Research Networking Programmes

Science Meeting – Scientific Report

The scientific report (WORD or PDF file - maximum of seven A4 pages) should be submitted online <u>within two months of the event</u>. It will be published on the ESF website.

<u>Proposal Title</u>*: Massive Stars and the Gaia-ESO Survey*

<u>Application Reference N°</u>: 5597

1) Summary

Organizers

Ronny Blomme (Royal Observatory of Belgium, Belgium)
Jorick Vink (Armagh Observatory, Northern Ireland)

Scientific Organization Committee

- A. de Koter (Sterrenkundig Instituut Anton Pannekoek, Netherlands)
- I. Negueruela (Universidad de Alicante, Spain)
- J. Puls (Universitätssternwarte, Ludwig-Maximilians-Universität München, Germany)
- S. Randich (Osservatorio Astrofisico di Arcetri, Italy)
- G. Rauw (Université de Liège, Belgium)
- S. Van Eck (Université Libre de Bruxelles, Belgium)

Due to other commitments, I. Negueruela and J. Puls were not able to attend the meeting. All other SOC members attended the meeting.

Local Organizing Committee

R. Blomme, A. Lobel, Y. Frémat, J. Vandekerckhove, J. Cuypers, E. Van Hemelryck (Royal Observatory of Belgium)

Venue

The workshop took place in the Meridian Room at the Royal Observatory of Belgium.

Participants

50 participants attended the meeting: this includes 6 SOC members, 11 invited speakers and 28 participants who gave a contributed talk. 45 participants work in institutes in 11 different ESF countries, 5 participants work outside the EU (Brazil, Lebanon, Russia, USA).

Subjects covered by the Workshop

The workshop had four sessions: Gaia and GES; Spectral analysis of massive stars; Massive star evolution; Massive stars in the cluster and galactic context. Two discussion sessions were organized.

Proceedings

There are no written proceedings, but pdf versions of the talk are available on the Workshop website: http://ges-ms.oma.be

Additional financing

We obtained additional funding from the Belgian *Fonds de la Recherche Scientifique (FNRS)* for travel and accommodation of two non-EU invited participants.
We are grateful to the Royal Observatory of Belgium for providing the meeting room, and the coffee breaks.

2) Description of the scientific content of and discussions at the event

Despite their importance for the star-formation history of the Universe, massive stars are particularly poorly understood. However, thanks to projects such as the ongoing Gaia-ESO Survey (GES) and the VLT-Flames Tarantula Survey (VFTS), progress in the number of massive stars with accurate parameters is rapidly growing. The Gaia-ESO Survey (GES) is an ambitious project to collect spectroscopic information on the various components of our Milky Way. Among the 100,000 stars to be observed, there is an important set of massive stars (here defined as stars with spectral types OBA). The stellar parameters and abundances determined in the GES allow for critical tests of stellar evolution modelling. Massive stars have a large influence on the clusters in which they form, by either halting or stimulating further star formation. They also provide information about Galactic abundance gradients. An important strength of the GES in this context is the homogeneity of the data set that will be available: all clusters will have been analysed with the same codes, using the same atomic data, and the same analysis techniques.

The **first session** of the meeting set the stage by introducing the Gaia-ESO Survey (GES) and its Workgroup 13 (WG13), which is responsible for the spectrum analysis of the O-, B- and A-type stars. GES currently has over 400 co-investigators from more than 95 institutes. Almost two-thirds of the observing runs have been done. The data include 28 clusters, covering a large range in galacto-centric distance and age. 34 refereed papers have been prepared (2/3 accepted/published), but none so far on massive stars.
WG 13 currently consists of four groups (called “nodes”) that use their own codes to analyse the spectra. More nodes will participate to the next data release. An important step in the procedure is that the results of these four nodes, as well as those from the other workgroups, need to be homogenized. This means that for any star, only a single set of “recommended” parameters is determined. Only these recommended parameters can be used in publications.
An important GES target for the massive-star community is the Carina nebula region. About 100 O stars are expected to be observed in this region (data were taken while the Workshop was in progress). In combination with existing data, this will result in a very complete dataset. A complication is the high nebular background, which is also spatially variable.
Automated spectral analysis of the data is important for such a large dataset. Such techniques have been used already on the VLT-Flames Tarantula Survey data. A large grid of models calculated with the non-LTE code CMFGEN was used to study the O-WNh transition region. A stronger dependence of the mass-loss rate on the Eddington factor is found for the WNh stars than for the O-type stars.
Another approach is taken by the GSSP (Grid Search in Stellar Parameters). It is based on a large set of LTE models. Best-fits to the data are derived by running the LTE SynthV line-synthesis code and comparing the resulting spectra to the observed ones. GSSP can handle both single and binary stars. The GSSP code is planned to be applied to the massive stars in the next GES data release.

The **second session** concentrated on the spectral analysis techniques for massive stars.
Results on A-type stars were presented from the ROB node, which studied A-type stars in two clusters and determined stellar parameters, abundances and micro-turbulence. This was done using a detailed spectrum synthesis with the SCANSPEC LTE code, based on a fine grid of ATLAS9 models. Considerable care was taken to re-normalize the spectra. An interesting science result is that a maximum micro-turbulence is found around Teff=8000 K. There are strong indications that this is physically linked with the maximum energy flux at the top of the convection zone in the models. Work is also ongoing on studying benchmark stars for the hotter temperature range.

Another technique to determine the stellar parameters of A-type, as well as B-type stars, is the PCA (Principal Component Analysis). This procedure has the advantage that it is automated. It has been applied to a subset of the GES data on massive stars.
A-type stars exhibit large star-to-star variations in their abundances. These abundance patterns tell us a great deal about transport processes in stellar interiors. Microscopic diffusion and macroscopic transport need to be added to standard evolutionary models to study these processes.
Magnetic chemically peculiar (Cp) stars show a decline of the magnetic field strength with age. Using evolutionary models, the evolution of the number distribution of Cp stars can be followed. This shows that these stars should already have their Cp characteristics as they arrive on the main sequence. This is a strong hint for the fossil origin for the magnetic field.

Results for B-type stars were derived by the WG13 Liege node. The stellar parameters of stars in NGC 3293 and Trumpler 14 are derived from a global fitting of the spectrum with a grid of non-LTE TLUSTY synthetic spectra The chemical abundances then follow from a spectral synthesis of selected wavelength regions. The procedure is not automated. The results show no clear evidence for any nitrogen-rich stars. Abundances in NGC 3293 are consistent with those reported by the VLT-FLAMES Survey of Massive Stars.
The cluster NGC 6067 contains 2 Cepheids, 13 luminous red stars, 15 B-giants and 2 A-supergiants. The age of the cluster was determined by isochrone fitting, and stellar parameters were determined using the StePar code. Abundances for some elements were also determined.
A detailed analysis of the spectral and photometric information of B stars allows us to derive effective temperature, surface gravity, micro- and, macro-turbulence, projected rotational velocity, chemical abundances, bolometric correction, colour excess, reddening, distance, mass, luminosity, and radius. Many sources of systematic uncertainties need to be taken into account. A further complication is the presence of an (undetected) binary companion. In such case, inconsistent results between various indicators could suggest the presence of such a binary companion. A reliable analysis requires several manual iterations and is very time consuming (1-2 stars per day). Attempts have been made to automate the process, but full automation is not yet possible.
Cepheids are the evolutionary descendants of B-type stars. Binary companions to these stars can be detected in a variety of ways: by high-spatial resolution observations by HST or ground-based adaptive optics. Alternatively, one can look for X-ray emission from a late-type companion.
Evolved massive stars were studied in W33 and in GMC 23.3-0.3. W33 hosts a population of massive O 4-7 stars with ages of about 2-4 Myr, and pre-stellar cores: this is clear evidence for sequential star formation. G23.3-0.3 has one of the longest star-formation histories.

The VLT-FLAMES Tarantula Survey has given us considerable information about the fraction of binary stars and the distribution of rotational velocities of O-type stars. Combining this information with evolutionary calculations shows that. rapidly spinning O stars must have had a binary interaction history. O-type stars are therefore never formed spinning rapidly.
The WG13 IAC node has worked on the analysis of O-type spectra from the GES. They use IACOB-GBAT, a fast, automatic tool that fits spectra with FASTWIND models. Compared to other surveys, the GES survey is limited in wavelength range (for the Giraffe data, which are the majority of the data). Tests with IACOB data limited to the Giraffe wavelength coverage show that GES has larger error bars, or more upper/lower limits. It also affects the He abundance determination for a fraction of the stars. The stellar parameter distributions of the stars studied so far in Carina are consistent with Galactic standards and stars. More observations of O-type stars are needed; this is currently underway.
The Liege node also studied the O-type stars, They first removed the SB2 binaries. CMFGEN models were used to fit the spectra of the presumably single O-type stars, giving stellar parameters and CNO abundances.

The IACOB project has as its objective the collection of a large, homogeneous, high-quality spectroscopic dataset and the analysis of these data with modern tools for the quantitative spectroscopic analysis of O and B-type stars. Currently the IACOB database holds 3705 spectra of 531 stars (157 O-type + 374 B-type). In the spectral analysis, first the rotational velocity is determined, then the stellar parameters, and finally the abundances. A large range of applications was presented, which include quantitative analysis of the whole grid of O-type standards for spectral classification, the observational spectroscopic HRD of Galactic massive stars, line-broadening characterization in O and B-type stars, and assessing the pulsational hypothesis to explain the physical origin of the macro-turbulent broadening.
Evolutionary calculations can be used to find out how many stars are the product of mergers and mass transfer. Galactic O-stars are predicted to contain many post-interaction binary products. Most of these post-interaction binary products appear as single stars.

Previous large surveys of massive stars are the VLT-Flames Survey of Massive Stars in the Magellanic Clouds and the Milky Way (Flames-I), and the VLT-Flames Tarantula Survey (Flames-II). From the first of these surveys, many things were learnt: massive star evolution is much more complicated than previously thought (e.g. the Hunter Diagram); binaries are everywhere; not enough O-stars were observed; selection effects are very hard to model; a ‘blind’ multi-epoch spectroscopic survey of many O-stars is needed to cover the phase space. The Flames-II survey had 1000 targets. Additionally, HST was used to study R136. In comparison to this, the GES seems to be still in the Flames-I stage. The Carina region could serve as a Milky Way Massive Star Deep Field. It is important to observe ‘everything’, in order to avoid the hard-to-model selection effects. When the Gaia results come along they will enable a complete 3D map of that star formation region (which cannot be done in the LMC).
For the spectral analysis of Wolf-Rayet stars, the PoWR code can be used. This code includes the calculation of non-LTE population numbers, the full radiative transfer in the co-moving frame, the hydrodynamically consistent treatment of the quasi-hydrostatic layers, and the effect of clumping. An important conclusion is that the Galactic picture of WRs differs from that in other galaxies. To solve this mystery, more accurate distances are a keystone ingredient, which Gaia can deliver.
The stellar winds of massive stars are studied with the Armagh code. Clumping is an important ingredient in this, and it is clear that this clumping already starts in the photosphere. An important result is the kink found in the mass-loss rate versus Eddington factor relation: for WN-h stars the relation is much steeper than for O-type stars.

The **third session** discussed the evolution of massive stars. Massive star evolution is determined by many parameters, including mass loss, wind clumping, overshooting, rotation, magnetic fields and interactions in close binaries. Modelling needs to include convection, which introduces additional parameters, so it needs to be calibrated against observations, such as number statistics or asteroseismology. The number statistics is an area where the GES can play an important role. Theoretical modelling of the secular evolution will remain largely in 1D, but certain effects could be modelled in 3D and then introduced in parameterized form in the 1D code.
Atomic diffusion and its resulting thermohaline mixing in A- and B-type stars is another process that influences the structure of the star, leading to important consequences for surface abundances and stellar oscillations.
It is challenging to compare interior models of massive stars and observations, because the stellar wind and atmosphere hide the interior. The solution is to plug in an atmospheric code in the evolution models. This allows a much better comparison between evolutionary and spectroscopic phases. Radiative transfer modelling can also be used to study the progenitors of supernova explosions.
Stellar evolution calculations can also be used to find out the final fate of massive single stars and stars that are member of a binary system.

Low-metallicity evolutionary tracks (from the updated PARSEC code) of massive and intermediate-mass stars have been used to test canonical stellar evolution in nearby star forming dwarf galaxies. This is needed to validate two important uncertainties: mass-loss rate and internal mixing. This is done by comparing synthetic colour-magniitude diagrams to the observed ones of three dwarf galaxies.

The **fourth session** put the massive stars in the cluster and galactic context.
Because clusters contain enough stars to populate parts of the colour-magnitude diagram (CMD) that usually only contain a handful of stars (due to rapid phases of stellar evolution), they can be used for stringent tests of isochrones. Some of these clusters have CMDs that suggest extended star formation histories. However, a distribution of rotation rates can also explain the observations.
Sco-Cen OB2 is one of the many associations in the Gould Belt. It shows clear evidence of sequentially triggered star formation. This was checked by determining the membership and age of the Sco-Cen OB2 stars.
The Syclist toolbox is intended to model populations of massive stars. Its basis is a new grid of stellar evolution models. These synthetic populations can be compared with observed ones, to constrain parameters of the stellar evolution models. The Syclist toolbox has been made publically available.
Dynamical ejection of O-type stars from clusters was studied with direct N-body calculations. Moderately massive clusters, which have formed about 10 O star systems, most efficiently eject their O stars through energetic encounters between massive stars in the cluster core. The dynamical ejection process populates about 16% of all O stars to the field. The runaway fraction of all O stars produced by the dynamical ejection would be about 5%.
Radial abundance gradients do exist in the Galactic Disk, but they are not well constrained. It is not clear what the value of the slope is. There could also be a break in the slope, and the slope might evolve with time. Specifically for B-type stars, the main difficulties are that most of them rotate fast, and the analysis is very difficult for rotational velocities above 100 km/s. Also, most B stars are in binary/multiple systems. In all, this leaves only about 30% of any unbiased sample suitable for chemical analysis, which has to be done in non-LTE.
N-body simulations can be used to study the evolution of clusters containing massive stars. These massive stars turn out to be extremely useful probes of initial conditions and the fraction of stars entering the field depends more on initial conditions of star formation than anything else. Velocity information from Gaia and ground-based surveys may provide further constraints.
While the massive stars influence the cluster, the cluster also influences the massive stars, even more so than the low-mass stars. Because of the cluster environment, there is a high likelihood of capture-induced binarity. Orbital decay might be the reason for the large fraction of close massive binaries. There are indications that different environments lead to differences in the most massive stars.
The VPHAS+ survey has been used to search for new OB candidates in the Carina Arm around Westerlund 2. In this way, a factor of ~10 more new OB stars down to g = 20 were found. Tests were performed to confirm that the method works with high reliability.
Most massive stars belong to a binary or a higher-multiplicity system. A combination of spectroscopic and interferometric observations allows a full coverage of the relevant periods. Binary fractions are so high that one should be wary of a single star: it could be an undetected binary, or the product of binary evolution, or a runaway (i.e. an ex-binary).
Because of these high binary fractions, and because of the important influence of binaries, theoretical population study of massive stars should include the effect of binaries.
Binaries can also be looked at in detail. A detailed analysis of eclipsing and spectroscopic binaries provides accurate astrophysical quantities. Abundances can be determined from disentangled individual spectra of components. Evolutionary models can be calibrated for masses, effective temperatures and rotation.

3) Assessment of the results and impact of the event on the future directions of the field

The workshop successfully achieved its aims of presenting the GES results to a wider community of massive-star experts and getting feedback from that community. This feedback from the various European massive-star groups allows us to improve our analysis techniques and to sharpen the focus on what is most relevant for the massive-star community.

In this respect, the major conclusions of the meeting are:
- **The high importance of the Carina region observations**
- **The necessity of completeness of these observations**
- **even if this would mean than no further massive-star clusters would be observed.**

These conclusions were the main result of the two discussion sessions held during the meeting.

From the discussions, it became clear that, with its substantial number of young massive O-type stars, the Carina nebula region will become a Rosetta stone, on a par with the Tarantula nebula for the LMC. What will make the Carina region unique is that Gaia data will provide a 3D view of this region, allowing to disentangle the projection effects along the spiral arm. An important point is that the data will be homogeneous, due to the design of the Gaia-ESO Survey. Another important point is that the observations should be complete, in the sense that no pre-selection should be done and that every object should be observed. This condition is fulfilled by the Gaia-ESO Survey observations, because they are basically complete for stars earlier than B3 (except for some heavily obscured stars), and are complete to mag ~ 13.5. There are complementary observations that go even deeper (but do not cover such a large area), going for the pre-main-sequence stars.

An additional grating (HR4, covering the Hγ line) for the early-type stars is strongly recommended. Using Gaia-ESO Survey observing time to complete the data in this way is considered more important than doing more clusters. It should also be explored if the additional grating helps for the B-type stars. For the sake of consistency, we would then need to redo the other massive-star clusters as well with this additional grating.

We will also be able to determine the binary fraction in the Carina nebula region. For more detailed information about the binary orbital parameters, a follow-up programme would be needed. Such follow-up programmes would need the Flames instrument. But Flames will be decommissioned. We should join the existing protest against this decommissioning.

Another point which was much discussed at the meeting was overshooting. The question was raised if you can use the Gaia-ESO Survey data to improve our knowledge of overshooting. You would need several tens/hundreds of stars to measure the main-sequence width, which would constrain overshooting. Besides the high quantity, data would also need to be of high quality, and homogeneous. Asteroseismology would help for overshooting (as well as rotational mixing). It is still unclear if you can extend this from the lower-mass stars to the higher-mass ones. You can also use eclipsing binaries. Constraining overshooting will require all three: asteroseismology, eclipsing binaries and large samples of stars.

The Gaia-ESO Survey is not optimized to look for binarity (only two epochs at best). But talks at the meeting showed that also on a single spectrum you can recognize, or suspect, the presence of a companion. Triple systems (probably hierarchical) also play a role.

In the cool-star part of the GES, benchmark stars are used to homogenize the results. The massive-star community at the meeting was skeptical whether this was the good approach for massive stars. Rather than using benchmark stars, it seems more obvious to split the temperature domain in segments that can be covered by the different model codes. But the overlap region between these codes is important for homogenization purposes. Data from various projects (such as IACOB) can be used to define a set of benchmark stars for the earliest stars.

On the practical side, the talks will be made available on the website dedicated to the workshop; no printed proceedings are provided.

4) Annexes 4a) and 4b): Programme of the meeting and full list of speakers and participants

Annex 4a: Programme of the meeting

Tuesday 5 May 2015

08:45-09:10 *Registration*
09:10-09:20 Ronny Blomme *Welcome*

Session 1: Gaia and GES

Chair: J. Vink

09:20-09:50 **Sofia Randich** ***Status of the Gaia-ESO Survey***
09:50-10:10 Ronny Blomme *GES-WG13: OBA star spectrum analyses*
10:10-10:40 **Jesús Maíz Apellániz** ***Observational planning and spectral classification***

10:40-11:15 *Coffee break*

11:15-11:35 Joachim Bestenlehner *Automated spectra analysis for a large sample of stars*
11:35-11:55 Andrew Tkachenko *Grid Search in Stellar Parameters (GSSP) code: a state-of-the-art software for the analysis of high-resolution stellar spectra*

Session 2: Spectral analysis of massive stars

11:55-12:25 **Alex Lobel** ***Spectral analysis of A-type stars in the GES***
12:25-12:45 Richard Monier *The A stars abundance patterns in open clusters and constraints on current evolutionary models*
12:45-13:05 Marwan Gebran *Fundamental parameters and chemical abundances of B and A stars in open clusters*

13:05-14:30 *Lunch*

Chair: S. Randich

14:30-15:00 **Thierry Morel** ***Spectral analysis of B-type stars in the GES***
15:00-15:20 Martin Netopil *The evolution of chemically peculiar stars*
15:20-15:40 Hugo Tabernero *Stellar Parameters of red giants: a new flavour of the StePar code*
15:40-16:00 Javier Alonso *Spectroscopic study of NGC6067*

16:00-16:35 *Coffee break*

16:35-17:05 **Maria Fernanda Nieva** ***Spectrum analysis for early B-type stars: stellar parameters and abundances***
17:05-17:25 Nancy Evans *Companions and Clusters: X-ray Certified*
17:25-17:45 Maria Messineo *Evolved massive stars in W33 and in GMC 23.3-0.3*
17:45-18:05 Alex de Koter *Rotation & rotational mixing in massive stars*

Wednesday 6 May 2015

Chair: A. Lobel

Session 2: Spectral analysis of massive stars (continued)

09:00-09:30 **Artemio Herrero** ***Spectral analysis of O-type stars in the GES***
09:30-09:50 Laurent Mahy *O and early B stars in the GES analysed by CMFGEN*
09:50-10:10 Sergio Simón-Díaz *The IACOB project: a new era in the study of Galactic massive stars*
10:10-10:30 Selma de Mink *Mergers hiding in the ESO-Gaia Survey*

10:30-11:05 *Coffee break*

11:05-11:35 **Danny Lennon** ***Tarantula Surveys with VLT-Flames, Hubble and Gaia***
11:35-11:55 Andreas Sander *Modeling the spectra of Wolf-Rayet and other hot massive stars*
11:55-12:15 Jorick Vink *Mass-loss rates of massive stars with GES*

12:15-13:05 Discussion (led by R. Blomme)

13:05-14:30 *Lunch*

Chair: S. Van Eck

Session 3: Massive star evolution

14:30-15:00 **Sylvia Ekström** ***Stellar evolution of massive stars***
15:00-15:20 Morgan Deal *Instabilities induced by element accumulation inside A and B stars: their internal structure and evolution revisited*
15:20-15:40 Jose Groh *Effects of mass loss on the evolution and death of massive stars*
15:40-16:00 Ilka Petermann *On the evolution and remnants of massive single and binary stars*
16:00-16:20 Jing Tang *New PARSEC evolutionary tracks of massive stars at low metallicity: testing canonical stellar evolution in nearby star-forming dwarf galaxies*

16:20-16:55 *Coffee break*

19:45 *Social dinner*

Thursday 7 May 2015

Chair: A. de Koter

Session 4: Massive stars in the cluster and galactic context

09:00-09:30 **Nate Bastian** ***Massive stars in the cluster context***
09:30-09:50 Guo Difeng *The Sco-Cen OB association*
09:50-10:10 Cyril Georgy *Modelling massive stars populations*
10:10-10:30 Seungkyung Oh *The dynamical ejections of O stars from young star clusters: the origin of field O stars*

10:30-11:05 *Coffee break*

11:05-11:35 **Simone Daflon** ***Galactic abundance gradient***
11:35-11:55 Richard Parker *Using massive stars as probes of star formation*
11:55-12:15 Susanne Pfalzner *How the cluster environment influences the formation of massive stars*
12:15-12:35 Michael Mohr-Smith *New OB star candidates in the Carina Arm around Westerlund 2 from VPHAS+*

12:35-14:30 *Lunch*

Chair: G. Rauw

14:30-15:00 **Hugues Sana** ***Binarity in clusters***
15:00-15:20 Dany Vanbeveren *The evolution of massive close binaries: the effect on overall massive star population synthesis*
15:20-15:40 Kresimir Pavlovski *Quantitative spectroscopy of stars in close binary systems*

15:40-16:30 Discussion (led by J. Vink)

16:30 *End of workshop & Coffee*

Annex 4b: Full list of speakers and participants

(I) = invited speaker; (C) = contributed talk; (P) = participant

(C) Javier Alonso	Universidad de Alicante, Spain
(I) Nate Bastian	Liverpool John Moores University, Liverpool, UK
(C) Joachim Bestenlehner	Max Planck Institute for Astronomy, Heidelberg, Germany
(C) Ronny Blomme	Royal Observatory of Belgium
(P) Constantin Cazorla	Université de Liège, Belgium
(I) Simone Daflon	Observatorio Nacional, Rio de Janeiro, Brazil
(C) Alex de Koter	Anton Pannekoek Institute for Astronomy, Netherlands
(C) Selma de Mink	Anton Pannekoek Institute for Astronomy, Netherlands
(C) Morgan Deal	Université de Montpellier, France
(I) Sylvia Ekström	University of Geneva, Switzerland
(C) Nancy Evans	SAO, Cambridge, USA
(P) Yves Frémat	Royal Observatory of Belgium
(C) Marwan Gebran	Notre Dame University - Louaize, Lebanon
(C) Cyril Georgy	Keele University, UK
(P) Eric Gosset	Université de Liège, Belgium
(C) Jose Groh	University of Geneva, Switzerland
(C) Difeng Guo	Anton Pannekoek Institute for Astronomy, Netherlands
(I) Artemio Herrero	Instituto de Astrofísica de Canarias, Spain
(P) Gonzalo Holgado Alijo	Instituto de Astrofísica de Canarias, Spain
(I) Danny Lennon	ESAC, Madrid, Spain
(I) Alex Lobel	Royal Observatory of Belgium
(C) Laurent Mahy	Université de Liège, Belgium
(I) Jesús Maíz Apellániz	Centro de Astrobiología (CSIC-INTA), Madrid, Spain
(P) Aleksei Medvedev	Saint Petersburg State University, Russia
(P) Thibault Merle	Université de Bruxelles, Belgium
(C) Maria Messineo	Max-Planck-Institut für Radioastronomie, Bonn, Germany
(C) Michael Mohr-Smith	University of Hertfordshire, UK
(C) Richard Monier	LESIA Observatoire de Meudon, France
(I) Thierry Morel	Université de Liège, Belgium
(P) Yael Nazé	Université de Liège, Belgium
(C) Martin Netopil	Masaryk University, Brno, Czech Republic
(I) Maria Fernanda Nieva	University of Innsbruck, Austria
(C) Seungkyung Oh	University of Bonn, Germany
(C) Richard Parker	Liverpool John Moores University, Liverpool, UK
(C) Kresimir Pavlovski	University of Zagreb, Croatia
(C) Ilka Petermann	Université de Liège, Belgium
(C) Susanne Pfalzner	Max-Planck-Institut für Radioastronomie, Bonn, Germany
(I) Sofia Randich	INAF-Osservatorio Astrofisico di Arcetri, Firenze, Italy
(P) Gregor Rauw	Université de Liège, Belgium
(P) Sara Rodríguez Berlanas	Instituto de Astrofísica de Canarias, Spain
(P) Frédéric Royer	GEPI, Observatoire de Paris, France
(I) Hugues Sana	Space Telescope Science Institute, Baltimore, USA
(C) Andreas Sander	Institute for Physics and Astronomy, Potsdam, Germany
(C) Sergio Simón-Díaz	Instituto de Astrofísica de Canarias, Spain
(C) Hugo Tabernero	Universidad de Alicante, Spain
(C) Jing Tang	SISSA, Italy
(C) Andrew Tkachenko	KULeuven, Belgium
(P) Sophie Van Eck	Université Libre de Bruxelles, Belgium
(C) Dany Vanbeveren	Vrije Universiteit Brussel, Belgium
(C) Jorick Vink	Armagh Observatory, Northern Ireland