ELODIE & SOPHIE spectrographs: 20 years of continuous improvements in radial velocities

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**ELODIE spectrograph (1993 - 2006)**

R = 42’000  
Δλ = 391 - 681 nm  
σRV = 13 ⇒ 8 m/s

Fiber-link echelle spectrograph using the simultaneous thorium technique for RV measurements

*Baranne et al. 1996*

R = 75’000 (HR)  
Δλ = 387 - 694 nm  
σRV = 5 ⇒ 2 m/s

σphot = 3 m.s⁻¹ for SN=150 (550nm / 3 km.s⁻¹)  
~ 20 mn on mv=7.5

**SOPHIE spectrograph (2006 - )**

R = 40’000 (HE)  
σRV = 15 ⇒ 7 m/s

Dispersive components inside a constant pressure tank  
3” fiber-acceptance on sky  
2 observing modes

*Perruchot et al. 2008  
Bouchy et al. 2009*

Photons in the tank  
σphot = 1 m.s⁻¹ for SN=200 (550nm / 3 km.s⁻¹)  
~ 15 mn on mv=7.5
Continuous improvements of SOPHIE spectrograph
- Adjustment of Atmospheric-Dispersion Correctors [2008]
- New guiding camera for centering and guiding on fiber entrance [2009]
- Continuous N2-dewar filling to avoid thermo-mechanical shocks [2010]
- Octagonal-section fibers to remove guiding and seeing effects due to insufficient scrambling [2011/2012] Bouchy et al. 2013
- New calibration unit in a thermal-controlled environment [2014]
- Upgrade of electronic and control-command of Cassegrain Fiber Adapter [2015]
- Installation of Fabry-Pérot etalon for drift measurement [end 2015]
- New thermal control to remove thermal bridge with telescope pillar [end 2015]
- Adaptation of the last HARPS data-reduction software [end 2015]
Exoplanet Surveys conducted with SOPHIE

Search for northern extrasolar planets

2680 stars / 150-180 nights.year⁻¹

SP1 : High-precision search for Neptunes and Super-Earths
SP2 : Giant planet survey on a volume-limited sample
SP3 : Search for exoplanets around M dwarfs
SP4 : Search for exoplanets around early-type main sequence stars
SP5 : Long-term follow-up of ELODIE long period candidates

+ search for exoplanets around young and active stars, around stars with debris disk, around stars on clusters
Giant exoplanets detected by Radial velocity

HD80606b
Naef et al. 2001
Moutou et al. 2009

HD189733b
Bouchy et al. 2005

51pegb
Mayor & Queloz 1995

Poster G. Hébrard
Giant exoplanets detected by Radial velocity

Planet/Brown-dwarf transition
HD22781 (Diaz et al. 2012)
HD16760 (Bouchy et al. 2009)
Giant exoplanets detected by Radial velocity

Jupiter Analog
HD24040 (Boisse et al. 2012)
HD222155 (Boisse et al. 2012)

Talk J. Rey
Talk R. Diaz
Giant exoplanets detected by Radial velocity

Multiple Systems
HD74156 (Naef et al. 2004)
HD9446 (Hébrard et al. 2010)
HD13908 (Moutou et al. 2013)
Exoplanet Surveys conducted with SOPHIE

Follow-up and characterization of transiting planets

50 - 70 nights.year$^{-1}$

- Follow-up of SWAPS, HAT, CoRoT, Kepler, K2 transiting candidates.
- Identification of false positives,
- mass and orbital eccentricity measurements,
- Host star spectroscopic classification
- Spin-orbit obliquity (Rossiter-McLaughlin effect)
- Long term FU for additional distant exoplanets
Giant exoplanets detected by Transit

Talk A. Santerne
Talk R. Alonso
Talk S. Barros
Giant exoplanets detected by Transit

Inflated hot Jupiter
Wasp-12b (Hebb et al. 2009)
Kepler-435 (Almenara et al. 2015)
Giant exoplanets detected by Transit

Massive Giants / Brown dwarfs
Kepler-39b (Bouchy et al. 2011)
CoRoT-3b (Deleuil et al. 2015)
Giant exoplanets detected by Transit

Misaligned spin-orbit XO-3b (Hébrard et al. 2008)
Giant exoplanets detected by Transit

Saturn-like giant
WASP-21 (Bouchy et al. 2010)
Kepler-425b (Hébrard et al. 2014)
Synergy with incoming space missions

- RV survey as targets provider for **CHEOPS** [ESA – 2018]

- Combine RV and **GAIA** [ESA – 2018] astrometry to refine orbital parameters of giant exoplanets

- RV follow-up of **transiting candidates from TESS** [NASA - 2018] and **PLATO** [ESA - 2024]
Strengths and benefits of SOPHIE@193

- Telescope mainly dedicated to exoplanet studies
- Long term programs with a large number of nights
- Very high flexibility
- High precision (2 m/s) and on going improvements
- Real time data reduction
- An excellent set of observers and telescope operators

ELODIE ARCHIVE  http://atlas.obs-hp.fr/elodie/
35’500 spectra corresponding to more than 3000 distinct objects

SOPHIE ARCHIVE  http://atlas.obs-hp.fr/sophie/
81’500 spectra corresponding to more than 6000 distinct objects.
  56’000 spectra are fully public.
  20’000 spectra available with the time information hidden (5-year)
  5’500 spectra are still under the normal 1-year embargo.