Scientific Report
Summary

On 23 & 24 June 2011 the ESF funded workshop “Stellar Atmospheres in the Gaia Era: Quantitative Spectroscopy and Comparative Spectrum Modelling” was organized at the Vrije Universiteit Brussel (VUB). A total number of 47 international researchers attended the workshop, mainly from European countries, although two scientists from the Academy of Sciences in Beijing, China were also present. The workshop followed the GREAT-ESF Plenary Meeting 4 (PM4) which was held 21-23 June at the Université Libre de Bruxelles (ULB). It allowed the PM4 attendees of various GREAT Working Groups (WGs) interested in the scientific program of the workshop to conveniently attend both meetings at the ULB and VUB during the same week without separate travel. The chief goal of the workshop was to enhance synergy between the Stellar Atmospheres Working Group (WGB4) and other GREAT WGs. The scientific presentations and discussions at the workshop addressed important topics in spectrum synthesis methods and detailed line profile calculations urgently needed for accurate modelling of ESA-Gaia spectra. It brought together leading scientists and students of the stellar physics communities investigating hot and cool star spectra. The workshop addressed and identified key areas for the improvement of model spectra from various modern spectral synthesis codes required to determine reliable physical parameters of hot and cool stars. The scientific (oral and poster) presentations and the discussion sessions at the workshop will be published in a peer reviewed science journal: IOPScience Journal of Physics: Conference Series (JPCS) at Bristol, UK. The workshop proceedings are edited by the workshop organizers (the LOC): Drs. A. Lobel (Royal Observatory of Belgium), J.-P. De Greve (VUB), and W. van Rensbergen (VUB). Co-sponsorship for the organization of the workshop was provided by the Research Foundation – Flanders (FWO-Flanders).

The scientific programme was composed of four chaired sessions (one morning and afternoon session per workshop day). Four invited speakers opened each session with 40 min. oral presentations, followed by 4 or 5 contributed 20 min. talks. The first day of the workshop focused on cool stars research, while the second day on hot stars. Two extra speakers were invited to report on ongoing research activities and results about stellar spectral libraries currently compiled in Gaia Coordination Unit 8 (CU8) by the Data Processing and Analysis consortium (DPAC), and on the development of automated classification algorithms for stellar spectra by the Generalized Stellar Parametrization (GSP-Spec) group within DPAC-CU8. Workshop attendees asked questions after each talk allowing for brief discussions with the speakers. The workshop programme incorporated four 30 min. general discussion sessions at the end of each morning and afternoon session. These main discussion sessions addressed a number of important science questions about current stellar atmospheres research that were requested from the registered participants prior to the workshop. Everyone participating in the discussion sessions was asked to write down (using special forms) answers to various questions that came up during the debates. The recorded discussions will be included in edited format in the JPCS workshop proceedings. Eleven participants presented a poster at the workshop. The posters were on display in a separate poster room at the VUB for both days of the workshop. Coffee, refreshments, and cake were served in the poster room. The scientific posters were complemented by seven promotional ESA posters about the Gaia mission overview,

observations, instruments, catalog, data processing & analysis, and science results. The scientific programme was closed by the convenor with the Workshop Summary, which provided a comprehensive (40 min.) overview of new research results presented at the workshop.

The financial support provided by the ESF and the FWO-Flanders allowed to cover the travel and accommodation expenses of 6 invited speakers (all SOC members). The travel expenses of one contributed speaker, and the accommodation expenses of another were also partially covered on request, allowing both researchers to attend the workshop. The workshop organizers negotiated a reduced room rate with a block reservation at a nearby hotel. For 13 workshop participants who booked a room, 30 % of the hotel expenses were covered, making the overall costs also affordable to students in the month of June (high season). In addition, two lunches at the VUB restaurant and four coffee breaks for all participants were offered without having to charge a workshop registration fee. The ESF and FWO-Flanders grants also covered the proceedings publication costs.

Scientific content and description of discussion

The scientific programme of the workshop consisted of talks (and posters) about cool stars (23rd June; *Comparative Spectrum Modelling and Quantitative Spectroscopy of Cool Stars*), and hot stars (24th June; *Quantitative Spectroscopy of Hot Stars*). The sessions of the first day highlighted new research results with the PHOENIX, MARCS, and MOOG spectral synthesis codes for cool stars, however also discussing advanced spectroscopic instrumentation in the Gaia Era. The sessions of the second day focused on new results with the ATLAS, TLUSTY, and CMFGEN synthesis codes applied for modeling the spectra of hot stars. Interestingly, during the second day a substantial number of presenters also addressed very recent research initiatives (with some preliminary results) for large spectroscopic surveys to support and/or complement future Gaia data analysis. The complete programme is available in the workshop website at http://great-esf.oma.be . It also offers the conference photograph, all paper abstracts & presentation viewgraphs in PDF format, and some nice photographs of the talks and poster breaks. A URL link to accepted papers published Open Access online-only (free to download and fully citable) by JPCS will be incorporated as soon it is publicly available (expected publication date: Dec. 2011). The Astrophysics Data System was contacted for on-line indexing of the JPCS workshop proceedings in the ADS.

Thu 23 June 2011

Quantitative Spectroscopy and Comparative Spectrum Modelling of Cool Stars

09:00 Welcome & Practical info by VUB Local Organizing Committee

Session 1: (Chair A. Korn)
09:10 U. Heiter: *Comparative Modelling of the Spectra of Cool Giants*

09:40 P. Hauschildt: *The PHOENIX Model Atmosphere Package*
10:20 M. Bergemann: *Non-LTE Line Formation of Fe-peak Elements and Application to Large-scale*

Stellar Surveys

10:40 Coffee break & Poster viewing
11:10 R. Collet: *The StaggerGrid Project: a Grid of 3D Model Atmospheres for High-precision Spectroscopy*
11:30 T. Aparicio Villegas: *Stellar Physics with the ALHAMBRA Photometric System*

11:50 A. Quirrenbach: *Spectroscopic Instrumentation in the GAIA Era*

12:10 Discussion Session I

12:30 Lunch at VUB restaurant

Session 2: (Chair U. Heiter)

13:30 B. Plez: *Model Atmospheres and Spectra for Cool Stars: Comparisons of MARCS and Other Brands of Models*
14:10 R. Sordo: *Libraries of Synthetic Spectra in the Gaia Mission*

14:50 A. Recio-Blanco: *Automatic Stellar Spectra Parametrisation in the IR Ca II Triplet Region*

15:20 Coffee break & Poster viewing
15:50 G. Pace: *The Metallicity Scale of Dwarf and Giant Stars*
16:10 N. Gorlova: *Abundance Analysis of Post-AGB Stars*
16:30 D. Montes: *High-resolution Spectroscopy of FGK Nearby Stars: Stellar Parameters and Chemical Tagging*
16:50 Discussion Session II

17:15 Poster viewing until **18:00**

Fri 24 June 2011

Quantitative Spectroscopy of Hot Stars

09:00 Practical info by VUB Local Organizing Committee

Session 3: (Chair A. de Koter)

09:10 N. Przybilla: *A Comprehensive Test of Common Hydrostatic LTE and non-LTE Model Atmosphere/Line-formation Codes for Quantitative Spectroscopy of Early-type Dwarfs and Giants*
09:50 N. Walton: *VAMDC: The Virtual Atomic and Molecular Data Centre*
10:10 T. Dall: *Modelling Rotating Geometrically Distorted Stars with Inhomogeneous Surface Features*
10:30 Coffee break & Poster viewing
11:00 F. Nieva: *High-precision Stellar Parameter and Abundance Determinations of OB Dwarfs and BA Supergiants*
11:20 R. Hudec: *Tests of Simulated Gaia Bp/Rp Spectra with LDS (Low Dispersion Spectroscopy) Photographic Sky Surveys*
11:40 R. Blomme: *Hot Stars in the Gaia-ESO Public Survey*

12:00 Discussion Session III

12:20 Lunch at VUB restaurant

Session 4: (Chair A. Herrero)

13:30 J. Groh: *Modeling the Wind and Photosphere of Massive Stars with the Radiative Transfer Code CMFGEN*
14:10 S. Simon-Diaz: *The IACOB Project (WP3: Quantitative Spectroscopic Analysis of Galactic OB stars)*
14:30 Coffee break & poster viewing (removing of posters from 15:00)

15:10 A. de Koter: *The VLT-FLAMES Tarantula Survey*
15:30 Y. Chen: *XSL: The X-Shooter Stellar Library*

15:50 Discussion Session IV

16:10 Summary of Workshop (A. Lobel)
16:40 Workshop closing and Farewell by VUB LOC

Workshop Posters:

P1 S. Van Eck: *A Grid of MARCS Model Atmospheres for S Stars*
P2 T. Morel: *Using CoRoT and Kepler Targets as Benchmarks for Spectroscopic Analyses of Cool Stars*
P4 J. Maldonado: *Spectroscopic Properties of Stars with Circumstellar Debris Discs*
P5 A. Chiavassa: *3-D Hydrodynamical Model Atmospheres: A Tool to Correct Radial Velocities and Parallaxes*
P6 L. Mahy: *A Quantitative Study of the O Stars in NGC 2244*
P7 F. A. Stap: *Quantitative IR Spectroscopy of Massive Stars*
P8 J. Zhang: *Stellar Parameter Estimation for the LAMOST Survey*
P9 P. Koubsky: *Gaia RVS Spectroscopy of Be Stars*

P10 P. Neyskens: *Abundance Patterns in S-type AGB Stars to Set Constraints on Nucleosynthesis and Stellar Evolution Models*

P11 A. Jorissen: *Chemically Tagging the Hyades Stream: Does it Partly Originate from the Hyades Cluster?*

The workshop started with an introductory talk about the Gaia satellite, the mission schedule, instruments design, an overview of its science goals, and the expected Gaia data products & analysis. Next, new results were discussed of the GREAT-ESF Stellar Atmospheres Workshop on Comparative Spectrum Modelling in Vienna of Aug 2010. Observed spectra of cool giants were modelled by 14 research groups with different atmospheric models and analysis approaches. For example, for α Tau the resulting atmospheric parameters effective temperature (Teff), atmospheric acceleration (log g), and metallicity ([Fe/H]) were found to vary by 200 K, 0.1, and 0.5 dex, respectively. However, the scientific scope of the VUB workshop was much broader and the oral and poster contributions can be grouped into five major research activities on stellar atmospheres:

1. Spectrum Synthesis Codes
2. Radiation Hydrodynamics Codes

3. Atmospheric Parameters, Abundance, Metallicity, & Chemical Tagging Studies
4. Large Spectroscopic Surveys
5. New Atomic Database

The talks on spectrum synthesis codes discussed important topics in spectrum synthesis methods and detailed line profile calculations urgently needed for the accurate modelling of Gaia spectra of cool and hot stars. The cool and hot stars communities use different spectrum modelling codes for determining basic parameters such as Teff, log(g), [Fe/H], and the chemical composition of stellar atmospheres. The invited speakers are leading developers of mainstream spectrum synthesis codes for cool stars (PHOENIX & MARCS), and for hot stars (TLUSTY, ATLAS, and CMFGEN). During the presentations they addressed important science issues by comparing detailed model spectra to identify important differences that can influence and bias the resulting atmospheric parameters . Theoretical line-blanketed model spectra were compared in detail to high-resolution spectroscopic observations. Stellar spectra computed (i.e., in the Gaia Radial Velocity Spectrometer wavelength range) with 1-D model atmosphere structures were mutually compared, but also to 3-D models from advanced radiation hydrodynamics codes. Atmospheric parameters derived from spectrum synthesis calculations assuming Local Thermodynamic Equilibrium (LTE) were evaluated against more sophisticated non-LTE models of metal-poor stars and the extended atmospheres of giants and supergiants.

Gaia will observe a billion stellar objects in the Galaxy and provide spectrophotometric and high-resolution spectra of an unprecedented amount of stars observed with a space-based instrument. The confrontation of these data with theoretical models will drastically advance our understanding of the physics of stellar atmospheres. New stellar populations such as previously unknown emission line stars will be discovered, and fundamental questions such as the basic scenarios of stellar evolution will be addressed with Gaia data. Contemporary theoretical models of high-resolution stellar spectra are however seriously hampered by systematic uncertainties due to inadequate input physics and inaccurate or incomplete atomic data. The second day included a contributed talk about a new atomic database (VAMDC) for stellar astrophysics, available on-line by 2012. During the main discussion sessions important questions were addressed such as: *what are the most important atomic and molecular data that should be improved or determined for realistic modelling of hot and cool star spectra? Which species and/or which type of data, e.g. level energies, transition probabilities, line broadening parameters, ...; what wavelength region?* A number of answers to these questions were discussed amongst the workshop participants, which will also appear in the workshop proceedings.

On the first day an invited speaker presented an overview of high-resolution synthetic spectral libraries of model spectra computed with the synthesis codes. The spectral model girds will be utilized to derive stellar parameters with the Discrete Source Classifier Algorithms currently under development in Gaia DPAC-CU8. They are implemented in the “Stellar Population Code” to train the Gaia data analysis algorithms for the classification of a wide variety of cool and hot star types; FGK & M stars, OB stars, white dwarfs, red supergiants, peculiar A and B stars, carbon stars, ultra cool dwarfs, various types of emission line stars, Be stars, Wolf-Rayet stars, etc.

A large number of talks and posters of the workshop discussed different techniques for measuring the abundance of various chemical elements from stellar spectra. The presented methods utilize spectra observed with large spectral dispersion, for example for accurately measuring [Fe/H], the abundance of carbon and nitrogen, or for example [Tc/Zr] in s-type stars. These methods are important for ongoing developments and testing of automated & supervised algorithms for determining detailed chemical composition and tagging studies in large (chemo-dynamical) spectroscopic surveys planned to complement the Gaia (astrometric and kinematic) census of the Galaxy. The Gaia-ESO Survey with VLT (FLAMES & Giraffe instruments) and the LAMOST Survey will observe the spectra of millions of stars. Smaller spectroscopic surveys of hot stars (Tarantula Survey, VLT-X-Shooter, VLT-CRIRES, IACOB project, Be-star survey, Low Dispersion Sky plate surveys) were also extensively discussed with quantitative analyses for determining stellar parameters and advanced spectral classification techniques (i.e. utilizing genetic codes).

Results

The GREAT-ESF workshop on Stellar Atmospheres in the Gaia Era held at the VU Brussels in June 2011 has considerably improved communication and established new science collaborations between members of the hot and cool stars communities, and among researchers of the GREAT WGs and the Gaia DPAC members for the development and application of advanced spectrum modelling codes. It addressed and identified key areas for the improvement of model spectra from various modern spectral synthesis codes required to determine reliable physical parameters of hot and cool stars. Its outcome forms the basis for future improvements in advanced spectrum synthesis calculations. The results represent a new milestone towards accurate stellar parameters of cool and hot stars that Gaia will observe, and for Gaia follow-up programmes.

The workshop proceedings will be published on-line in the public domain by IOPScience Journal of Physics: Conference Series. They will include a Preface by the LOC, about 33 peer reviewed science papers by the workshop contributors (talks and posters), a Workshop Summary of science results presented at the meeting, and the (4) main discussion sessions highlighting important question & answer interactions. A summary of the VUB workshop and an overview of results will be presented at the 5th GREAT plenary meeting in Rome, Italy of July 2012. The workshop proceedings and the presentations and discussions of new research results and initiatives will further stimulate and enhance scientific interaction organized by the GREAT Stellar Atmospheres Working Group B4 (currently counting 32 registered members from 24 research institutions;http://camd08.ast.cam.ac.uk/Greatwiki/WGB4StellarAtmospheres). Its co-facilitators will continue encouraging new networking activities through scientific meetings, tele-conferences, and mailing lists.

Participant list

1. T. Aparicio Villegas (Inst. Astro. Andalucia, Granada, Spain)
2. M. Bergemann (MPI for Astrophysics, Garching, Germany)
3. R. Blomme (Royal Obs. Belgium, Brussels)
4. T. Dall (ESO, Garching, Germany)
5. A. de Koter (Univ. Amsterdam, The Netherlands)
6. Y. Chen (Univ. Groningen, The Netherlands)
7. A. Chiavassa (Univ. Libre de Bruxelles, Belgium)
8. R. Collet (MPI for Astrophysics, Garching, Germany)
9. J.-P. De Greve (Vrije Univ. Brussel, Belgium)
10. N. Gorlova (Univ. Leuven, Belgium)
11. J. Groh (MPI for Radioastronomy, Bonn, Germany)
12. P. Hauschildt (Obs. Hamburg, Germany)
13. A. Herrero (Inst. Astrofisica de Canarias, Spain)
14. U. Heiter (Univ. Uppsala, Sweden)
15. A. Hervé (Univ. Liege, Belgium)
16. L. Houziaux (Royal Academy of Belgium, Brussels)
17. R. Hudec (Academy of Sciences, Czech Rep.)
18. A. Jorissen (Univ. Libre de Bruxelles, Belgium)
19. A. Korn (Univ. Uppsala, Sweden)
20. P. Koubsky (Astron. Inst. Ondrejov, Czech Rep.)
21. A. Lobel (Royal Obs. Belgium, Brussels)
22. A. Luo (Nat. Astron. Obs., Academy of Sciences, Beijing, China)
23. L. Mahy (Univ. Liege, Belgium)
24. Z. Magic (MPI for Astrophysics, Garching, Germany)
25. J. Maldonado (Univ. Autonoma Madrid, Spain)
26. T. Masseron (Univ. Libre de Bruxelles, Belgium)
27. J. Montalban (Univ. Liege, Belgium)
28. D. Montes (UCM, Univ. Complutense Madrid, Spain)
29. T. Morel (Univ. Liege, Belgium)
30. P. Neyskens (Univ. Libre de Bruxelles, Belgium)
31. F. Nieva (MPI for Astrophysics, Garching, Germany)
32. G. Pace (Univ. Porto, Portugal)
33. E. Pancino (INAF - Obs. Bologna, Italy)
34. B. Plez (Univ. Montpellier, France)
35. N. Przybilla (Obs. Bamberg, Germany)
36. A. Quirrenbach (Obs. Heidelberg, Germany)
37. A. Recio-Blanco (Obs. Cote d'Azur, France)
38. L. Sbordone (MPI for Astrophysics, Heidelberg, Germany)
39. S. Simon-Diaz (Inst. Astrofisica de Canarias, Spain)
40. R. Sordo (INAF Padova, Italy)
41. F. A. Stap (Univ. Amsterdam, The Netherlands)
42. M. Valentini (Univ. Liege, Belgium)
43. G. Van de Steene (Royal Obs. Belgium, Brussels)
44. S. Van Eck (Univ. Libre de Bruxelles, Belgium)
45. W. van Rensbergen (Vrije Univ. Brussel, Belgium)
46. N. Walton (Inst. Astronomy, Univ. Cambridge, United Kingdom)
47. J. Zhang (Nat. Astron. Obs., Academy of Sciences, Beijing, China)

List of speakers (in chronological order)

1. J.-P. De Greve (Vrije Univ. Brussel, Belgium) - LOC Welcoming
2. A. Lobel (Royal Obs. Belgium, Brussels) - Introduction & Workshop Summary
3. U. Heiter (Univ. Uppsala, Sweden)
4. P. Hauschildt (Obs. Hamburg, Germany)
5. M. Bergemann (MPI for Astrophysics, Garching, Germany)
6. R. Collet (MPI for Astrophysics, Garching, Germany)
7. T. Aparicio Villegas (Inst. Astro. Andalucia, Granada, Spain)
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14. D. Montes (UCM, Univ. Complutense Madrid, Spain)
15. N. Przybilla (Obs. Bamberg, Germany)
16. N. Walton (Inst. Astronomy, Univ. Cambridge, United Kingdom)
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