

Report for the GREAT/ESF Workshop: The metallicity distribution in the Milky Way discs 29-31 May 2012, Bologna, Italy

Summary

Organizers :

Angela Bragaglia (INAF-Osservatorio Astronomico di Bologna, Italy)
Sofia Randich (INAF-Osservatorio Astrofisico di Arcetri, Italy)
Antonella Vallenari (INAF-Osservatorio Astronomico di Padova, Italy)

Scientific Organizing Committee :

Thomas Bensby (Lund University, Sweden)
Ronny Blomme (Royal Observatory, Belgium)
Patrick François (Observatoire de Paris, France)
Eileen Friel (Indiana University, USA)
Carme Jordi (Universitat de Barcelona, Spain)

All attended the meeting, except P. François due to University commitments.

Local Organizing Committee :

A. Bragaglia, S. Caddeo, O. Diodato, A. Piccioni (INAF- Osservatorio Astronomico di Bologna),
and P. Donati (Dipartimento di Astronomia, Università di Bologna)

Participants :

The participants were 55: 7 of the organizers/SOC members, 16 invited, 32 registered. Participants came mainly from Italian (24) and European (25) institutes; 6 of them came from extra-European countries (Australia, Brazil, USA). We reached a fair balance (about 50-50%) both for gender and age/career, with a few PhD students -part of whom gave talks- and many postdocs -most of whom gave talks.

Invited & contributed talks :

We invited 16 astronomers, again maintaining a fair gender and career balance, to cover with general/review talks the main topics. In total we had 21 invited talks of 25 minutes, counting also the SOC members, compared to 17 contributed talks of 15 minutes. The detailed programme is at the end of the report.

Subjects covered by the talks :

The Workshop was divided in four main sessions: a) The theorists views and wishes (stellar yields, chemical evolution models, formation of the discs); b) The current empirical scenario (structure of the discs, abundance distributions from several indicators); c) Taking the global picture (more empirical evidence and use of large samples); d) Expectations from Gaia and large Spectroscopic surveys (Gaia and present and future surveys). The Workshop presentations and results were described by A. Vallenari at the *5th GREAT Plenary Meeting*, 4-6 July 2012, Rome (Italy).

Webpage :

The general Workshop webpage is <http://www.bo.astro.it/great-esf-gradient/>.
Since there are no proceedings, a PDF file of all the talks was obtained from the speakers and linked at http://www.bo.astro.it/great-esf-gradient/participants_talks_final.html.

Location :

We had planned to use a room in the old University building in the city centre, which was free of cost for us and in a very convenient location near hotels and the Dipartimento di Astronomia / Osservatorio Astronomico. However, we could use it only the first half-day, then we had to move to other buildings for security reasons (an earthquake on May 29) and missed the first afternoon. All the talks were rescheduled, unfortunately at the cost of discussion time. We gratefully acknowledge the hospitality of the INAF-Istituto di Radioastronomia and the Dipartimento di Astronomia and Osservatorio Astronomico for the days of 30-31 May.

Description of the scientific content

How did our Galaxy form and what was the evolutionary path that led to its present structure? These are key questions that have a direct application also to the general mechanism of galaxy formation and evolution: the Milky Way is the privileged site to constrain in detail these processes, through the study of the location, kinematics, age, and chemistry of stars in the field and stellar clusters. Whilst significant progress both in theory and observations has been achieved in the last two decades a number of major problems remain open.

The next decade will witness a revolution and significant step forward in the general field of Galaxy formation and evolution, as well as of the more specific topic of the metallicity distribution in the thin and thick disc. Specifically, the Gaia mission will bring us into a new domain of studies of Galactic stellar populations. At the same time, new and homogeneous spectroscopy obtained in ground based surveys that are starting now or will start in the near future will complement Gaia astrometry and allow the measurement of abundances of several chemical elements in hundreds of thousands of stars belonging to different populations.

The community should prepare for the exploitation of the huge amount of new information that will arrive during the next decade. This is an opportune time for the presently rather disconnected communities working on specific aspects of this topic to gather together and to devise a more global and coordinated approach.

The Workshop was intended as a forum to start this preparation process, by stimulating discussion and fostering new collaborations among experts from different fields. The Workshop brought together scientists working on the different kinds of stellar populations, both observers and theoreticians, to review the current status of knowledge, to compare and discuss the different results already available, to investigate the possible systematics, to review available tools and models and to discuss possible improvements, and finally to discuss synergies to best derive a common, complete, and coherent picture of the chemical evolution of our own Galaxy.

The Workshop was divided in four sessions, three of half-a-day length and the fourth taking one whole day; they covered the theoretical scenario and expectations, the observational evidence, the future challenges.

1) *The theorists views and wishes* - Talks in the first session, dedicated to theory, focused on models of both stellar and Galactic evolution.

Specifically, the physical mechanisms leading to element nucleosynthesis in stars of different masses were reviewed by various speakers, focusing on the different types of elements. The role of rotation and metallicity were discussed and the major challenges were evidenced.

As for Galactic chemical evolution, the various processes proposed as responsible for the origin and evolution of gradients were summarized and it was discussed how models can be compared with the observed distributions. Whilst different classical models do all envisage the same formation scenario in the local disc, the same models still fail to provide a consistent picture of the formation and evolution of the Milky Way.

It has been stressed that availability of the chemo-dynamic distribution thanks to Gaia and large spectroscopic surveys from the ground will certainly allow a big step forward. At the same time it has also been discussed how the already available -and rapidly growing- observational database suggests to include in the computations mechanisms so far overlooked, such as radial mixing and merger history, and to couple chemical models with dynamical and cosmological models.

2) *The current empirical scenario* - In the second session, dedicated to the observations, recent results for the different Galactic populations were presented. This was the one day-long session.

The structure of the disc(s) was discussed, including scales, spiral arms, flares, warps, bar, as traced by different indicators. The importance of kinematical and dynamical information in addition to chemistry in defining the properties of the discs was discussed, with emphasis on what we expect from future missions, like Gaia.

The talk on the thin disc, as traced by field stars, discussed the metallicity and abundance distribution

in the solar vicinity, where a cosmic scatter is seen, as well as the distributions at larger distances from the Sun, that may be characterized by a gradient. It has been anticipated (see also session 4) and stressed that we are now in the era of large surveys and that these will likely change our understanding of the Milky Way.

The abundance distribution and, more specifically, the radial metallicity gradient, as derived from many tracers have also been presented in detail. OB stars, HII regions, and Cepheids are excellent indicators of the present-day gradient, while open clusters and planetary nebulae allow recovering the evolution with time of the gradient. Whereas all tracers evidence the presence of a negative radial gradient in metallicity, the detailed shape is more complex than a single slope and the issue of the time evolution remains uncertain.

Results from archive data, in particular the high resolution spectra available in the ESO archive (e.g. the FEROS spectra), were presented. These huge collections of data, when reanalyzed homogeneously, can yield very useful information even from sparse and inhomogeneous samples. Also the importance of large and uniformly analyzed photometric data, e.g. for open clusters, was discussed, in particular with reference to distance and age measurements.

Both iron and other elements can -and should- be used to define the abundance distribution and evolution, and results should be compared to better constrain models. Examples include the light elements usually measured in early type stars and PNe and C,N,O as measured in field and open cluster stars of different evolutionary phases. The situation for PNe was later discussed again (see Session 4) on the basis of very large samples.

There was also a presentation on the situation in other nearby spiral galaxies, where the abundance gradients can be traced for the whole disc e.g. using PNe. As in the Milky Way, a limited evolution with time and a flattening in the external part of the disc are found, probably indicating a universal mechanism.

The review on the thick disc included a summary on the discovery of the thick disc, along with a presentation of its chemical and kinematic properties, based on different samples and covering both the inner and outer disc. A comparison with both the thin disc and the bulge has been shown; the latter may suggest a bulge - thick disc connection.

As for the bulge itself, whilst the classical, simple view described it as old and metal rich, the large amount of observations collected in recent years has suggested the presence of a gradient in metallicity along the minor axis and has suggested that the bulge is made of two (or more) populations and that its shape is complex (x-shaped).

In all the talks caveats and challenges have been evidenced; these include: sample selection, systematic offsets and problems (like e.g. NLTE effects) in abundance determinations which could bias the results, population assignment, distance determination, the effect of radial migration, and, overall the need for large, uniformly analyzed samples.

3) *Taking the global picture* - In a way continuing the presentations of the initial session, in the third session the interaction between theory and observations was again amply discussed, this time with more relevance given to the empirical side.

Improved theoretical models for stellar evolution were presented; they take into account up-to-date physics and a series of phenomena, like rotation, convection, diffusion, modified chemistry, and the like. On the other hand, open clusters could be thought as a sort of observational isochrones, once their properties can be properly assessed (like e.g., the distances - with Hipparcos data for the closest clusters, and with Gaia data in the next future and for a large fraction of the Galactic open cluster population).

Asteroseismology has important potential in measuring fundamental stars properties with very high precision (e.g., the mass). This was presented and the impact of the Corot and Kepler satellites on Galactic studies was underlined.

The importance of chemical tagging as a powerful tool to test membership to different groups or populations was discussed. In particular it can help isolating kinematic groups or can probe the -

suspected- differences between ensembles of stars, as for the planet-host and isolated stars. This of course require large samples, and results based on the HARPS data were presented.

4) *Expectations from Gaia and large Spectroscopic survey* - Finally, in the forth session important ground- or space-based surveys and missions were presented, again focusing on their impact on our knowledge of the Milky Way.

Expectations from the Gaia mission were central in the whole Workshop, and we had a presentation with a general, updated description of the satellite and the foreseen precision and results, together with indications of the sectors where major improvements will obtained. A smaller size, yet to be completely finalized space mission (the WSO-UV) was presented and its relevance to Galactic astrophysics was highlighted.

The SEGUE data and results were presented; this survey has been active for a while and is bringing new, improved information on the Milky Way, both because of the large samples of objects and the large distances it reaches. The metallicity and alpha-elements distributions were discussed, together with their implications for Galactic formation. A critical subject (the existence of the thick disc) where contrasting conclusions were reached on the basis of (slightly) different analyses was amply debated. Other large scale high resolution spectroscopic surveys presented were HERMES (to start in the next years and to cover all the southern sky), APOGEE (just started, in the near infrared and concentrated on the inner Galaxy, the bulge and the galactic plane), and the Gaia-ESO Survey (just started, and targeting all the Galactic components). The expectations and the challenges were discussed.

Results and future impact

- Following the meeting “spirit”, theoreticians pointed out areas where progress has already been achieved and areas still awaiting for new observations;
- the reverse was also true, and critical points requiring theoretical improvements were indicated;
- all observational talks provided a clear historical perspective and comprehensively reviewed current status and scenarios. At the same time they clearly evidenced that new results open new challenges;
- observational and measurement uncertainties were spelled out. The role of random and -even more insidious- systematic errors was made clear;
- improvements in precision, hence in significance, were demonstrated to be possible when the right samples and procedures are used;
- all the major surveys either already on-going or planned, including Gaia, were presented, giving people not directly involved the opportunity to be aware and ready to interpret and work on their results.

The interaction between theoreticians and observers, as well as among people working on different stellar populations, or with different methods, was very fruitful and lively, as expected. New ideas and collaborations were started, new possibilities and perspectives will be considered by many participants. Finally, the presence of many young astronomers, both at the PhD and early postdoc level, was an important part of the Workshop success. They both presented very interesting talks, either contributed or invited, and participated to the discussions after the talks and during the breaks. We think that this will be helpful for their career as astronomers.

FINAL PROGRAMME		
May 29 : first day		
9:30	G. Zamorani	Welcome of the Director OABO
Session 1 : The theorists view and wishes (chair E. Pancino)		
9:45-10:10	A. Chieffi	Stellar yields
10:10-10:25	A. Nanni	Asymptotic Giant Branch dust production at different metallicities
10:25-10:40	E. Maiorca	The s-element evolution in the Galactic disc. The role of open clusters and the new s-process scenario
10:40-10:55	O. Straniero	The fundamental role of the metallicity in the nucleosynthesis of heavy elements <i>coffee break</i>
11:20-11:45	D. Romano	Chemical evolution models
11:45-12:00	V. Grieco	Chemical evolution of the Galactic Bulge
12:00-12:15	J. Rybizki	Correlations between stellar dynamics and metallicity in the discs from a theorists' perspective
12:15-12:30	A. Font	The formation of the Milky Way disk in the cosmological context <i>lunch</i>
May 30 : talks rescheduled (chair A. Recio Blanco)		
9:00 - 9:15	F. Calura	Chemical abundances and cosmological simulations: how far from the truth?
9:15 - 9:40	R. Roskar	Stellar migration
Session 2 : The current empirical scenario		
9:40 - 10:05	A. Moitinho	The structure of the Galactic discs
10:05 - 10:30	C. Allende-Prieto	The abundance distribution in the thin disc
10:30 - 10:55	T. Bensby	The abundance distribution in the thick disc <i>coffee break</i>
11:20 - 11:45	M. Lattanzi	Gaia and the Galactic thin and thick discs
11:45 - 12:10	O. Gonzalez	The metallicity distribution in the Galactic Bulge
12:10 - 12:35	N. Przybilla	The radial metallicity gradient from OB star and HI region measurements
12:35 - 13:00	B. Lemasle	The radial metallicity gradient from Cepheids measurements <i>lunch</i>
(continued) (chair S. Lucatello)		
14:05 - 14:20	C. Worley	Metallicity distribution with the FEROS archived spectra
14:20 - 14:45	E. Friel	The radial metallicity gradient as traced from open clusters
14:45 - 15:00	R. Carrera	Open clusters and abundance trends in the Galactic disc
15:00 - 15:15	P. Donati	The BOCCE project: open clusters as tracers of the Galactic disc
15:15 - 15:40	G. Tautvaisiene	CNO abundances in open clusters and field stars
15:40 - 16:06	L. Magrini	The metallicity gradients in Local Group galaxies <i>coffee break</i>

Session 3 : Taking the global picture (chair R. Blomme)		
16:30 - 16:55	A. Bressan	Evolutionary models and age determinations
16:55 - 17:20	F. van Leeuwen	Open clusters as observational isochrones
17:20 - 17:35	L. Stanghellini	Planetary Nebulae as probes of the Milky Way structure
17:35 - 17:50	A. Miglio	Asteroseismology
17:50 - 18:05	M. Valentini	Application of asteroseismic results in the field of Galactic research
18:05 - 18:20	E. Delgado Mena	Galactic stellar populations and planets for the HARPS GTO sample
May 31 : final 1/2 day		
9:15 - 9:30	D. Montes	Chemical tagging of FGK stars: testing membership to stellar kinematic groups
Session 4 : Expectations from Gaia and large spectroscopic Surveys (chair C. Cacciari)		
9:30-9:55	C. Jordi	Gaia
9:55-10:20	S. Randich	The Gaia-ESO Survey
10:20-10:35	P. Sestito	The world Space Observatory - Ultraviolet (WSO-UV) mission
10:35-11:00	K. Freeman	HERMES <i>coffee break</i>
11:35-11:50	A. Vallenari	More on GES clusters
11:50-12:15	J. Johnson	SEGUE and Apogee
12:15-12:30	J. Sobek	Recent SEGUE $[\alpha/\text{Fe}]$ findings
12:30-12:55	G. Gilmore	Conclusions and Perspectives
END of Workshop		

NOTES: The first-day programme had to be interrupted because of the earthquake that hit Bologna on May 29 (first at about 9am, then at about 1pm). All University buildings were closed by the Dean for security reasons and reopened only on May 31. We could reconvene on the second day at the CNR buildings; we thank Luigina Feretti, Director of the INAF-IRA for the hospitality and G. Zamorani for his help in arranging the new Workshop locations. On May 30 we were able to reschedule almost all the talks missed (one went to the third day), but had to skip the discussion sessions. For the final half-day we could use the facilities of the INAF-Osservatorio Astronomico di Bologna and Dipartimento di Astronomia.