Gaia Chemo-Dynamical Survey: Survey science

Summary:

Prompted by the recognised need to secure a ground-based spectroscopic complement to Gaia, we have organized a workshop entitled "Gaia Chemo-Dynamical Survey" (GCDS) Survey science", aiming to open the initial GCDS to supporting communities, to enhance its scientific outcome and discuss its implementation across the existing and planned instruments, in particular the letters of intent that were sent in response to the ESO call for Large Public Spectroscopic Survey.

The workshop was supported by the ESF through the GREAT network, and co-supported by the French Programme National Galaxies (PNG) as well as the Laboratoire Cassiopée. **The workshop was held 2-4 november 2010 in "La Maison du Séminaire", Nice, France, and gathered a total of 50 participants, 20 of which were sponsored thanks to the ESF** (registration fees and/or local expenses and/or travel expenses). Participants included researchers from 11 countries, staff, postdocs and students. The website for the event can be viewed on:

http://cassiopee.oca.eu/spip.php?article324

The meeting was a great success both from the point of view of the attendance (50, as anticipated, and very high turn-up rate), and the high quality of talks (now available on the workshop website) and liveliness of the discussions sessions. The science case for GCDS has clearly benefited from these contributions.

One expected outcome was the organisation of the GCDS consortium, and particularly in the proposed ESO Large Public Spectroscopic Survey component, that is currently the most advanced. Many of the discussions concentrated on this aspect, and have lead to organising a steering group for the survey, a steering group coordinating efforts to prepare the spectral analysis (stellar parameters and chemical composition), that is one of the most challenging part of such a massive survey. A workshop dedicated to this aspect is foreseen for 2011.

Science Organising Committee:
Olivier Bienaymé
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Sofia Feltzing
Eva Grebel
Gerry Gilmore
Amina Helmi
Vanessa Hill (Chair)
Nami Mowlavi
Sofia Randich
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Nic Walton

Local Organising Committee:
Alejandra Recio-Blanco
Patrick de Laverny
Clare Worley
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Scientific content:

Context:

Gaia will provide an unprecedented map of the positions, kinematics and spectrophotometry of a billion stars in the Milky Way, allow a quantum leap on our knowledge of the Galaxy and its stellar populations. We will be able to dissect the different Galactic components and confront this detailed structure with models of galaxy formation and their cosmological context. The full three dimensional velocity vector of a large number of stars, and their detailed chemical composition will allow to address crucial questions such as the amount and distribution of dark matter in the Galaxy and the formation and evolution of the different Galactic components. Nonetheless, our picture of the Milky Way will be hampered in two ways: the low resolution spectrograph on-board (RVS) will not reach the same limiting magnitude as the rest of the Gaia instruments and its resolution (R=11 500 for stars brighter than about 10 and a R<6500 for fainter stars) and small wavelength coverage, are not well suited for detailed studies of elemental abundances.

Indeed, the radial velocity measurements for faint stars (i.e. distant, but also the much more numerous less evolved stars) do not match the accuracies obtained for the tangential motions (proper motions), and in particular, for very faint stars (V > 17) no radial information will be available. As a consequence, the dynamical map of the Milky Way will be incomplete and restricted to the nearby few kiloparsecs limiting the scientific impact on certain high-priority questions. Furthermore, the metallicity measurements obtained from the low resolution spectra means that the metallicity distribution function will be available from Gaia only within this sphere of influence, leading to a highly incomplete, and biased, view of the Milky Way.

Secondly, to underpin the evolution of the Milky Way requires knowledge of a time variable, which can be provided by detailed elemental abundance studies. This is much needed to understand the star formation, chemical evolution history and the coupling to the dynamics, all processes that have determined the way the Milky Way looks today. Since elemental abundances (α-elements which tell about the supernova type II, iron-peak elements which are related mostly to supernova type Ia, r- and s- process which measure the impact of winds from evolved stars) are either not provided at all by Gaia, or restricted to a small number of elements (Mg, Si, Ca, Ti, and Fe) in a limited sample of the cool stars brighter than about 12.

For all of the above reasons, wide field medium and high resolution spectroscopic surveys from ground based facilities appear as a necessary complement to guarantee the maximum scientific throughput of the Gaia mission. This need has been recognised in a number of reports, and highlighted in the Science Vision report by Astronet: “It is crucial to supplement the Gaia data-set with dedicated ground-based spectroscopic programmes, in order to obtain the radial velocity and detailed chemical abundances for fainter stars.”

The recent efforts by the GREAT network and in particular its GREAT Chemical Tagging Working Group (WGA3), and subsequent discussions with a number of other GREAT WGs (e.g. WGA1) has resulted in the proposal to form an inclusive consortium to undertake an ambitious Gaia Chemo-Dynamical Survey (GCDS) of the Milky Way. The kick-off meeting took place in Paris on the 27th of April 2010, and efforts are ongoing to lay the foundations of this very large collaborative effort. It is now time to open the discussions to a wider community, and the “GCDS: Survey Science” workshop in Nice brought together the galactic archaeology, galactic dynamics, and stellar physics communities to lay out and discuss the main science cases for the GCDS, and their best implementation across the various existing and planned instrumentation available to Europeans.

The first concrete opportunity to initiate a large survey on a GREAT-wide scale was offered by the call for Large Public spectroscopic Survey issued by ESO (in August 2010), for up to 300 night’s

worth. Particular emphasis was given to discussions over the two letters of intent which were sent 15th October 2010 by two groups under the umbrella of GREAT, in response to the call for Large Public Spectroscopic Survey (LPSS) issued by ESO. Opportunities are also arising for developing new instrumentation to suit the needs of the Gaia complement (e.g. several letters of intent answering the ESO call for new MOS instrument went out with Gaia-related science), and the workshop was timely to hear updates (or even first presentations in a Gaia context) on these new projects.

Workshop scientific programme:

The workshop was thus organised around three major issues:

1) Contributions to the science cases for GCDS, and in particular to the cases put forward in the two letters of intent sent to the ESO LPSS call. This was addressed during session II, following the four Science Experiments (SEs) that have been identified within GREAT:
   - SE1: Mass Distribution of the Galaxy
   - SE2: How did galaxies form as traced by chemistry
   - SE3: How clusters and stars formed and evolved
   - SE4: Additional Science (includes various science topics that will benefit from the survey, mainly in stellar physics -variable stars, hot stars, …)
2) Adressing the GCDS consortium organisation;
3) Contributions and discussions on future (planned/proposed) instrumentation that may contribute significantly to GCDS. This included presentations of ongoing or planned (and funded) surveys, as well as plans for future instrumentation on 4m-class telescopes (Gyes/CFHT, WEAVE/WHT, 4mMOSS/VISTA), aswell as for 8mT (IR spectrograph for VLT).

The detailed program is attached at the end of the report. Key speakers (invited) included:
Carine Babusiaux; Eva Grebel (who had to cancel at the last minute); Gerry Gilmore; Robert Jeffries; Nami Mowlavi; Alejandra Recio-Blanco; Timo Prusti; Nic Walton.

Venue:
The workshop was held in "La Maison du Séminaire" in Nice (http://www.maison-seminaire-nice.cote.azur.fr/page_en_1.html), which meeting room can accommodate up to 70 participants and is conveniently located close to the Nice harbour. Most participants took advantage of the reasonable price accommodation provided by the "Maison du Séminaire" (~65€/n).
Coffee breaks as well as lunches were organised at the meeting venue, and included in the 120€ registration fee for the workshop.

Attendance and sponsoring:
A total of 50 participants attended the workshop, which was the right size to allow for lively discussions, of which there was plenty.
Special care was taken to include participants from most GREAT-participating countries, and insure the accessibility of young researchers to the workshop by sponsoring their expenses. In total, 20 participants were sponsored to participate to the workshop (fees and/or travel and/or local expenses).

Outcome and impact of the workshop

The outcome of the workshop include :

- *Presentation of key GCDS science challenges and cross-discussions of the various Science experiments / GREAT working groups :*

The science case for GCDS has clearly benefited from the high quality of talks (presentations now available on the workshop website: http://cassiopee.oca.eu/spip.php?article324) and liveliness of the discussions sessions. The workshop was, as anticipated, an arena for different scientific ideas/strategies for the GCDS to be expressed, thus broadening significantly the initial group who laid the grounds of the GCDS science case. In particular, many additional science cases (piggy-back programs, additional science to be carried out with the same data, …) were presented. Probably the most noteworthy was the addition of interstellar medium science into the GCDS (constructing reddening maps, using the survey sample globally), which has an impact on the wavelength regions to be chosen for the surveys. The second aspect of the anticipated discussions concerned the overlap between the four science experiments in which the GCDS was divided (DE1 to SE4), and specifically, between the SE1+SE2 on the one hand, and SE3 on the other hand, that answered the ESO call for large public survey with two separate letters of intent.

- *Implementation of a response to the ESO call for Large spectroscopic Surveys.*

Perhaps the most urgent expected outcome from the workshop, was the organisation of the GCDS consortium, particularly for the proposed ESO Large Public Spectroscopic Survey component, that is currently the most advanced. Many of the discussions concentrated on this aspect, and have lead to organising a steering group for the survey, a group coordinating efforts to prepare the spectral analysis (extraction of accurate stellar parameters and chemical composition, in a fully automated fashion), that is one of the most challenging part of such a massive survey. A workshop dedicated to this latter aspect is foreseen for 2011 (to be held in Lund, Sweeden, and for which ESF support will be seeked). The spectral analysis group already agreed during the Nice workshop, on the scheme for testing various methods (developed in 5 groups across Europe), ahead of the ESO Large Public Spectroscopic Survey full proposal writing (i.e. before april 1st 2011). This activity is fully operational as this report is being written.

- Organisation of GCDS consortium on the longer/broader term

On the longer term, the GCDS should span across a variety of facilities/instruments, some of which have to be developed entirely. The workshop was timely to discuss on the various options for building a wide field highly multiplexe spectrograph on a 4m class telescope: Gyes/CFHT, WEAVE/WHT, 4mMOSS/VISTA... Technical challenges and solutions envisaged by the various instruments were discussed, particular science case focuses were exposed, that make sure that the various project don't compete with one another but are rather developed in a complementary fashion. Furthermore, this was an opportunity for the GREAT/GCDS to declare its strong interest for such projects publicly, a statement of interest that can then be used by the instrument teams to build their science case and defend their projects to funding agencies.

The workshop was also an opportunity for the students and young researchers present, to build new collaborations, and to enter the GCDS survey planning and organisation. We anticipate that these students/postdoc (and future young researchers that will be hired in the near future, including through the GREAT ITN ESR programme), will take a major role in the analysis and exploitation of the survey in the future. An early involvement, and building of European links between young researchers is clearly an asset.

Final Program of the workshop:

Tuesday 2nd November

Session I : Context, Udate on Gaia performances

9:30 - Welcome and meeting scope

9:40 - Gaia Status (T. Prusti)

10:10 - Specificities of the RVS observations, processing and performances (D. Katz)
10:30 Coffee break

Session I : Context, udate on Gaia performances

11:00 - LSST Chemo-Dynamical Survey of the Milky Way and Synergy with Gaia (Z. Ivezic)
11:20 - GREAT Intro and Status Updates; The GCDS programme (N. Walton)

Session II : VLT Spectroscopic Public Survey: Reports on the LoIs submitted to ESO

11:35 - Report from the GCDS-Milky Way (G. Gilmore)
12:10 - Report from the GGCDS-Open Cluster (R. Jeffries)
12:45 Lunch

Session II (continued): VLT Spectroscopic Public Survey: Contributions to the Science cases

14:00 - What we do not know about the halo (R. Schoenrich)
14:20 - The early evolution of globular clusters and their stellar contribution to the Galactic halo (C. Charbonnel)
14:40 - Radial velocities from the GCDS and the kinematic groups induced by the bar and the spiral arms of the MW (T. Antoja)
15:00 - Transient spiral arms and chemo-dynamics of the Galactic disk (D. Kawata)
15:20 - GAIA and 3D mapping of the ISM (R. Lallemend)
15:40 - discussions
16:00 Coffee break

Session II (continued): VLT Spectroscopic Public Survey: Contributions to the Science cases

16:30 - Old open clusters and the Galactic disk (A. Bragaglia)
16:50 - Abundance studies in massive clusters: why and how (C. Gonzales)
17:10 - Pre-main sequence stars in open clusters (A. Delgado)
17:30 - discussions
18:00 end of the day

Wednesday 3rd November

Session II (continued): VLT Spectroscopic Public Survey: Contributions to the Science cases

9:00 - SE4 in the GCDS and the contribution of chemical tagging to the exploitation of Gaia data for the study of variable stars (N. Mowlavi)
9:30 - Stellar archeology with GAIA: the galactic white dwarf population (S. Jordan)
9:50 - Cepheid distance scale in the era of spectroscopic surveys (B. Lemasle)
10:10 - A MARCS grid of stellar atmospheres for giants with 0.5<C/0<1: stellar parameters and abundance determinations (S. Van Eck)
10:30 Coffee break

Session III : VLT Spectroscopic Public Survey: survey strategies and tradeoffs

11:00 - VLT Spectroscopic Public Survey: Survey Strategy (C. Babusiaux)
11:30 - Discussions: optimizing the survey strategy; GCDS consortium organisation

Session IV : Analysing spectroscopic data: current methods & performances, needs for new developments

12:00 - Algorithms developed in the Gaia context and their applicability (A. Recio-Blanco)
12:30 Lunch

Session IV (continued): Analysing spectroscopic data: current methods & performances, needs for new developments

14:00 - Lessons from RAVE for stellar science with GCDS (T. Zwitter)
14:30 - Extracting velocities and chromospheric activity indices from fibre spectroscopy in the far red (R. Jeffries)
14:50 - SPADES: a Stellar PArameter DEtermination Sorftware (H. Posbic)
15:10 - Automated Abundance Analyses with SME — current limitations and future prospects (P. Gruyters)
15:30 - The AMBRE Project: Tests of MATISSE on large spectral datasets from the ESO archive (C. Worley)
15:50 Coffee break

Session V GCDS consortium organisation

16:30 - Discussions: organisation for the proposal stage, ESO-survey management plan
17:30 - CFHT/Gyes spectrograph (P. Bonifacio)
18:00 end of the day

Thursday 4th November

Session VI: Reports on new instrumental developments and ongoing/planned surveys

9:00 - GALEP, the EMIR survey of the Galactic plane (F. Garzon)
9:20 - Progress update for LAMOST and related surveys (M. Smith)
9:40 - Discussions: planning the GCDS in the era of other surveys (complementarity/co-operation/competition)
10:30 Coffee break

Session VI : Reports on new instrumental developments and ongoing/planned surveys

11:00 - IR multi-object spectrographs for VLT and VISTA (A. Fergusson)
11:10 - 4mMOSST - 4m Multi-Object Spectroscopic Survey Telescope (de Jong)
11:30 - WHT/WEAVE (G. Dalton)
11:50 - Science with GO-IRS: an optical multi-object spectrograph proposed for the 10.4m Gran Telescopio Canarias (D. Montes)
12:10 - Discussions: planning the GCDS beyond existing instrumentation
13:00 Lunch
14:00 end of the plenary session