CHARA/SPICA WS (19/03/2020)

From 14h00 to 16h30 (French Time)

Participants (16):
Roxanne Ligi (WP1)
Orlagh Creevey (WP2)
Kevin Belkacem (WP3)
Sébastien Deheuvels (WP3)
Markus Wittkowski (WP4)
Tabetha Boyajian (WP5)
Darek Graczyk (WP6)
Nicolas Nardetto (WP7)
Denis Mourard (WP8)
Armando Domiciano (WP9) => Not available
Stefan Kraus (WP10)
Antonio Claret (WP11) => Not available

And from ANR Project "Stars4Planets"
Pierre Kervella, specialist of interferometry, SBCR
Yveline Lebreton, specialist of evolution code
Aurélien Crida, planetologue

And also, Mikolaj Kaluszynski Phd Student with Darek Graczyk, who made the first version of the Python code for the dynamical database.

And Gail Schaefer from CHARA

Agenda:

As the WS meeting will be short, our first objective is to set a list of tasks. Our CHARA/SPICA SG regular meetings on Tuesday should be used to follow these tasks regularly.

1. The CHARA/SPICA development of the instrument, Denis (10')
    a. **(see presentation here)**
    b. Current status of the instrument
    c. First light of CHARA/SPICA end of 2021, start of operation April 2022
    d. All the tool for observations should be ready from A to Z (list of stars, CHARA/SPICA module of observation, DRS, criteria of quality, stellar activity flag, automatic calculation of high-level parameters, …). System highly automatic.
    e. The need to make a choice for spectral resolution modes
    f. Task:
        i. Validate the spectral resolution. We converge to LR and HR in principle but HR + Binning may degrade the sensitivity for MR. Zemax modelling will help for the decision

ii. The CHARA/SPICA SG need to clarify the operational, data reduction (DRS) and analysis tools he needs. DM/NN will write documents to be shared with the SG.

2. Remind the objectives of the CHARA/SPICA Science Group, Nicolas (10')
    a. 1000 stars to be observed: 800 diameters, 200 images in 3 years. WP 1 to 6 are for diameters determination in different parts of HR diagram and also to characterize stellar activity (spots, wind, environment, granulation). WP7 will use data from other WP to build Surface-Brightness Color Relations (SBCRs) and estimate the impact of stellar activity on them, WP8 is for binaries, WP9 for rotation, WP10 YSOs and WP11 for LD measurement.
    b. Concretely, each WP needs to:
        i. define its astrophysical objectives, define the way he will build the list of targets (diameter and/or imaging) using input parameters, clarify the way between the CHARA/SPICA observables to high-level parameters. This has to be summarized in overleafs. *Note: the overleaf is not a proposal, it is a summary of the methodology that will be useful to merge the list of stars; thus it can be very synthetic.*
        ii. Build effectively the dynamical list using the python codes (links on the website). This is a proposition, other solutions can be discussed.
        iii. interface with instrument
    c. Notes:
        i. DM: Need of support manpower for observations/runs from the SG
        ii. DM: Need of grant in order to buy nights. 6000$/night and possible agreement with CHARA for doubling the number of nights.
        iii. SK: remote control rooms; also combining two instruments might be difficult, but doable said DM. FT will probably be operated by the CHARA operator (this point is part of the documents we need to write soon).
        iv. Granted time + open time in //
        v. NOAO time should be led by people outside consortium
    d. Taks:
        i. each WG should finish the overleaf
        ii. each WG has to use the python code to build the CHARA/SPICA input catalogue

3. *Methodology for the meeting, please remind:*
    a. *summary of objectives*
    b. *current progress*
    c. *issues*
    d. *upcoming tasks and schedule*
4. Summary of WPs made by Nicolas if necessary (link)
5. WP1 : Exoplanet host stars, Roxanne+all, 10'
    a. Objectives
        i. individual analysis of exoplanets: planetary parameters depend on stellar parameters (R, M, rho).
        ii. characterisation of exoplanetary systems at the statistical level: need of precise stellar parameters in general : age, Teff, metallicity,

rotation... Lead to the understanding of formation and evolution of these systems.

b. Status
   i. the objectives are now well defined.
   ii. the overleaf is almost finished but should be updated with simple equations and final summary slides (made with Nicolas).
   iii. a first target list is done (10 stars)

c. Issues
   i. not clear how many stars will be characterised with SBCR => later, for PLATO follow-up
   ii. should we include exoplanets hosts with no transit but good SBCR, precise RV? (for now, we said yes but did not discuss the strategy) => no transit + possibility of CHARA/SPICA direct observations, to be discussed (to be included or not ? how ?) ; no transit + SBCR, same as point i), for later
   iii. similarly, should we include transit stars with no good accuracy on the diameter, but better anyway that what already exists? (I would say that we will need to prioritise the targets) => connected to Tasks d.iii I would say.
   iv. how to identify the 5 stars for which we will get an image? NN made some tests with Spots, probably to be check again with RL/DM

d. Tasks/Schedule
   i. RL: improve the section of the overleaf corresponding to high-level parameters in order to implement the equations easily in the python database
   ii. RL+: use the python code to get a dynamical target list (for now 10 targets).
   iii. RL+: need to refine the selection criteria according to:
      1. precision on transit depth/duration
      2. RV data
      3. On the expected radius -> need to test the expected precisions and accuracy as a function of magnitude and diameter (Denis's algorithm).
   iv. RL/OC/SD+: coordination with WP2 and 3 for stellar ages determination based on evolution codes. Define the methodology: which evolution codes ? Good to investigate different evolution codes, in parallel to PLATO for comparison (WP2 ANR actually)

e. Notes:
   i. Common ID for targets between WPs for coordination
   ii. WP1 is really dedicated to direct interferometric study of exoplanet host stars. These measurements will also feed the work on the SBCR calibration, which will then be used for faint exoplanet host stars for which no direct interferometric measurement is possible.

6. WP2 : Asteroseismic main sequence stars, Orlagh+all, 10'
   a. Objectives
      i. See overleaf of Orlagh for details about objectives
      ii. TBC: Use benchmark asteroseismic targets with full frequencies and interferometric CHARA/SPICA observations in order:

1. To calibrate ‘seismic scaling relations’
2. Test SBCR
3. To provide robust masses for evolution codes, and age (for WP1: age of exoplanet systems)
4. Differential rotation (with M. Bazot)
5. Solar analog

b. Status
   i. overleaf to be finished and shared
c. Issues
   i. Requirement on observations. What SPICA can give in terms of precision in terms of magnitude ? => DM/NN have to work on it in order to provide a easy-to-use tool !
d. Tasks/Schedule
   i. OC: Finish the overleaf and share it
   ii. OC/KB/SD: Explore the different catalogues: SONG, Kepler, CoRoT, TESS
   iii. OC will send inputs to DM/NN to characterize the expected precision of CHARA/SPICA.
   iv. SK: impact of Fringe Tracking systematics on the angular diameter estimate. Something to check (DM/SK).

7. WP3 : Asteroseismic sub-giants and giants stars, Kevin/Sebastien+all, 10’
   a. => see pdf by Sebastian
   b. Objectives
      i. To constrain poorly understood physical processes in stellar physics using precise and accurate interferometric radii with special emphasis on stars exhibiting mixed modes. This will be done on a set of benchmark stars with high S/N solar-like oscillation + interferometry.
      ii. To calibrate seismic scaling relations for evolved stars (see pdf for methodology). Once calibrated: Gaia + CHARA/SPICA (**direct or SBCR measurement**) + Sismology ==> full model-(almost)independent estimate of stellar parameters (M, R, Teff)
   c. Status
      i. Objectives clarified. Class IV into WP3.
   d. Issues
      i. Definition of seismic and interferometric radii => do we measure the same thing ? Then, is it relevant to compare ? Should it be an objective in itself ? Discussion to have.
   e. Tasks/Schedule
      i. NN: Clarify on the web pages (etc..) that class IV are in WP3
      ii. SD/KB/NN: put the sentence and main ideas of pdf into the overleaf document.
      iii. SD/KB: Estimate required precision on the interferometric radius to constrain physical processes using stellar models (different stellar masses and evolutionary stages should be explored).
      iv. SD/KB/DM/NN: Use SPICA predictions for dR/R as a function of mass and radius to determine the maximum magnitude for which the requirements of step 1 are satisfied. KB/SD have to same what they need exactly to DM/NN. DM/NN on their side need to build an abaque

(important for all WPs): precision on theta as a function of mV and for different spectral type.

v. KB/SD/OC: Cross-correlate with existing CoRoT, Kepler, K2, and TESS catalogues and expected performances (for TESS). Need to define a list (coordination WP2/WP3 because the same databases will be used for slightly different objectives). Note: TESS is not enough for a detailed asteroseismic analysis, except for some targets (20 targets in south mV< 9).

vi. SD/KB/NN: End-up with lists of targets (given an expected limit %R/R) to be done in python script.

f. Notes:
   i. DM => issue of binaries for class IV ? Mix of everything ? OC: Good classification from Astero or Gaia in principle.
   ii. Gaia, DR3 delay possible, beginning of 2022

8. WP4 : B4-F4 stars, Markus+all, 10'
   a. Objectives:
      i. 252D+22I = 275*, stars from B4 to F5
      ii. Find stars of spectral type B4-F4 for the purpose of SBCRs, that is stars that do not have any special features, such as binaries, disks, winds, etc
      iii. Find interesting stars for imaging, that is the complement to i., i.e. stars with disks, winds, etc
      iv. Statistics on pulsation, multiplicity, disks, circumstellar diameter for a large number of stars
   b. Status:
      delayed, overleaf startet, needs to be finalized
   c. Issues:
      i. Should the analysis of winds, disks, pulsating stars, etc. be a part of this WP, or should that be a separate WP? Includes both hot star winds and cooler star winds => We decide to separate WP4 (SBCR) and create a new WP for the wind WP12, which should probably include M-giants (not considered at the moment).
      ii. What about winds of K/M giants that we discussed at the meeting last year? Is that covered anywhere? => to be included in this new WP12
      iii. Find experts for winds of hot stars => NN will think about it
   d. Tasks/Schedule
      i. NN: Create a new WP12 for winds (study all over the HR diagram, with the objective also to evaluate the impact on the SBCR). Verify the contributions of colleagues in WP4 and in this new WP12.
      ii. The JSDC catalogues is a good source to identify the targets for both objectives. Exact criteria still to be defined.
      iii. Next steps: iterate between Markus and Nicolas, look at python script, then distribute among the group
   e. Note (from Denis): Detailed studies of CSE of cool stars should not be a part of the core CHARA/SPICA program. However, statistics of the influence of pulsation, CSE, multiplicity, winds etc, on this large number of stars is a part of this WP.

9. WP5 : K8-M dwarfs, Tabetha+all, 10'
    a. Objectives
        i. Find non-active M dwarves in order to calibrate SBCR in this part of the diagram
        ii. Fundamental parameters of M-dwarfs are important in order to constrain evolution code in the context of PLATO
        iii. Find M-dwarf targets (if any) for stellar activity characterization
        iv. Metallicity
    b. Status
        i. overleaf to be done
        ii. python code well advanced: 32 stars identified including 10 binaries; LD measurement seems possible for 2 stars (TBC)
    c. Issues
    d. Tasks/Schedule
        i. TB/NN: write the overleaf to characterize the methodology in detail
        ii. TB/NN: actualize the python code, add parameters for SBCR determination
        iii. TB/NN/DM: check targets for imaging/LD
10. WP6 : O, B1, B2, B3 stars, Darek+all10'
    => see overleaf
    a. Objectives
        i. 83D+7I = 90* stars from O to B3
        ii. derive precise SBCR for O, B1, B2, B3 stars. Derive the distance of eclipsing binaries in M31/M33
        iii. study early-type stars supergiants for distance determination
        iv. characterize stellar activity in this part of the diagram (binaries, rotation, wind)
    b. Status
        i. overleaf to be completed
        ii. python well advanced: 193 stars identified including 37 'stars' (standard), 18 Blue supergiants, and many other active stars
    c. Issues
        i. A lot of binaries (90 %), rotating stars, … handle stellar activity, when building the list of stars, and afterwards, when observing => global problem to all WPs to be discussed.
        ii. Issue of extinction. Much different results depending on extinction. 3D extinction map from Stilism or Pan-STARRS are used. Or Schegel => tests currently done by DG and MK.
        iii. Medium spectral resolution in order to derive extinction differently proposed by Darek => To be discussed.
    d. Tasks/Schedule
        i. DG/NN: finish the overleaf
        ii. DG/MK/NN: update the python code, with a careful check of activity; add parameters for SBCR, etc…
        iii. NN/DG: Find good targets for imaging
        iv. All: Tool to characterize stellar activity. Dynamical list of targets, trial observations of each target to flag unknown binary systems and to check if they are suitable for SBCR.

11. WP7 : SBCRs, Nicolas+all, 10'
    a. Objectives
        i. Derive homogeneous, precise, and robust Surface Brightness Color Relations (SBCRs) in the Gaia/2Mass system all over the HR diagram (typically 4 stars per sub-spectral type and class), for exoplanet space missions (including PLATO), determination of distance of eclipsing binaries (LMC, M31, M33), etc...
        ii. Precision of 0.022 mag (1%) for stars later than B4, and 0.044 mag for O, B1, B2, B3 stars (2%).
        iii. Quantify the impact of stellar activity on these SBCRs by comparing the rms of the SBCR based on inactive stars, with the rms of a SBCR based on active stars
    b. Methodology:
        i. On one side, WP7 will use as a priority the list of stars from other WPs to build SBCRs. On the other side, a list of specific targets will be identified in WP7, that will be used at the end (when we will merge all tables) to fill the HR diagram (if necessary) in terms of spectral type and class. A coordination between WP7 and all other WP is necessary.
        ii. It means that, if possible, all WP 1-6 should:
            1. provide G, Ks, A_G, the expected precision on the LD CHARA/SPICA angular diameter, and an activity flag in their list of stars
            2. put higher priorities on stars with precise Ks magnitude (<0.03 mag for WP6 and <0.015 mag for all other WPs), when building their list of targets
            3. put higher priority for stars with A_G more precise than 0.15 magnitude
            4. cover the HR diagram spectral type / classes as much as possible
    c. Status
        i. The overleaf is finished. To be shared with colleagues of the WP.
        ii. The methodology is clear based on a paper, A Salsi et al. that will be submitted soon: SBCRs for dwarfs and Giants in V/V-K and G/G-K systems, based on the JMDC database
        iii. A list of 11 benchmark stars has been extracted from Salsi et al. paper with a precision on the measured angular diameter lower than 1%, eKs < 0.03 mag, diam < 1.5 mas.
    d. Issues
        i. Define stellar activity flags when building the input list of stars. How ? => Task e.i
        ii. Define stellar activity flags from CHARA/SPICA observations. How ? => Task e.ii
        iii. Photometry for bright stars ? Gaia Ok, from OC (7-9-10). Might be a problem for WP6 indeed => we might need to use other bands, to be discussed.
    e. Tasks/Schedule

i. 2020: build a list of non-active targets suitable for SBCRs in all HR diagram in order to fill the gaps at the end if necessary. Build stellar activity flags based on Salsi+ experience
ii. 2020: Using aspro2 to build an activity flag from CHARA/SPICA observations
iii. Understand physically the difference of SBCR between dwarfs and giants; Salsi et al., paper 2 in prep.

f. Notes:
i. Do not limit the number of stars

12. WP8: Binaries, Denis+all, 10' (link to the presentation)
a. Objectives
i. Determination of masses for feeding the evolution models
ii. Masses and individual radii ⇒ strong constraint on evolution
iii. Importance of additional data: spectroscopy, photometry, astrometry
b. Catalogs
i. Araucaria EBs: 16 targets
ii. Eker: 25 targets
iii. Gaia/hipparcos astrometric >3000 targets
c. Potential performance of SPICA for binaries
d. Tasks
i. Compute flux ratio on the basis of spectral types?
ii. Identify criteria for selecting good astrometric targets
iii. Stay open to 'bad' targets of other WPs.
iv. Overleaf to be written when stabilization of ideas
v. On the example of Denis: Check degeneracy between flux ratio and separation at low flux ratio/small separation (SK/NN, others)
add other catalogues SB, SB2 (Gail)
vi. Check for the upper limit in terms of separation for SPICA.

13. WP9: rotating stars, Nicolas if Armando not here+all, 10'
a. Objectives
i. presentation here
ii. Study Gravity darkening for fast rotating stars from O to F stars.
iii. Explore the synergy between slow rotation (1-2% of flattening) and asterosismology.
b. Catalogs
i. From Van Belle, 27 top priority targets (images) and 179 second priority (gravity darkening should be measurable)
c. Status
i. overleaf ready.
d. Issues
i. Identify pole-on fast rotators, how ? To be discussed.
e. Tasks/Schedule
i. adapt the code used to find the targets to the collaborative python code to have a dynamical database.
ii. Work with WP7 in order to flag rotation activity. To be explored: If a expected non active star of WP2 or 3 is actually slowly rotating, we can use rotation/asterosismic models.

14. WP10: YSOs, Stefan+all, 10'
    a. Objectives
        i. slide by Stefan: WP10-slides.2020Mar19b.pdf
    b. Status
        i. paper on overleaf
        ii. compiled target list from literature, taking MIRC-X experience into account
    c. Issues
        i. Sensitivity/SNR essential for WP, so R=3000 interesting if sensitivity gain possible
        ii. Can H-alpha and continuum data be extracted from same data, or are dedicated low spectral resolution observations needed to achieve best visibility calibration?
    d. Tasks/Schedule
        i. for continuum science case: quantify what visibility calibration accuracy is needed to provide meaningful constraints on stellar evolutionary models
        ii. keep look out for additional targets
15. WP11: LD measurements, Denis/Nicolas+all, 10'
    a. Objectives
        i. slide by Nicolas: pdf
        ii. Direct limb-darkening measurement (theta > 0.8 mas and mV < 6)
        iii. Build a grid of observed limb-darkening all over the HR diagram
        iv. Use this grid to convert UD to LD for all CHARA/SPICA targets
    b. Status
        i. Antonio wrote information into the overleaf
        ii. Nicolas made a python collaborative tool to identify the targets and did some tests
    c. Issues
        i. Which procedure to convert UD to LD ? Under discussion in WP122300 of PLATO as well.
    d. Tasks/Schedule
        i. Define the angular diameter over which CHARA/SPICA is sensitive to LD. If sensitive, which precision on the LD ? If not, how do we convert UD to LD. In any case, use state-of-the art methods.
16. Summary, organization, additional tasks, all, 20'
    a. Regular meetings tuesday 15h30 for progress of WPs
    b. Do not hesitate to rely on the colleagues in your group
    c. Important to link the CHARA/SPICA-SG to the development of the instrument (tools)