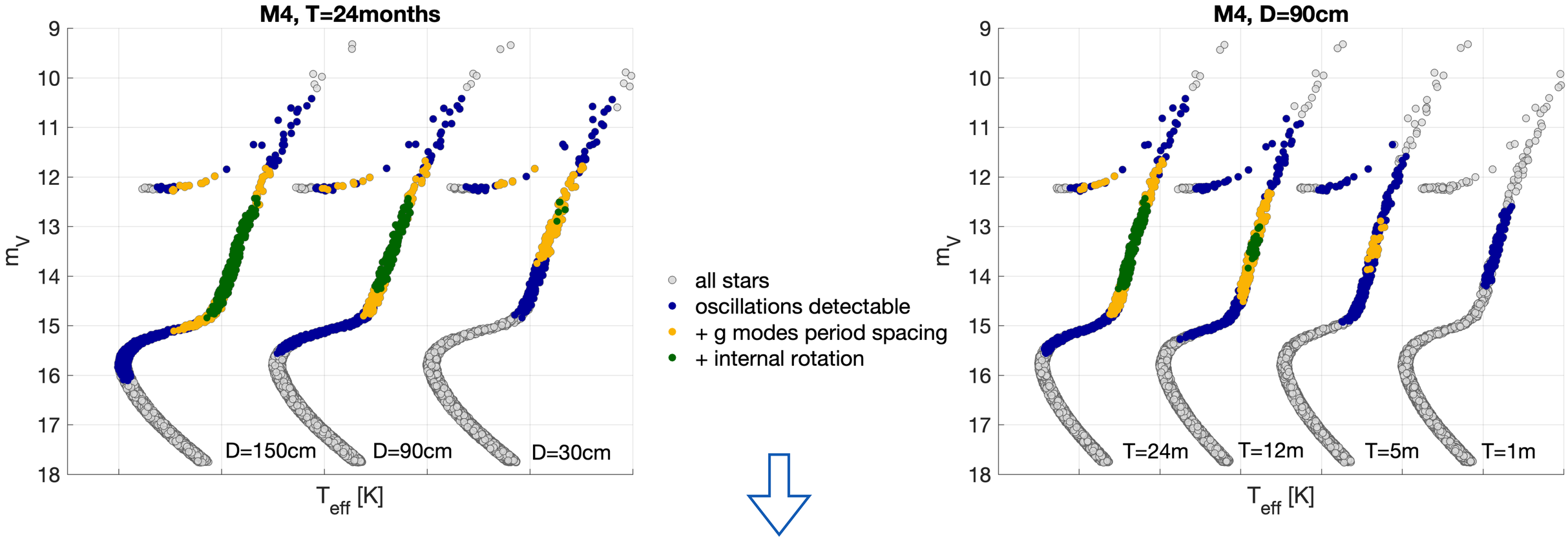
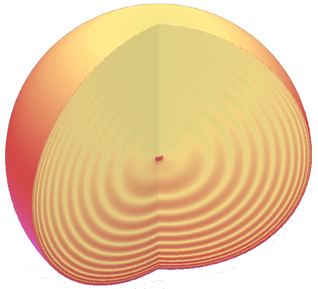


all science objectives achievable with D=90 cm and a combination of 6-24 months-long runs

SUMMARY

- relevance and potential of asteroseismology demonstrated by CoRoT, *Kepler*



  - ultimate tool to tests stellar physics
  - infer precise, accurate ages

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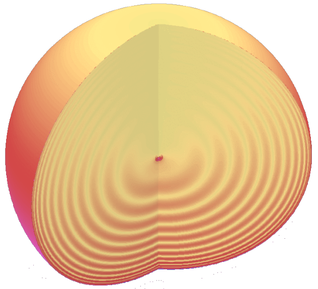

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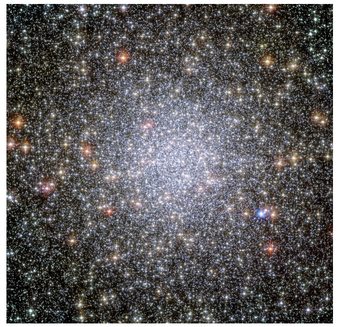
- simple mission concept would overcome limitations of past/current/planned missions



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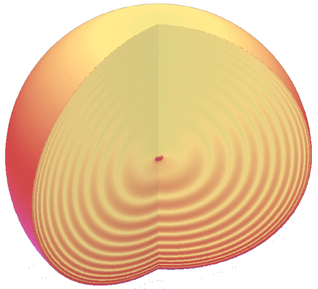

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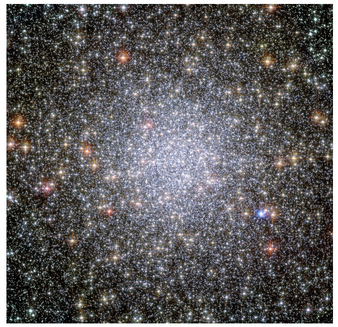


SG1 high-precision stellar astrophysics

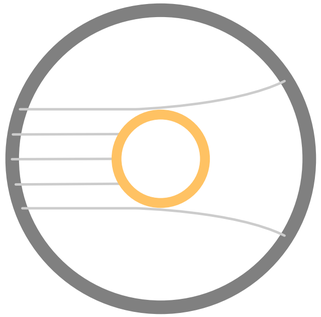
SG2 evolution and formation of stellar clusters

SG3 assembly history of the Milky Way's bulge and dwarf galaxies.

promote development of the next generation of stellar models

ensure continued European scientific leadership in these areas

haydn



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https://www.asterochronometry.eu/haydn

haydn@asterochronometry.eu

thanks to:

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Silvia Toonen
Amaury Triaud
Fiorenzo Vincenzo

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