

OAB E EXOPLANETS

E. Poretti

Interesse per gli exoplanets come diretta conseguenza di mutazioni scientifiche:

- Localmente: inizio della connessione fra osservazioni asterosismologiche e exoplanetarie in CoRoT (tesi di F. Borsa).

Il progetto SPACEINN (FP7-SPACE) chiude l'esperienza ed il lavoro fatto da OAB a sostegno di CoRoT. Prevede un archivio pubblico di oltre 7000 spettri HARPS@ESO (Assegno a Monica Rainer).

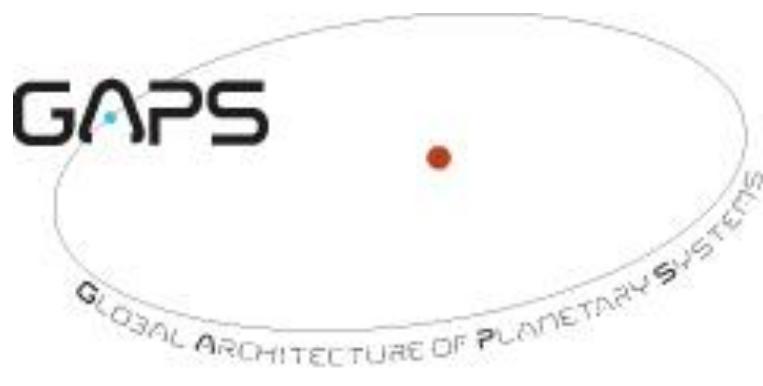
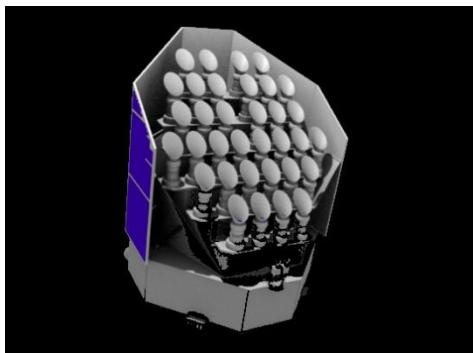
Tesi di laurea su exoplanets. Dopo F. Borsa (specialistica Bicocca+ PhD Insubria), A. Zannoni (triennale Statale con G. Lodato su ricerca candidati transiti) e G. Frustagli (specialistica Bicocca con M. Colpi su 'stellar jitter' + lavoro preparatorio ESPRESSO)

- A livello (inter)nazionale: progressivo inquadramento delle conoscenze dell'astrofisica stellare nello studio dei sistemi planetari.

OAB E EXOPLANETS

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- INSERIMENTO OAB IN **GAPS** (F. Borsa, M. Rainer, E. Poretti)
- PARTECIPAZIONE OAB NEL PREMIALE INAF **WOW** (Assegno a F. Borsa)
- INTERESSE TECNOLOGICO IN **ESPRESSO** (vedi F. Zerbi)
- INTERESSE SCIENTIFICO IN **ESPRESSO** (E. Poretti, ...)
- INTERESSE SCIENTIFICO OAB IN **PLATO** (E. Antonello, F. Borsa, E. Poretti, M. Rainer)
- INTERESSE TECNOLOGICO OAB IN **PLATO**, attraverso partecipazione Italiana nel Consorzio Europeo (S. Basso, M. Ghigo, D. Spiga)

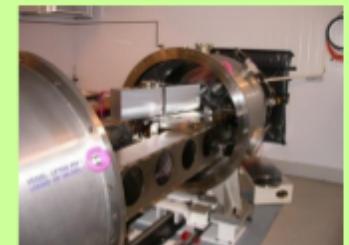


The GAPS Project

- **GAPS**, *Global Architecture of Planetary Systems*, is a long-term programme for the comprehensive characterization of the architectural properties of planetary systems as a function of the hosts' characteristics (mass, metallicity, environment).
- GAPS has been approved by Italian TNG TAC:
 - **AOT 26** (Aug 2012-Jan 2013): 36 nights
 - **AOT 27** (Feb 2013-Jul 2013): 40 nights
 - + long-term status → proposal approved for 2 years.
 - till Feb 2015



INAF Guidelines to TAC: to dedicate ~80 nights/year of TNG to a large coordinated effort of the Italian community willing to study exoplanets with HARPS-N.





The GAPS Team



~ 61 INAF and associated scientists in Italy;

~ 16 scientists from foreign institutes.

Wide range of expertise

- High resolution spectroscopy
- Stellar rotation and activity
- Crowded stellar environments
- Formation of planetary systems
- Planetary dynamics



GAPS Science Themes



Search for low mass planets orbiting M dwarfs

32.5%



Search for low mass companions in known
planetary systems

32%



Frequency of Neptune-mass
companions around Low [Fe/H] stars

12.5%



Search for GP orbiting stars
in crowded environments

15%

Characterization of
planetary orbits
through RML effect

6%

Asteroseismology
Star-Planet
Interaction

2%

The GAPS programme with HARPS-N at TNG*

I. Observations of the Rossiter-McLaughlin effect and characterisation of the transiting system Qatar-1***,***

E. Covino¹, M. Esposito^{2,19}, M. Barbieri³, L. Mancini⁴, V. Nascimbeni^{3,5}, R. Claudi⁵, S. Desidera⁵, R. Gratton⁵, A. F. Lanza⁶, A. Sozzetti⁷, K. Biazzo^{1,6}, L. Affer⁸, D. Gandolfi⁹, U. Munari⁵, I. Pagano⁶, A. S. Bonomo⁷, A. Collier Cameron¹⁰, G. Hébrard²¹, A. Maggio⁸, S. Messina⁶, G. Micela⁸, E. Molinari^{11,12}, F. Pepe¹³, G. Piotto^{3,5}, I. Ribas¹⁴, N. C. Santos^{15,16}, J. Southworth¹⁷, E. Shkolnik²³, A. H.M.J. Triaud^{13,24}, L. Bedin⁵, S. Benatti⁵, C. Boccato⁵, M. Bonavita⁵, F. Borsa^{20,26}, L. Borsato³, D. Brown¹⁰, E. Carolo³, S. Ciceri⁴, R. Cosentino¹¹, M. Damasso^{3,27,7}, F. Faedi¹⁸, A. F. Martínez Fiorenzano¹¹, D.W. Latham²⁵, C. Lovis¹³, C. Mordasini⁴, N. Nikolov⁴, E. Poretti²⁰, M. Rainer²⁰, R. Rebolo López^{2,19}, G. Scandariato⁶, R. Silvotti⁷, R. Smareglia²², J. M. Alcalá¹, A. Cunial³, L. Di Fabrizio², M.P. Di Mauro²⁸, P. Giacobbe^{7,27}, V. Granata³, A. Harutyunyan², C. Knappic²², M. Lattanzi⁷, G. Leto⁶, G. Lodato²⁹, L. Malavolta³, F. Marzari³, M. Molinaro²², D. Nardiello³, M. Pedani², L. Prisinzano⁸, and D. Turrini²⁸

ramme with HARPS-N at TNG

II. No giant planets around the metal-poor star HIP 11952*,**

S. Desidera¹, A. Sozzetti², A. S. Bonomo², R. Gratton¹, E. Poretti³, R. Claudi¹, D. W. Latham⁴, L. Affer⁵, R. Cosentino^{6,7}, M. Damasso^{8,9,2}, M. Esposito^{10,11}, P. Giacobbe^{12,2}, L. Malavolta^{8,13,1}, V. Nascimbeni^{8,1}, G. Piotto^{8,1}, M. Rainer³, M. Scardia³, V. S. Schmid¹⁴, A. F. Lanza⁶, G. Micela⁵, I. Pagano⁶, L. R. Bedin¹, K. Biazzo¹⁵, F. Borsa^{3,16}, E. Carolo¹, E. Covino¹⁵, F. Faedi¹⁷, G. Hébrard¹⁸, C. Lovis¹³, A. Maggio⁵, L. Mancini¹⁹, F. Marzari^{20,1}, S. Messina⁶, E. Molinari^{7,21}, U. Munari¹, F. Pepe¹³, N. Santos^{22,23}, G. Scandariato⁶, E. Shkolnik²⁴, and J. Southworth²⁵

The GAPS Programme with HARPS-N at TNG *,**

III: The retrograde orbit of HAT-P-18b

M. Esposito^{1,2}, E. Covino³, L. Mancini⁴, A. Harutyunyan⁵, J. Southworth⁶, K. Biazzo⁷, D. Gandolfi⁷, A. F. Lanza⁷, M. Barbieri⁸, A. S. Bonomo⁹, F. Borsa¹⁰, R. Claudi¹¹, R. Cosentino⁵, S. Desidera¹¹, R. Gratton¹¹, I. Pagano⁷, A. Sozzetti⁹, C. Boccato¹¹, A. Maggio¹², G. Micela¹², E. Molinari^{5,13}, V. Nascimbeni¹¹, G. Piotto^{8,11}, E. Poretti¹⁰, and R. Smareglia¹⁴

LETTER TO THE EDITOR

The GAPS programme with HARPS-N at TNG

IV. A planetary system around XO-2S^{*,**}

S. Desidera¹, A. S. Bonomo², R. U. Claudi¹, M. Damasso^{2,3}, K. Biazzo⁴, A. Sozzetti², F. Marzari^{5,1}, S. Benatti¹, D. Gandolfi^{4,6}, R. Gratton¹, A. F. Lanza⁴, V. Nascimbeni^{7,1}, G. Andreuzzi⁸, A. Bignamini¹⁰, M. Bonavita¹, F. Borsa¹¹, P. Calcidese³, J. M. Christille¹², M. Esposito¹⁴, P. Giacobbe², A. Harutyunyan⁸, D. Latham¹⁵, M. Lattanzi¹, A. Maggio⁹, L. Malavolta^{7,17}, L. Mancini¹⁸, A. F. Martinez Fiorenzano⁸, G. M. U. Munari¹, I. Pagano⁴, M. Pedani⁸, F. Pepe¹⁷, G. Piotto^{7,1}, E. Poretti¹¹, M. G. Scandariato⁴, R. Silvotti², J. Southworth²³, and R. Zanmar Sanchez³, I. Ribas¹², N. Santos^{13,14,15}, L. Affer¹⁶, G. Andreuzzi⁸, M. Barbieri⁴, L. R. Bedin⁴, S. Benatti⁴, Bernagozzi², E. Bertolini², M. Bonavita⁴, F. Borsa¹⁰, L. Borsato⁵, W. Boschin⁸, P. Calcidese², A. Carbognani², I. Cenadelli², J.M. Christille^{2,17}, R.U. Claudi⁴, E. Covino¹⁸, A. Cunial⁵, P. Giacobbe¹, V. Granata⁵, A. Harutyunyan⁸, G. Lattanzi¹, G. Leto³, M. Libralato^{4,5}, G. Lodato¹⁹, V. Lorenzi⁸, L. Mancini²⁰, A.F. Martinez Fiorenzano⁸, F. Marzari^{4,5}, S. Masiero^{4,5}, G. Micela¹⁶, E. Molinari^{8,21}, M. Molinaro²², U. Munari⁴, S. Murabito^{6,7}, I. Pagano³, L. Poretti⁵, M. Rainer⁵, L. Malavolta⁴, L. Affer⁶, M. Barbieri⁴, L.R. Bedin⁴, C. Boccato⁴, M. Bonavita⁴, F. Borsa⁵, S. Ciceri³, R.U. Claudi⁴, D. Gandolfi^{2,7}, P. Giacobbe¹, T. Henning³, C. Knapić⁸, D.W. Latham⁹, G. Lodato¹⁰, A. Maggio⁶, J. Maldonado⁶, F. Marzari^{11,4}, A.F. Martinez Fiorenzano¹², G. Micela⁶, E. Molinari^{12,13}, C. Mordasini³, V. Nascimbeni⁴, I. Pagano², M. Pedani¹², F. Pepe¹⁴, G. Piotto^{11,4}, N. Santos^{15,16}, G. Scandariato², E. Shkolnik¹⁷, and J. Southworth¹⁸

The GAPS Programme with HARPS-N@TNG

V. A comprehensive analysis of the XO-2 stellar and planetary systems ^{*}

M. Damasso^{1,2}, K. Biazzo³, A.S. Bonomo¹, S. Desidera⁴, A.F. Lanza³, V. Nascimbeni^{4,5}, M. Esposito^{6,7}, G. Scandariato³, A. Sozzetti¹, R. Cosentino^{3,8}, R. Gratton⁴, L. Malavolta^{5,9}, M. Rainer¹⁰, D. Gandolfi^{3,11}, E. Poretti¹⁰, Zammar Sanchez³, I. Ribas¹², N. Santos^{13,14,15}, L. Affer¹⁶, G. Andreuzzi⁸, M. Barbieri⁴, L. R. Bedin⁴, S. Benatti⁴, Bernagozzi², E. Bertolini², M. Bonavita⁴, F. Borsa¹⁰, L. Borsato⁵, W. Boschin⁸, P. Calcidese², A. Carbognani², I. Cenadelli², J.M. Christille^{2,17}, R.U. Claudi⁴, E. Covino¹⁸, A. Cunial⁵, P. Giacobbe¹, V. Granata⁵, A. Harutyunyan⁸, G. Lattanzi¹, G. Leto³, M. Libralato^{4,5}, G. Lodato¹⁹, V. Lorenzi⁸, L. Mancini²⁰, A.F. Martinez Fiorenzano⁸, F. Marzari^{4,5}, S. Masiero^{4,5}, G. Micela¹⁶, E. Molinari^{8,21}, M. Molinaro²², U. Munari⁴, S. Murabito^{6,7}, I. Pagano³, L. Poretti⁵, M. Rainer⁵, L. Malavolta⁴, L. Affer⁶, M. Barbieri⁴, L.R. Bedin⁴, C. Boccato⁴, M. Bonavita⁴, F. Borsa⁵, S. Ciceri³, R.U. Claudi⁴, D. Gandolfi^{2,7}, P. Giacobbe¹, T. Henning³, C. Knapić⁸, D.W. Latham⁹, G. Lodato¹⁰, A. Maggio⁶, J. Maldonado⁶, F. Marzari^{11,4}, A.F. Martinez Fiorenzano¹², G. Micela⁶, E. Molinari^{12,13}, C. Mordasini³, V. Nascimbeni⁴, I. Pagano², M. Pedani¹², F. Pepe¹⁴, G. Piotto^{11,4}, N. Santos^{15,16}, G. Scandariato², E. Shkolnik¹⁷, and J. Southworth¹⁸

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LETTER TO THE EDITOR

The GAPS Programme with HARPS-N@TNG

VI: The Curious Case of TrES-4b ^{*}

A. Sozzetti¹, A.S. Bonomo¹, K. Biazzo², L. Mancini³, M. Damasso¹, S. Desidera⁴, R. Gratton⁴, A.F. Lanza², E. Poretti⁵, M. Rainer⁵, L. Malavolta⁴, L. Affer⁶, M. Barbieri⁴, L.R. Bedin⁴, C. Boccato⁴, M. Bonavita⁴, F. Borsa⁵, S. Ciceri³, R.U. Claudi⁴, D. Gandolfi^{2,7}, P. Giacobbe¹, T. Henning³, C. Knapić⁸, D.W. Latham⁹, G. Lodato¹⁰, A. Maggio⁶, J. Maldonado⁶, F. Marzari^{11,4}, A.F. Martinez Fiorenzano¹², G. Micela⁶, E. Molinari^{12,13}, C. Mordasini³, V. Nascimbeni⁴, I. Pagano², M. Pedani¹², F. Pepe¹⁴, G. Piotto^{11,4}, N. Santos^{15,16}, G. Scandariato², E. Shkolnik¹⁷, and J. Southworth¹⁸

The GAPS Programme with HARPS-N at TNG

VII. Putting exoplanets in the stellar context: the pathfinder case of τ Bootis A*

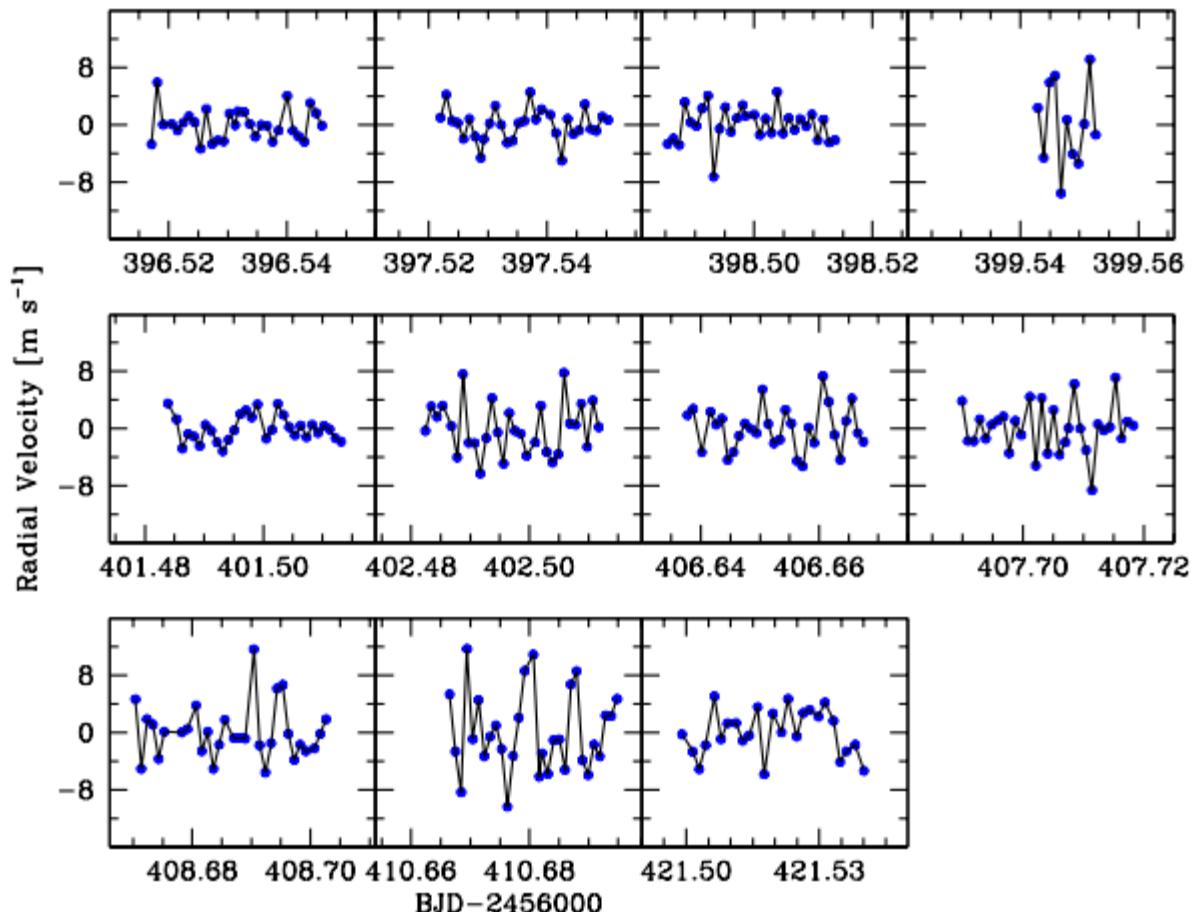
F. Borsa^{1***}, G. Scandariato² et al.

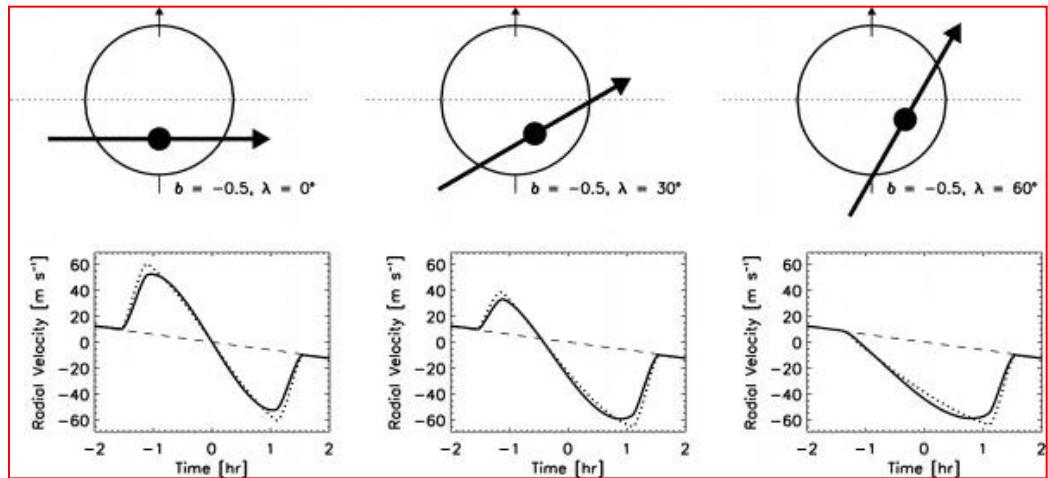
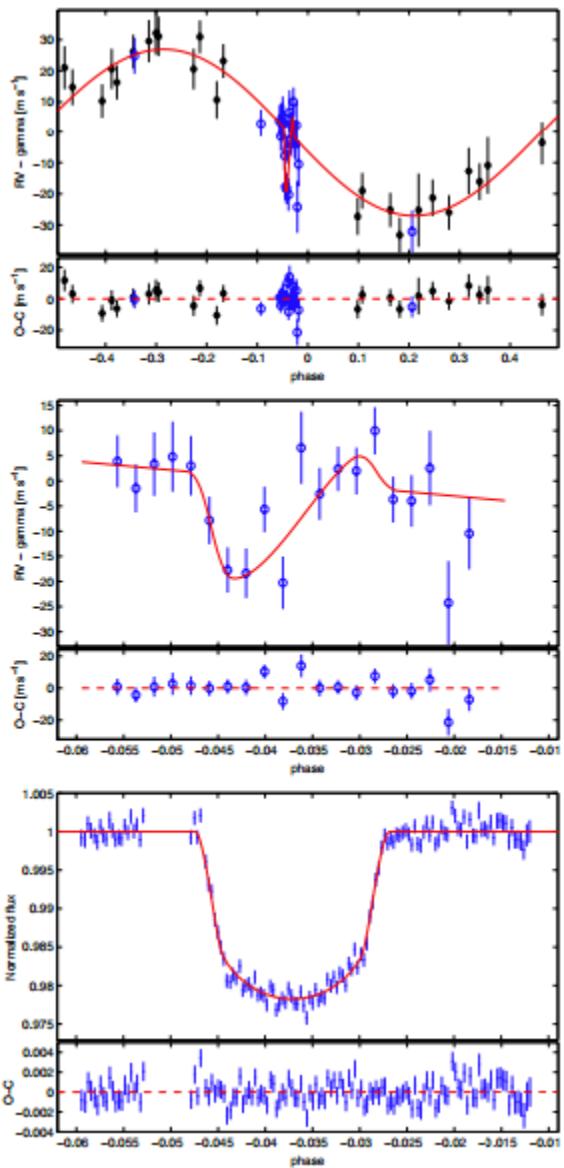
¹ INAF – Osservatorio Astronomico di Brera, Via E. Bianchi 46, 23807 Merate (LC), Italy

² INAF – Osservatorio Astrofisico di Catania, Via S.Sofia 78, I-95123, Catania, Italy

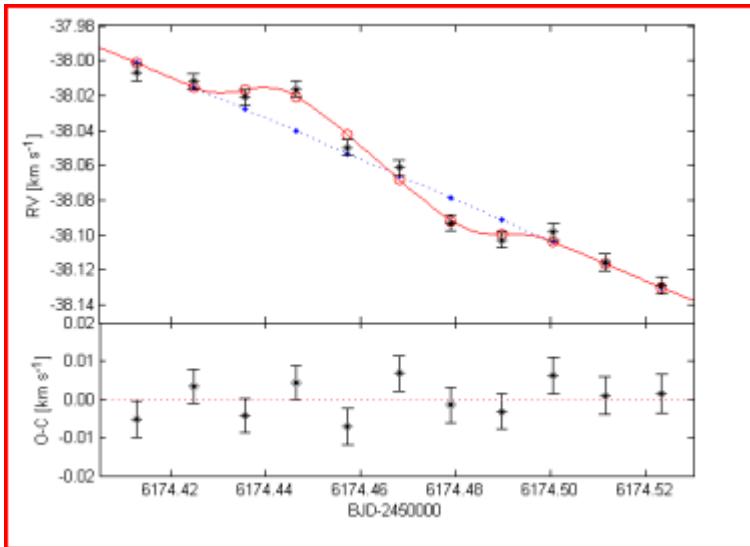
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F. Borsa, G. Scandariato et al.: Putting exoplanets in the stellar context: the pathfinder case of τ Bootis A





EFFETTO ROSSITER-MC LAUGHLIN



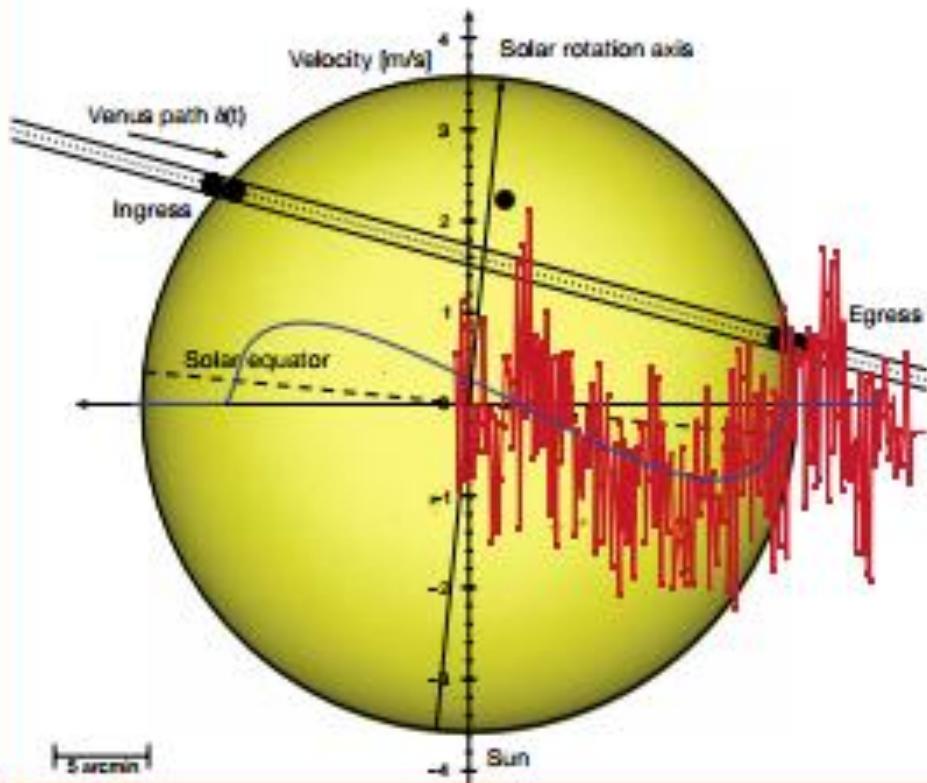


Figure 4. The Solar disc from the Solar Dynamics Observatory image of the Sun on 6 June 2012 with the path of the transit of Venus as seen from the centre of the Moon drawn in. Radial velocity measurements (the red points connected by the red line) from the 227 Solar spectra during the transit are shown (x-axis is time). The thin continuous blue line shows the theoretical RM effect. The radial velocities show clearly the 5-minute Solar oscillations as well as a decrease in the second part of the transit, up to 80 cm s^{-1} , due to the partial coverage of the receding Solar hemisphere by Venus.



Contesto

- Attività organizzata nell'ambito del progetto premiale **WOW (A Way to Other Worlds)**
- Coordinamento delle attività scientifiche nazionali sui pianeti extrasolari
 - Informazione
 - Link fra le diverse (numerose) realtà
 - Sviluppo di nuove idee



Gli obiettivi di **WOW** includono:

- Armonizzazione delle attività nazionali
- Raggiungimento e consolidamento della massa critica necessaria per competere a livello internazionale
- Formazione di giovani nel campo degli esopianeti
- Ottimizzazione dell’uso delle risorse e opportunità

2 AU

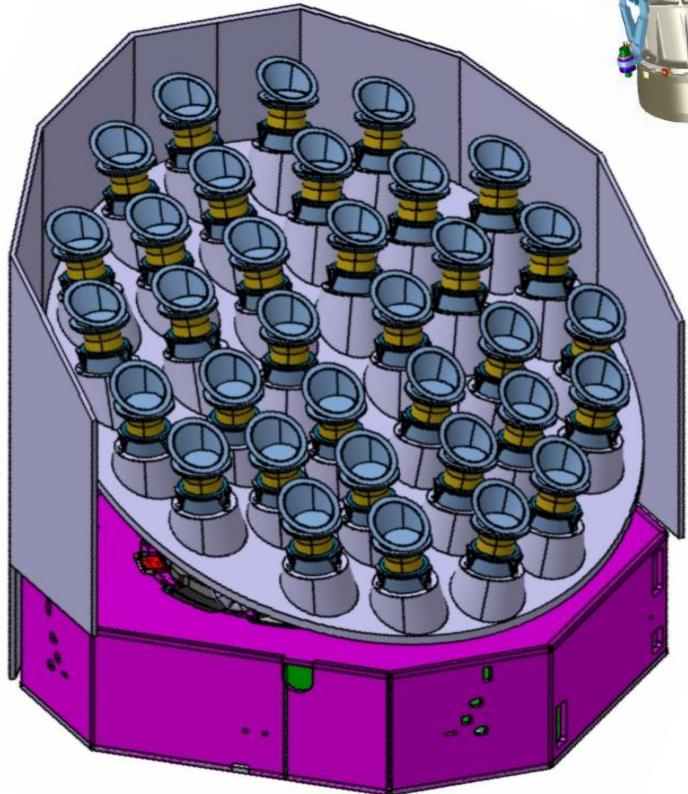
PLATO 2.0 (M3 ESA mission)

PLAnetary Transits and Oscillations of Stars

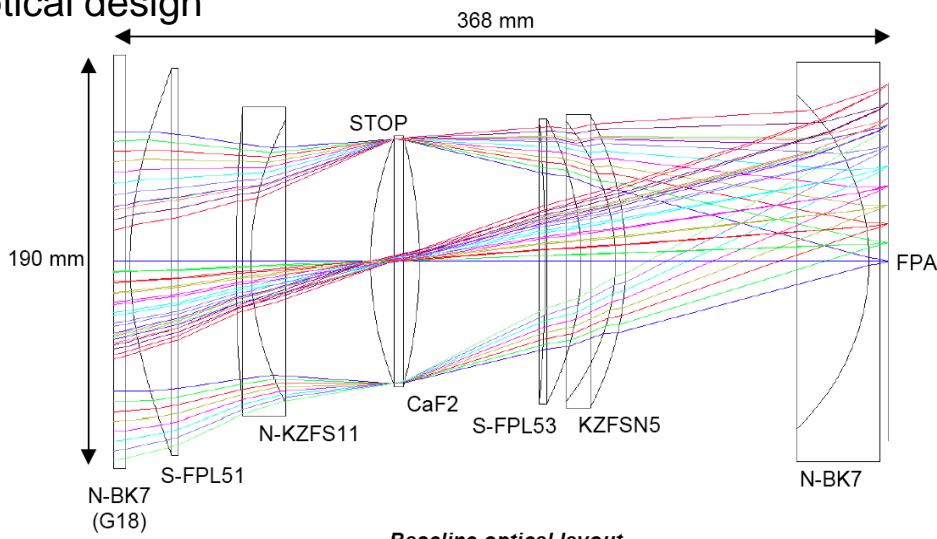
The exoplanetary system explorer

Instrumental Concept

Very wide field + large collecting area :
multi-instrument approach



optical design



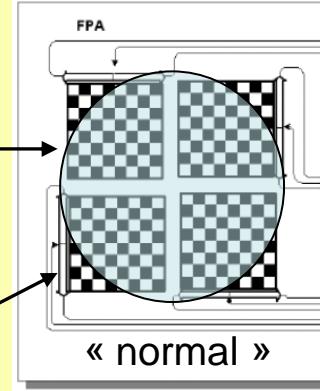
Baseline optical layout

fully dioptric, 6 lenses + 1 window

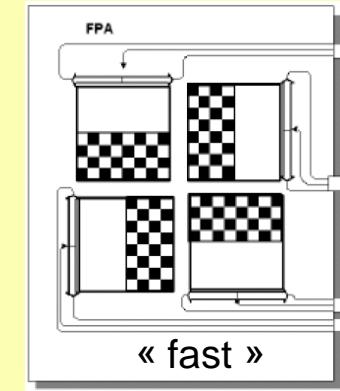
focal planes

optical field
37°

4 CCDs:
 $4510^2 \text{ } 18\mu\text{m}$



« normal »



« fast »

- 32 « normal » cameras : cadence 25 sec
- 2 « fast » cameras : cadence 2.5 sec, 2 colours
- pupil 120 mm
- dynamical range: $4 \leq m_V \leq 16$

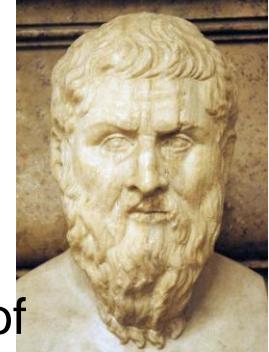
On board data treatment: 1 DPU /2 cameras + 1 ICU
Science ground segment

Orbit around L2 Lagrangian point, 6+2 year lifetime

PLATO Science Objectives

Main objective:

- detect and **characterize** exoplanets of all kinds around stars of all types and all ages \Rightarrow full statistical study of formation and evolution of exoplanetary systems
- including telluric planets in the habitable zone of their host stars



Three complementary techniques:

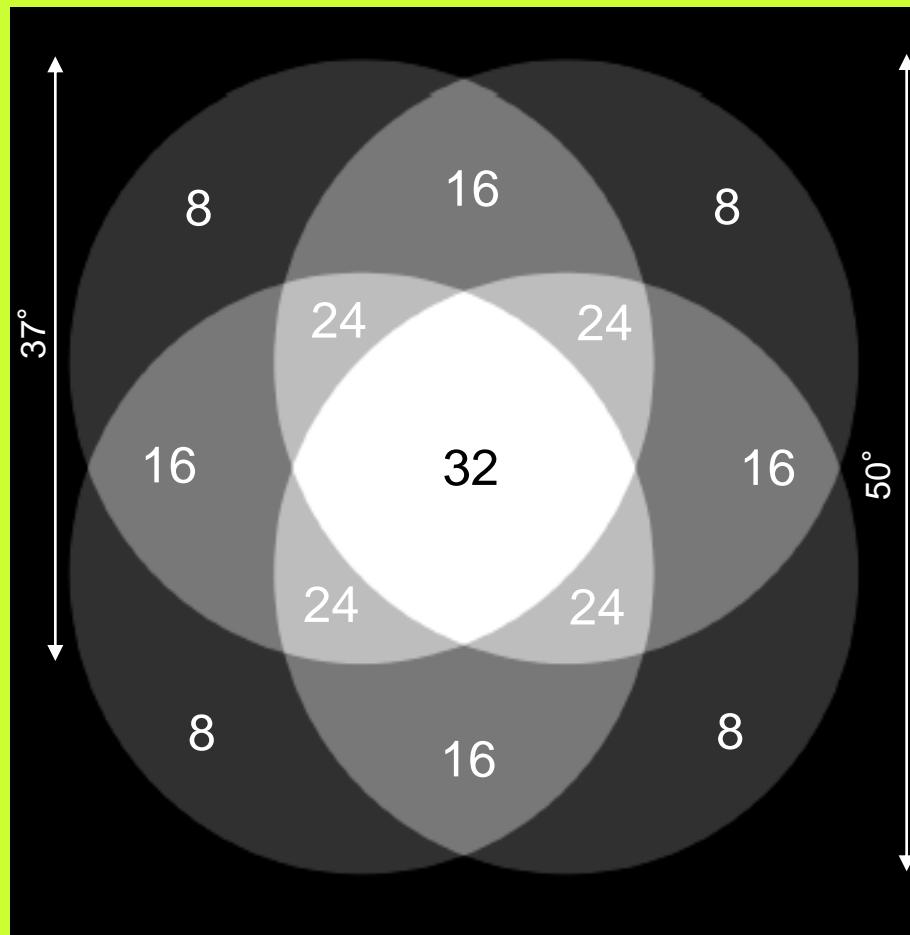
- photometric transits : R_p/R_s (R_s known thanks to Gaia)
- groundbased follow-up in radial velocity : M_p/M_s
- seismic analysis of host-stars (stellar oscillations) : R_s , M_s , age
 - > measurement of radius and mass, hence of planet mean density
 - > measurement of age of host stars, hence of planetary systems

Tool:

- ultra-high precision, long, uninterrupted, CCD photometric monitoring of very large samples of **bright stars**: CoRoT - Kepler heritage
- bright stars: efficient groundbased follow-up and capability of seismic analysis

Concept of overlapping line of sight

4 groups of 8 cameras with offset lines of sight
offset = $0.35 \times$ field diameter



Optimization of number of stars at given noise level
AND of number of stars at given magnitude

PERSPECTIVES WITH



ESPRESSO: The next European exoplanet hunter

E. Pepe^{1,*}, P. Molaro^{2,4}, S. Cristiani², R. Rebolo³, N.C. Santos^{4,12}, H. Dekker⁵, D. Mégevand¹, E.M. Zerbi⁶, A. Cabral⁷, P. Di Marcantonio², M. Abreu⁷, M. Affolter⁹, M. Aliverdi⁶, C. Allende Prieto³, M. Amate³, G. Avila⁵, V. Baldini², P. Bristow⁵, C. Broeg⁹, R. Cirami², J. Coelho⁷, P. Conconi⁶, I. Coretti², G. Cupani², V. D'Odorico², V. De Caprio⁶, B. Delabre⁵, R. Dorn⁵, P. Figueira⁴, A. Fragozo³, S. Galeotta², L. Genolet¹, R. Gomes⁸, J.I. González Hernández³, I. Hughes¹, O. Iwert⁵, F. Kerber⁵, M. Landomi⁶, J.-L. Lizon⁵, C. Lovis¹, C. Maire¹, M. Mannetta⁶, C. Martins⁴, M. Monteiro⁴, A. Oliveira⁸, E. Poretti⁶, J.L. Rasilla³, M. Riva⁶, S. Santana Tschudi³, P. Santos⁸, D. Sosnowska¹, S. Sousa⁴, P. Spano¹¹, F. Tenegi³, G. Toso⁶, E. Vanzella², M. Viel², and M.R. Zapatero Osorio¹⁰

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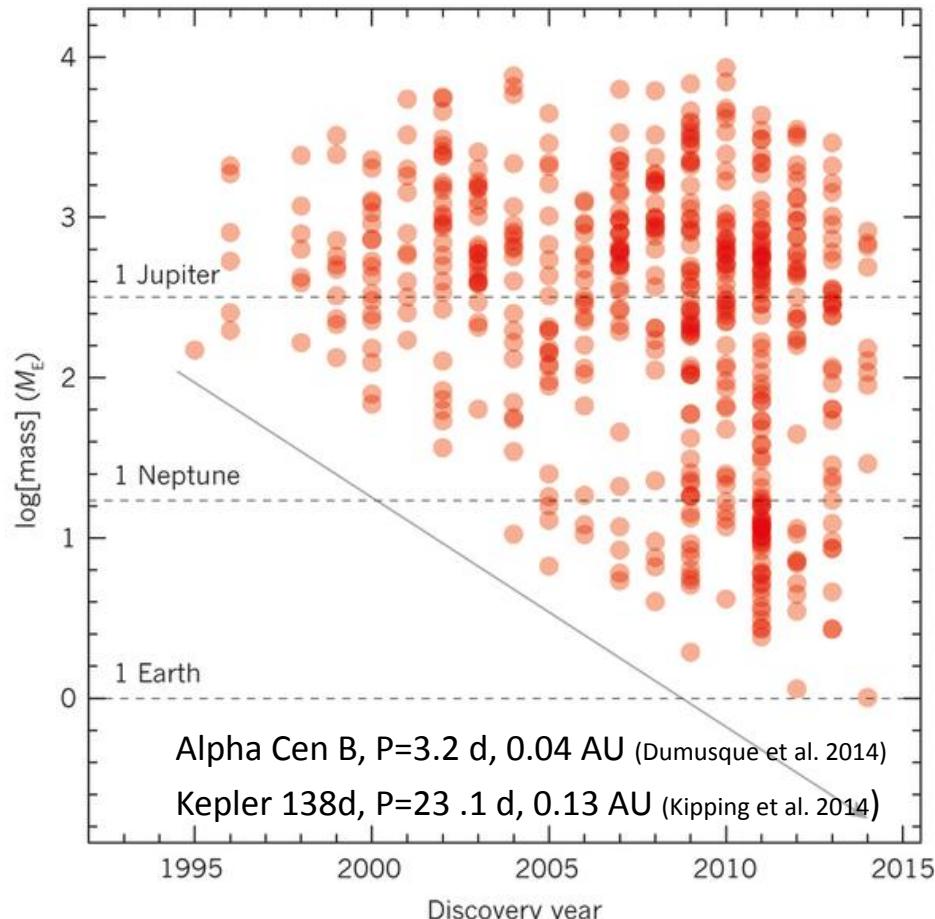
⁸ LOLS, Faculty of Sciences, Univ. of Lisbon, Estrada do Paco do Lumiar 22, 1649-038 Lisbon, Portugal

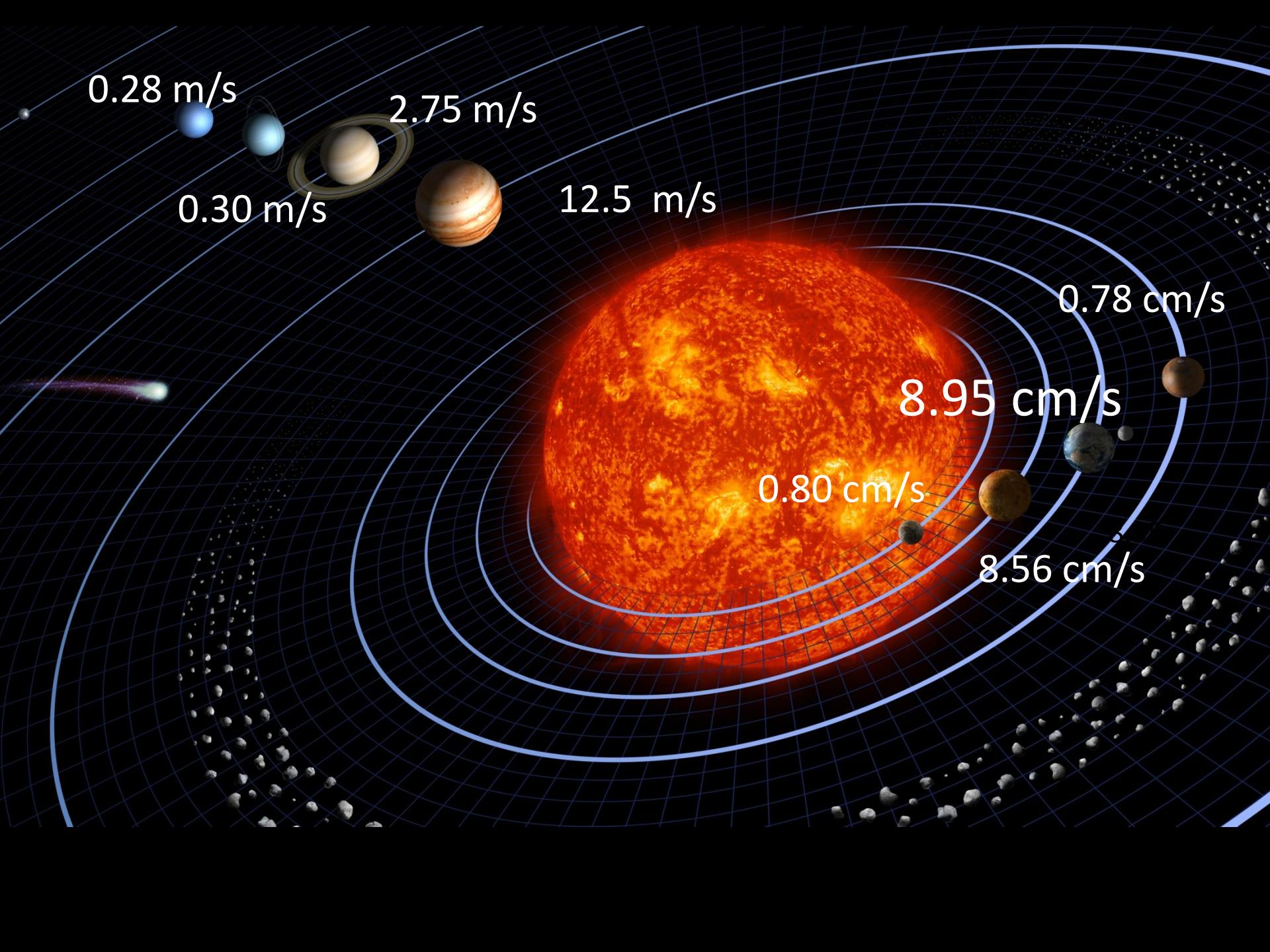
⁹ Physics Institute of University of Bern, Siedlerstraße 5, CH-3012 Bern, Switzerland

¹⁰ Centro de Astrobiología, INTA, Carretera Ajalvir km 4, 28850, Torrejón de Ardoz, Madrid, Spain

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0.28 m/s

0.30 m/s

2.75 m/s

12.5 m/s

0.78 cm/s

8.95 cm/s

0.80 cm/s

8.56 cm/s