ABSTRACT BOOKLET

@gbx2018   #gbx2018

The **Galactic Bulge**
at the crossroads

Background image: WISE/NASA

Introduction
Alvio Renzini (Italy)

Review Talks
Cristina Chiappini (Germany)
Oscar Gonzalez (UK)
Andrea Kunder (USA)
R. Michael Rich (USA)
Natascha Forster-Schreiber (Germany)
Juntai Shen (China)
Sandro Tacchella (USA)
Elena Valenti (ESO)

Conference Summary
Ivo Saviane (ESO)

Scientific Organising Committee
Lia Athanassoula, LAM
Beatriz Barbuy, IAG
Bruno Dias, ESO (co-Chair)
Doug Geisler, U. Concepción
Dante Minniti, UNAB
Sergio Ortolani, U. Padova
Alvio Renzini, INAF Padova
Ivo Saviane, ESO (Chair)
Manuela Zoccali, PUC (co-Chair)

Local Organising Committee
Doug Geisler, U. Concepción (Chair)
María Eugenia Gómez, ESO
Paulina Jirón, ESO
César Muñoz, U. Concepción
Joyce Pullen, UNAB

Invited Speakers
Beatriz Barbuy (Brazil)
Thomas Bensby (Sweden)
Michele Cirasuolo (ESO)
Roger Cohen (USA)
Victor Debattista (UK)
Bruno Dias (ESO)
Heino Falcke (The Netherlands)
Noriyuki Matsunaga (Japan)
Dante Minniti (Chile)
David Nataf (USA)
Livia Origlia (Italy)
Alejandra Recio-Blanco (France)
Alvaro Rojas-Arriagada (Chile)
Ricardo Schiavon (UK)
Igor Soszynski (Poland)
Manuela Zoccali (Chile)

ESO Conference, Pucón, Chile
9–14 December 2018

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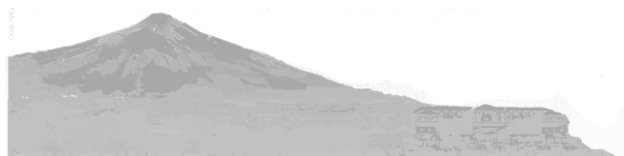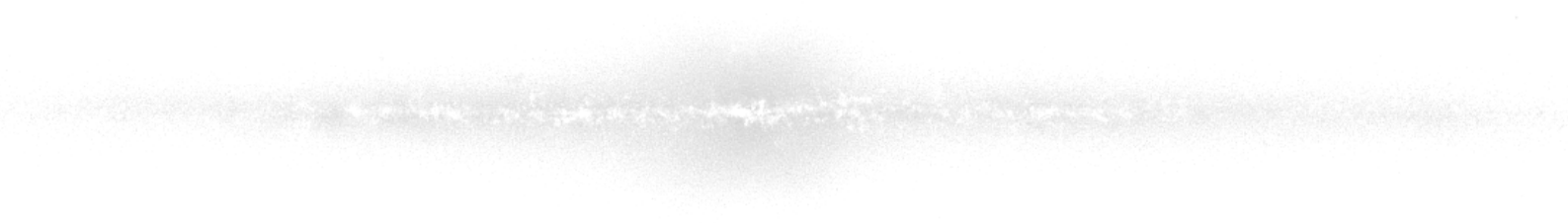
Scientific Rationale

The bulge is a primary component of the Milky Way, comprising ~25% of its mass. All major Galactic stellar populations intersect there, reaching their highest densities. Thus it is truly a crossroads. Current theory suggests that the bulge is the most ancient component of the Galaxy. Therefore, exploring the bulge is fundamental to understanding Galactic formation, structure and evolution.

Indeed, thanks to the advent of multiplexed spectrographs on 8m-class telescopes, and to the availability of resolved, wide-field NIR photometry, our knowledge of the structural, chemical and kinematical properties of the Galactic bulge has improved dramatically in the last few years. At the same time, the interpretation of the accumulated data from this complex region is not straightforward, and many fundamental questions still remain to be answered. E.g. What is the age of the oldest stars? How was the metal-poor spheroid formed? What is the 3D shape of the bulge? What is the connection and interplay between the bulge and bar? Is there a separate bulge globular cluster population? What is the relationship of the central supermassive black hole with the bulge?

Fortunately, this area of investigation is moving forward at a fast pace: since 2013, when the last large international conference on the bulge was organized, progress has been truly impressive. New massively multiplexed spectroscopic surveys (Gaia-ESO Survey, APOGEE South, MOONS., new deeper NIR photometric surveys (e.g., VVVX, the extension of the VVV Survey. as well as Gaia have recently begun or will begin imminently. Concomitantly, ever more detailed studies of galaxies at high-redshift promise to catch bulges at the time of their formation. **A host of exciting new results are thus expected in 2018, and it would be very timely to gather the international astronomical community in late 2018 to present and discuss them**, and to begin to establish a consensus on their interpretation. Thus, our understanding of the bulge is also at a crossroads. These intense observational efforts are now matched by the excellent progress in cosmological simulations, which boast better mass resolutions and larger ranges of physical processes, leading to the possibility of very fruitful synergy between theorists and observers that we will promote.

The emerging picture of the present-day bulge is that of an old, spheroidal, metal-poor, and alpha-enhanced population, embedded in a younger, bar-like, metal-rich population showing a declining trend of alpha-elements with metallicity. From a chemical point of view, the latter population resembles the thick disk, so ideas about a common formation of the two structures have been put forward. Observations of extragalactic bulges suggest different channels of formation, but larger samples are needed to establish the preferential bulge formation mechanism. Recent, AO-assisted observations have been able to resolve galaxies at z~2, which apparently show no sign of the presence of a bar. Another question is then if and how the formation and evolution of bars and bulges are linked. Gathering samples of galaxies at even higher redshifts would clearly be a major step forward.

The main sections of the conference are proposed to be the following:

1. Bulge vs. bar vs. disk
2. Chemical evolution of the bulge
3. Globular clusters towards the bulge
4. VVVX studies of the bulge
5. Bulge structure and kinematics
6. Stellar populations in the bulge
7. Bulge formation
8. Comparison to extragalactic bulges

Conference email: gbx2018@eso.org

Organizers: ESO, ALMA, UConcepcion, CATA, MAS, UPadova, CASSACA

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Code of Conduct for ESO Workshops & Conferences

ESO is committed to creating a work environment that is safe, professional and of mutual trust where diversity and inclusion are valued, and where everyone is entitled to be treated with courtesy and respect. ESO organisers commit to making conferences, workshops, and all associated activities productive and enjoyable for everyone. We will not tolerate harassment of participants in any form.

Please follow these guidelines:

1. Behave professionally. Harassment and sexist, racist, or exclusionary comments or jokes are not appropriate. Harassment includes sustained disruption of talks or other events, inappropriate physical contact, sexual attention or innuendo, deliberate intimidation, stalking, and photography or recording of an individual without consent. It also includes offensive comments related to individual characteristics, for example: age, gender, sexual orientation, disability, physical appearance, race, nationality or religion.

2. All communication should be appropriate for a professional audience including people of many different backgrounds. Sexual or sexist language and imagery is not appropriate.

3. Be respectful and do not insult or put down other attendees or facilitators of the event. Critique ideas not people.

4. Should a participant witness events of bullying, harassment or aggression, we recommend that they approach the affected person to show support and check how they are. The witness may also wish to suggest that the person report the inappropriate behaviour. However, it is up to the affected person alone whether or not they wish to report it.

5. If participants wish to share photos of a speaker on social media, we strongly recommend that they first get the speaker's permission. Participants may also share the contents of talks/slides via social media unless speakers have asked that specific details/slides not be shared.

Each Local Organising Committee has up to two members who are designated as the contact points for all matters related to this code. Participants can report any violation of these guidelines to these designates in confidence. If asked to stop inappropriate behaviour participants are expected to comply immediately and, in serious cases, may be asked to leave the event without a refund. ESO will not tolerate retaliation against anyone reporting violations of this code of conduct.

Thank you for helping to make ESO workshops welcoming for all.

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Chair Guidelines

In addition to the above code of conduct the following Chair guidelines will be used during this meeting.

The Chair's actions can have a significant impact in making the workshop an enjoyable experience for all participants. To this end, we have compiled recommendations and best practice tips based on previous experience.

Chairs are broadly responsible for ensuring a professional atmosphere and for speakers keeping to time so that the question and answer sessions are as effective as possible. Therefore, Chairs may want to familiarise themselves with the workshop code of conduct.

1. Introduce yourself at the start of the session.

2. Introduce yourself to the speakers in your session beforehand (where possible., and ensure you know how to pronounce their names so that you can introduce them appropriately.

3. All questions should be asked and answered using a microphone to ensure that all participants can benefit from the answer.

4. If you deem a question to be inappropriate or unprofessional, it is expected that you intervene or take another question.

5. Chairs are encouraged to be conscious of their biases and avoid preferentially selecting some people and/or paying attention to only some parts of the room.

6. After the talk ends, try to wait a few seconds longer than you normally would before choosing the first question. This gives time for more people to formulate their questions and can help encourage more questions from early career scientists.
   If there is someone being very active and asking questions after each talk, feel free to skip their hand and choose someone else sometimes.

7. Letting the questions run for a full 5 minutes (10 minutes for invited talks. is preferable to allowing the speaker to run over his/her time.

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Programme

December 9 (Sunday. : Enjoy Pucon / Gran Hotel Pucon

17:00 - Registration

19:00 - Welcome cocktail at the venue (Enjoy Gran Hotel Pucon) 22:30 - End of cocktail

Program Overview

Day 1, Monday, December 10 : Chemistry, ages, Gaia

Day 2, Tuesday, December 11 : Ages, globular clusters, mass, formation

Day 3, Wednesday, December 12 : Variability

Day 4, Thursday, December 13 : Chemodynamics, structure, extinction

Day 5, Friday, December 14 : Extragalactic bulges, future surveys, instrumentation Poster contributions

IR= Invited Review; **IT**= Invited Talk; **CT**= Contributed Talk

Activities and eating in Pucon

The Pucon area is lovely, hosting very active volcanoes, mountain lakes, several national parks and a wealth of outdoor activities.

During the free Wednesday afternoon, you will have the chance to enjoy some of these activities. The weather SHOULD be conducive for this - expect typical highs around 25 and low around 10 with the possibility of rain showers at times during the week. Some of the more popular activities include hiking, rafting, natural hot springs, kayaking, horseback riding, fishing, tour of ice caves, sky diving etc. The Conference is not organizing any tours, but information on existing tours can be found at the tour desk at the entrance to the Gran Hotel Pucon or in various places around town.

Climbing the nearby Volcan Villarrica is a fantastic experience but requires a full day starting very early and is quite expensive and you are forbidden to do it during the conference! Do it before or after... in fact, after - just in case...

If you are interested in indoor activities, there is a casino...

Restaurants

There are a number of good restaurants nearby. A few of our favorites include:

o La Maga (Geronimo de Alderete 276, Pucón) - excellent (and expensive) meat, parrilla (barbeque grill)
o Pizza Cala (Lincoyán 361, Pucon)
o Restaurant Cassis (Pedro de Valdivia 191, Pucon) - great cafe, pastries, ice cream, sandwiches, chocolates, onces Aleman
o Cafe Berlin (Miguel Ansorena 160 - in front of Casino Enjoy, Pucon)
o Hosteria École (Gral. Urrutia 592, Pucon) - great vegetarian lasagna, homemade brownies
o Restaurant La Suiza (Av. Libertador Bernardo OHiggins 116, Pucón) - good all around food, icecream

Enjoy! Note that a 10% tip is standard.

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DAY 1: MONDAY, DECEMBER 10: CHEMISTRY, AGES, GAIA

SESSION 1: Chemistry, ages, Gaia **Chair: Ivo Saviane**		
08:30	Registration	
09:00	Chair welcome - Ivo Saviane, Chair of GBX2018, Site manager of La Silla	
09:05	VIP welcome - Carlos Barra, Mayor of Pucon	
09:10	Renzini, Alvio	Introduction
Chair: Beatriz Barbuy		
09:40	(IR) Chiappini, Cristina	Chemo(dynamical) evolution of the Galactic Bulge: the need for better observational constraints
10:20	(IT) Nataf, David	He abundances of Galactic bulge stars
10:45	(CT) Matteucci, Francesca	The chemical evolution of the Galactic Bulge
11:00	**Coffee break**	
Chair: Manuela Zoccali		
11:30	(IT) Schiavon, Ricardo	Peculiar bulge stars
11:55	(CT) Sbordone, Luca	The GIRAFFE Inner Bulge Survey (GIBS). Lithium-rich giants towards the Milky Way Bulge
12:10	(CT) Ryde, Nils	Detailed Abundances of Giants in the Inner Bulge and Galactic Centre
12:25	(CT) Arentsen, Anke	Uncovering very metal-poor stars in the Galactic bulge with the Pristine survey
12:40	**Lunch**	
Chair: Doug Geisler		
14:30	(IR) Rich, R. Michael	Bulge Stellar Metallicities from the Center to the Bar
15:10	(IT) Bensby, Thomas	Ages and abundances of microlensed bulge stars
15:35	(CT) Navarro, Maria Gabriela	Microlensing events in the Galactic Bulge
15:50	**Coffee break**	
Chair: Tali Palma		
16:20	(IT) Recio-Blanco, Alejandra	The galactic bulge as seen by Gaia
16:45	(CT) Simion, Julia	Orbital properties of Galactic Bulge giants with Gaia DR2
17:00	(CT) Majewski, Steve	APOGEE's plans for exploring the bulge
17:15	Discussion	Chair: Saito, Roberto
18:00	End of the day	

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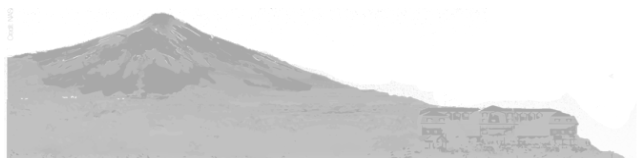
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DAY 2: TUESDAY, DECEMBER 11: AGES, GLOBULAR CLUSTERS, MASS, FORMATION

SESSION 2: Ages, globular clusters, mass, formation **Chair: Francesca Matteucci**		
09:00	(IR) Valenti, Elena	Bulge stellar ages
09:40	(IT) Barbuy, Beatriz	The globular cluster system of the Galactic bulge
10:05	(CT) Geisler, Doug	The bulge Cluster APOgee Survey: CAPOS
10:20	(CT) Muñoz, Cesar	Chemical Analysis of Four Metal-rich Bulge Galactic Globular Clusters
10:35	**Coffee break**	
Chair: Bruno Dias		
11:05	(IT) Cohen, Roger	Bulge Stellar Populations from HST Observations
11:30	(CT) Saracino, Sara	GEMINI/GeMS Observations of GCs in the Galactic Bulge
11:45	(CT) Salinas, Ricardo	GLIMPSE-C01: the most massive intermediate-age star cluster in the Galaxy
12:00	**Lunch**	
Chair: Javier Alonso-Garcia		
14:00	(IT) Zoccali, Manuela	The mass and stellar populations of the Galactic bulge
14:25	(CT) Perez-Villegas, Angeles	Assembling Galactic globular clusters using orbital criteria
14:40	(CT) Schultheis, Mathias	The Nuclear Star Cluster
14:55	(CT) Morihana, Kumiko	Near-Infrared Study of the Galactic Bulge X-ray Emission
15:10	**Coffee break**	
Chair: Victor Debattista		
15:40	(IR) Tacchella, Sandro	Bulge formation scenarios
16:20	Poster session (TBD)	
16:50	Discussion	Chair: Renzini, Alvio
17:35	End of the day	
19:00	Outreach Talk (Spanish) **Dante Minniti: "Viaje al centro de la Galaxia"**	

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DAY 3: WEDNESDAY, DECEMBER 12: VARIABILITY

SESSION 3: Variability Chair: Roberto Saito		
09:00	(IT) Soszynski, Igor	The Galactic bulge as seen by the OGLE survey
09:25	(CT) Calamida, Annalisa	New Cepheids identified towards the Galactic bulge: Does the disk extend for more than 80 kpc? *[presented by Bhardwaj, Anupam]*
09:40	(CT) Vivas, Kathy	RR Lyrae stars as Reddening Probes: Calibration in the DECam Optical Bandpasses
09:55	(CT) Bhardwaj, Anupam	Predicting physical parameters of RR Lyrae based on the light curve morphology : Bulge variables
10:10	(CT) Minniti, Javier	Classical Cepheids in the direction of the Galactic bulge
10:25		Coffee break
Chair: Elena Valenti		
10:55	(IT) Minniti, Dante	Near-IR variability of the bulge stellar population
11:20	(CT) Gran, Felipe	Unleashing the inner Galaxy: the proper motion revolution
11:35	(CT) Hempel, Maren	The VVV & VVVx survey- Status Report
11:50	(CT) Braga, Vittorio Francesco	The structure of the old Galactic Bulge revealed by Type II Cepheids
12:05	(CT) Alonso-Garcia, Javier	A billion-source atlas of the inner Milky Way
12:20		Box lunch offered by the LOC
14:20	Free afternoon	
20:30	Outreach : Talk in Spanish **Cesar Muñoz: "Brevísima Historia de la Astronomía en Chile"**	
21:30	Outreach activity: Sky observations with small telescopes	

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DAY 4: THURSDAY, DECEMBER 13: CHEMODYNAMICS, STRUCTURE, EXTINCTION

SESSION 4: Chemodynamics, structure, extinction **Chair: Dante Minniti**		
09:00	(IR) Kunder, Andrea	Bulge structure and kinematics
09:40	(IT) Rojas-Arriagada, Alvaro	Correlations between kinematics and metallicity of bulge stars
10:05	(CT) Zasowski, Gail	Stellar Chemodynamics in the Inner Milky Way and Beyond
10:20	(CT) Tang, Baitian	Chemical and Kinematic Analysis of CN-strong Metal-poor Field Stars in LAMOST DR3
10:35	(CT) Zhou, Yingying	Chemical abundances and ages of the bulge stars in APOGEE high-velocity peaks
10:50	(CT) Clarkson, Will	Chemically-dissected rotation curves of the inner Galactic bulge
11:05		Coffee break
Chair: Mathias Schultheis		
11:35	(IT) Matsunaga, Noriyuki	Interstellar extinction toward the Galactic bulge
12:00	(CT) Nogueras Lara, Francisco	The star formation history and metallicity in the galactic inner bulge revealed by the RGBB
12:15	(CT) Saito, Roberto	Exploring windows of low extinction in the Galactic plane with VVV
12:30	(CT) Saha, Abhijit	Extinction corrected CMDs of bulge stars from multiband (ugriz) light curves of RR Lyrae stars
12:45		Lunch
Chair: Cristina Chiappini		
14:45	(IR) Shen, Juntai	Dynamical models of the Galactic bulge
15:25	(IT) Debattista, Victor	Understanding the chemodynamics of the Bulge
15:50		Coffee break
Chair: Sergio Ortolani		
16:20	(CT) Lee, Young-Wook	Assembling the Milky Way bulge from globular clusters: Evidence from the double red clump
16:35	(CT) López-Corredoira, Martín	No X-shape in the Milky Way bulge
16:50	(CT) Chung, Chul	Bulge and Globular Cluster Connection: Evolutionary Population Synthesis with Multiple Populations
17:05	Discussion	Chair: Chiappini, Cristina
17:50		End of the day
19:00		Dinner aperitif at hotel terrace, accompanied by folkloric group MasDanza
19:30		Conference dinner at hotel restaurant (Chilean buffet)
21:30		End

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DAY 5: FRIDAY, DECEMBER 14: EXTRAGALACTIC BULGES, FUTURE SURVEYS, INSTRUMENTATION

SESSION 5: Extragalactic bulges, future surveys, instrumentation **Chair: Alvio Renzini**		
09:00	(IR) Gonzalez, Oscar	Bulges in nearby galaxies
09:40	(CT) Li, Zhao-Yu	Shape of LOSVDs in Barred Disks: Implications for Future IFU Surveys
09:55	(IR) Foerster-Schreiber, Natascha	Bulges in high redshift galaxies
10:35	(CT) Gargiulo, Ignacio	Formation and properties of galactic bulges in MW-sized haloes in the AURIGA simulations
10:50		**Coffee break**
Chair: Celeste Parisi		
11:20	(IT) Dias, Bruno	Chemical tagging of stars based on low-resolution spectroscopy
11:45	(CT) Lim, Dongwook	Yonsei Spectroscopic Survey for Bulge Red Clump Stars
12:00	(CT) Ivanyuk, Oleksiy	Accuracies of abundance determinations in large spectroscopic surveys
12:15		**Lunch**
Chair: Noriyuki Matsunaga		
14:15	(IT) Origlia, Livia	Future surveys of the bulge stellar populations
14:40	(CT) Tucci Maia, Marcelo	Building sets of reference stars for current and future spectroscopic survey stellar parameters
14:55	(IT) Cirasuolo, Michele	The Extremely Large Telescope: the future of European ground-based astronomy [*remote presentation*]
15:20	(CT) Penny, Matthew	The WFIRST Microlensing Survey: Symbiosis with Galactic Bulge studies
15:35		**Coffee break**
Chair: Oscar Gonzalez		
16:05	(IT) Falcke, Heino	Imaging the Event Horizon in the Galactic Center and M87
16:30	(CT) Gordon, Chris	Is the Galactic Bulge Shining in Gamma Rays
16:45	Saviane, Ivo	Summary
17:15		End of the day

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Poster Contributions

	LIST OF POSTER CONTRIBUTIONS	
1	Cortés, Caddy	Search for Exoplanet Transits in the Galactic Bulge
	Ernandes, Heitor	A MUSE analysis of inner bulge globular cluster Terzan 9
	Gotta, Vanessa	Terzan 5, a fossil relic of the galactic bulge
	Gramajo, Luciana	New near-IR curves modelling of newly discovered BHB binary stars
	Hajdu, Gergely	Visual - near-infrared properties of the interstellar extinction towards the Galactic bulge with RR Lyrae stars
	Hong, Seungsoo	Discovery of a significant population of CN-enhanced stars with globular cluster origin in the Milky Way
	Jang, Sohee	Common origin of two RR Lyrae populations and the double red clump in the Milky Way bulge
	Kerber, Leandro	Accurate Ages of Bulge Globular Clusters from Deep and Proper-motion-cleaned HST and Gemini CMDs (*presented by Stefano Souza and Raphael Oliveira*)
	Lagioia, Edoardo	Kinematic study of the bulge globular cluster NGC6528
10	Maia, Francisco	Unveiling the RR Lyrae population of bulge globular clusters
	Mauro, Francesco	SkZpipe: A Python3 module to produce efficiently PSF-fitting photometry with DAOPHOT, and much more
	Montecinos, Carolina	Chemical analysis of the Bulge Globular Cluster NGC 6553
	Muniz, Leonardo	Abundances in the globular cluster NGC 6558
	Olivares, Julio	The first spectroscopic analysis of the newly discovered VVV-CL001 cluster with MUSE
	Oliveira, Raphael	Multiple Populations Analysis of Six Bulge Globular Clusters using the HST UV Legacy Survey
	Palma, Tali	VVV Survey and Milky Way Globular Clusters
	Parisi, Celeste	CaT study of Bulge Globular Clusters
	Saito, Roberto	The VVV-Gaia catalogue for the Galactic bulge
	Souza, Stefano	The SIRIUS code: Statistical Inference of physical paRameters of sIngle and mUltiple populations in Stellar clusters
20	Surot, Francisco	A new PSF-fitting photometry and reddening map for the VVV bulge area

Back to programme

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ORAL CONTRIBUTIONS

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Chemo(dynamical) evolution of the Galactic Bulge: the need for better observational constraints

Cristina Chiappini, Leibniz IoA Potsdam, Germany

ABSTRACT

The lack of large samples of high-resolution spectra of individual stars tracing large areas around the Galactic Bulge and inner-most regions of the Galaxy has been a long-standing missing information piece. This has prevented so far a clearer picture of how the Bulge/bar was formed, its connection to the thin disk inside-out grow as well as to a pristine thick disk and halo. In this review I present a summary of where we stand in our understanding of the properties of the Bulge stellar populations, with focus on chemistry and ages, and on the still open issues. I briefly summarise the different theoretical approaches that have been used to describe the Bulge assembly history underlying how the lack of better constraints have still hampers the construction of a self-consistent picture for the Bulge assembly and evolution. I then show how in the Gaia era, the combination of photometric and spectroscopic surveys will be a game change in this field, with a particular focus on APOGEE and Gaia DR2. In addition, I discuss how could we attempt to provide more robust comparisons of the bulge stellar populations with other galactic components such as the inner-thin and thick disks as well as the halo. Once sub-populations are more robustly traced, we enter in a new phase where the abundance patterns of different chemical elements, for different galactic components, will be able not only to provide more stringent constraints to chemodynamical models, but also to much more efficiently help constraining stellar yields of the several nucleosynthetic channels. I close the review with a look into the future and discuss an opportunity not to be missed by the Galactic Archaeology community in the era of massive spectroscopic follow-up of Gaia, namely: to obtain a large number of red giant stars with seismic information using PLATO. This will provide the only direct age measurements (to the 10-20% precision level) of large samples of stars in the Bulge area, complementing what is now done for a few Bulge micro-lensed stars.

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He abundances of Galactic bulge stars

David Nataf, Johns Hopkins Univ., USA

ABSTRACT

The chemical evolution of the Galactic bulge stellar population need not have followed a solar helium-to-metals enrichment ratio, DeltaY/DeltaZ ~ 1.50. At lower metallicity, there is evidence of a helium spread from the CNO abundances of stars observed by APOGEE, which suggest that these stars are former globular cluster stars. The RR Lyrae stars also show a bimodality in the period-amplitude plane. At higher metallicity, the evidence for enriched helium is that age determinations are not converging -- they are strongly dependent on the method used. AGB stars, planetary nebulae, and spectroscopic abundances suggest an older age, whereas turnoff studies and chemical evolution arguments suggest an old age. Prospects for resolving this discrepancy are discussed.

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The chemical evolution of the Galactic Bulge

Francesca Matteucci, Trieste Univ., Italy

ABSTRACT

I will discuss the chemical evolution of the Galactic Bulge in the light of recent spectroscopic observations. I will analyse the existence of two main stellar populations in the Bulge and their possible origin and timescales of formation. I will then discuss the chemical evolution of the Galactic center in the inner 200 pc of the Bulge.

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N-rich stars in the inner Milky Way and in other galaxies

Ricardo Schiavon, Astrophysics Research Institute, UK

ABSTRACT

We have discovered a population of stars in the inner 2 kpc of the Milky Way (MW) presenting an abundance pattern that resembles that of stars previously discovered in Galactic globular clusters (GCs). They are enriched in N and Al and those abundances are anti-correlated with that of C. The metallicity distribution of these stars differs significantly from that of the MW globular cluster system and that of the MW bulge as well. We hypothesise that these N-rich stars belong to the MW's inner stellar halo and that they result from the destruction of an early population of Galactic GCs. In that case about ~25% of the stellar mass of the inner halo may result from GC dissolution. In this talk I will report the analysis of spatially resolved integrated spectra of a small sample of early type galaxies to search for signatures of N-rich stars in their inner regions, to test whether this is a common phenomenon in the local universe.

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The GIRAFFE Inner Bulge Survey (GIBS). Lithium-rich giants towards the Milky Way Bulge

Luca Sbordone, ESO, Chile

ABSTRACT

I report on the chemical analysis of the UVES sample of the GIBS survey, comprising 90+ clump red giants in the inner disk / outer bulge, for which detailed abundances for up to 25 elements from Lithium to Yttrium, comprising all the main nucleosynthetic channels. The sample is mostly constituted by metal rich to moderately metal poor (-1.5<~[Fe/H]<~0.3). Among other results, we confirm the trend for inner-disk giants to display a markedly under-solar [Zn/Fe] ratio, already observed by us in the Gaia ESO UVES sample, and tentatively interpreted as due to increased Fe enrichment by Type 1a SN. The most striking result is the presence in the sample of 10 Li-rich giants, with Li abundances in some cases close to the meteoritic value. Lithium abundance in giant atmospheres is supposed to decrease dramatically once the star evolves up the red giant branch, due to the increasingly deep atmospheric convection that burns Lithium in the inner layers of the envelope. About 2% to 5% of giants, however, display various degree of Li enrichment, whose origin is still hotly debated. The number of Li-rich stars in our sample is surprisingly high, about 10%, which probably points to a selection effect in the sample. Li abundances were derived with state of the art NLTE computations, and calculations were performed by mean

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The **Galactic Bulge**
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Detailed Abundances of Giants in the Inner Bulge and Galactic Centre

Nils Ryde, Lund Obs., Sweden

ABSTRACT

Owing to their extreme crowding and high and variable extinction, stars in the Galactic Bulge, within 2 degrees of the Galactic plane, and especially those in the Nuclear Star Cluster, have only rarely been targeted for an analyses of their detailed abundances. There is also some disagreement about the high end of the abundance scale for these stars. It is now possible to obtain high dispersion, high S/N spectra in the infrared K band (2.0-2.4 microns) for these giants; we will review our progress at Keck and VLT in using these spectra to infer the composition of this stellar population.

The Galactic Bulge
at the crossroads

Uncovering very metal-poor stars in the Galactic bulge with the Pristine survey

Anke Arentsen, Leibniz IfA Potsdam, Germany

ABSTRACT

The chemistry and kinematics of the oldest and most metal-poor stars teach us about star formation, star deaths and galaxy formation in the early Universe. A prediction of simulations is that the fraction of metal-poor stars that are also very old is highest towards the centers of galaxies. However, the ARGOS survey for example reported only 0.1% of their sample to have [Fe/H]<-2, which shows that targeted surveys are needed to uncover large samples of very metal-poor stars in the bulge. The Pristine survey is such a survey, which uses a narrowband Ca H&K filter on CFHT MegaCam to very successfully uncover metal-poor stars. Here I will present new spectroscopic follow-up results of the Pristine bulge survey, which is building towards an unprecedented large sample of very metal-poor stars in the bulge region. I will discuss the chemistry, kinematics and spatial distribution of the stars, and their implications for our understanding of the early build-up of the center of our Galaxy.

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Bulge Stellar Metallicities from the Center to the Bar

R. Michael Rich, UCLA, USA

ABSTRACT

I will briefly review the history of bulge metallicity measurements from early studies to the present, including photometric constraints. I will consider the upper limit of iron metallicity in the bulge, how the field relates to chemically complex clusters, metallicity gradients, and the question of bimodality. Recent studies suggest that extremely high metallicities and unusual compositions might be found in Galactic Center stars; I will consider current data in assessing those findings.

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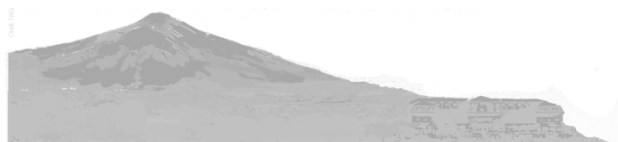
The **Galactic Bulge**
at the crossroads

Ages and abundances of microlensed bulge stars

Thomas Bensby, Lund Obs., Sweden

ABSTRACT

Dwarf stars in the bulge are generally too faint too observe with high-resolution spectrographs under normal observing conditions. However, during gravitational microlensing events they may brighten by factors of several hundreds. Since 2009 we have conducted an observing campaign, through a target-of-opportunity program with UVES at VLT, to catch these elusive events. The results have dramatically changed the picture of the Milky Way bulge and I will in this talk present the most recent results about the age and abundance structure of the Milky Way bulge based on microlensed dwarf and subgiant stars.

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The **Galactic Bulge**
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Microlensing events in the Galactic Bulge

Maria Gabriela Navarro, UAndres Bello, U Roma, Chile / Italy

ABSTRACT

In this work the search or microlensing events in the inner part of the bulge using the VVV data. We have detected 630 microlensing events within an area of 20.68deg2 around the galactic center.
The Einstein ring crossing time is the only parameter which has a physical meaning and is degenerate thus can only be studied statistically in large numbers including in the calculations the distributions of the parameters involved which require models of the Milky Way. In this case, the proper motions distribution of different galactic populations can be useful to interpret the results. Also, the study of specific events became attractive. The long timescale events favor the presence of dark stellar remnants such as black holes and neutron stars which are important ingredients in our understanding of stellar evolution, mass distribution, galaxy evolution and structure, dark matter balance, etc.

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The **Galactic Bulge**
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The galactic bulge as seen by Gaia

Alejandra Recio Blanco,

ABSTRACT

In this talk I will review the impact of the Gaia mission data, in the present and future data releases, for the study of the galactic bulge. The contribution of the different types of Gaia data (astrometry, BPRP data and RVS data) will be presented, including their respective limitations for the bulge context. In addition, the combination of Gaia data with ground base surveys will be analysed.

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The **Galactic Bulge**
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Orbital properties of Galactic Bulge giants with Gaia DR2

Iulia Simion, Shanghai Astronomical Obs., China

ABSTRACT

Gaia DR2 is set to revolutionize our understanding of the Milky Way's past. I built a catalog of Bulge stars with 6D phase space information and metallicity from existing large-scale Bulge spectroscopic surveys (e.g. ARGOS), which provide line-of-sight velocities and metallicity measurements for 2MASS Red Giant Branch stars, and from Gaia DR2, which provides accurate proper motions. Using this information it was possible to integrate their orbits and thus, gain insight into their origin, opening a small window into the history of formation of the Galactic Bulge/Milky Way.

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The **Galactic Bulge**
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APOGEE's plans for exploring the bulge

Steve Majewski, University of Virginia, USA

ABSTRACT

APOGEE is nearing the end of its 10 year, high resolution, infrared spectroscopic survey of stellar chemical abundances and kinematics. The Galactic bulge is a primary focus of APOGEEís goal to probe all parts of the Milky Way, and this region of the Galaxy will be probed both with giant stars and RR Lyrae stars. The latter target class provide a kinematic census of the old bulge, while the former enables the Metallicity Distribution Function and detailed chemical abundance patterns of the bulge to be derived. The status of the APOGEE exploitation of the bulge will be discussed.

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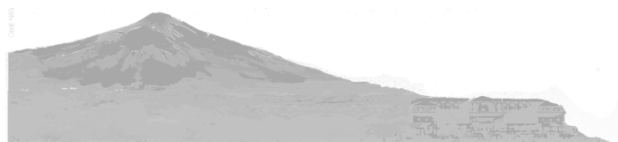at the crossroads

Bulge stellar ages

Elena Valenti, ESO, Germany

ABSTRACT

A number of recent photometric and spectroscopic surveys are producing a comprehensive and coherent picture of the Milky Way bulge through the detailed properties of its stellar content.
While there is a general consensus on the overall morphology, 3D structure, kinematics and metallicity of the bulge, a still debated question regards the age of its stellar population. Photometric studies find the bulk of the bulge stellar population to be consistently old (i.e. >10 Gyr) across different fields. Yet, this picture of a purely old bulge has been challenged by recent spectroscopic results, which advocate for the presence of a substantial fraction of young-intermediate-age population (i.e. <5Gyr).
In this context, I will provide an overview of all stellar age determinations in the bulge, highlighting pros and cons of all different methods. The impact of different age estimates on the formation and evolution of the bulge is also discussed.

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Globular clusters in the Galactic bulge

Beatriz Barbuy, Univ. de Sao Paulo, Brazil

ABSTRACT

The possible mechanisms for formation of the globular clusters located in the central parts of the Galaxy will be shortly reviewed. The characteristics of the bulge globulars, including age, metallicity and abundances will be presented.
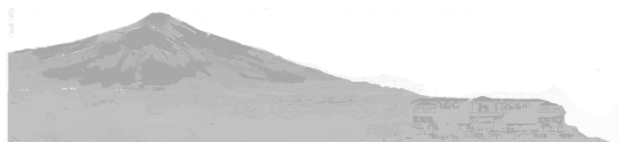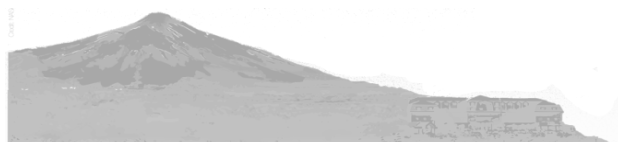
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The bulge Cluster APOgee Survey: CAPOS

Doug Geisler, UConcepcion, Chile

ABSTRACT

We present the CAPOS survey, a long term project to investigate all of the known bulge globular clusters lying within the VVVX area using the APOGEE-2S high resolution multiobject spectrograph. We give the current status and some preliminary results.

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Chemical Analysis of Four Metal-rich Bulge Galactic Globular Clusters

Cesar Muñoz, U Concepción, Chile

ABSTRACT

The Bulge Globular Clusters (GCs) are key tracers of this central ancient component of our Galaxy. It is essential to understand their formation and evolution to study that of the bulge, as well as their relationship with the other Galactic GC systems (halo and disk GCs). Our main goals are to obtain detailed abundances for a large sample of red giant members of each GCs of our sample: NGC~6440, NGC~6528, NGC~6553 and NGC~6569, in order to characterize its chemical composition and study the relationship of these GCs with the bulge, and with other bulge, halo and disk GCs. Moreover, we analyze these cluster's behavior associated with the Multiple Populations (MPs) phenomenon. We obtained the stellar parameters and chemical abundances of light elements, iron-peak elements, alpha-elements and heavy elements for all the star in each GC from our sample using high resolution spectroscopy from FLAMES-UVES. In this talk we will present the most important findings of our research.

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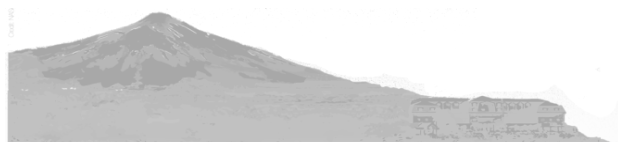
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Bulge Stellar Populations from HST Observations

Roger Cohen, STScI, USA

ABSTRACT

The photometric and astrometric precision of the Hubble Space Telescope (HST) has enabled detailed studies of stellar populations towards the Galactic bulge. I will highlight several recent results obtained from HST imaging of the bulge, and discuss near-term future prospects using existing HST instrumentation. These science cases will be placed in the context of both the advantages and limitations of HST as well as current and planned ground- and space-based facilities.

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GEMINI/GeMS Observations of GCs in the Galactic Bulge

Sara Saracino, Univ. of Bologna, Italy

ABSTRACT

Bulge globular clusters are key tools to constrain the properties of the bulge, as they share kinematics, spatial distribution and composition with bulge field stars. However, these systems have been widely excluded from large surveys due to observational limitations, and remained poorly studied so far. By exploiting the superb capabilities of the near-infrared GSAOI camera in tandem with the MCAO system GeMS at the Gemini South Telescope, we started an observational campaign aimed at characterizing the stellar content and the structural properties of a sample of GCs orbiting the innermost part of the MW bulge. In this talk I will give an overview of the results recently achieved in this field, from the low-reddening NGC 6624 to the highly obscured Liller 1, passing through the moderately-reddened NGC 6569. This approach promises to open a new line of investigation for all of those systems in the Galaxy for which optical observations are almost totally useless.

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GLIMPSE-C01: the most massive intermediate-age star cluster in the Galaxy

Ricardo Salinas, Gemini Observatory

ABSTRACT

The heavily obscured (Av~15) star cluster GLIMPSE-C01 has been the subject of several studies with a variety of conflicting results regarding its age, with estimates widely varying between 500 Myr up to 12 Gyr. Using deep FourStar JK data we reach for the first time the MSTO of the cluster, ruling out any ages below 1 Gyr, and placing it close to 5 Gyr. Structural parameters place the cluster mass slightly above 10^5 solar masses. This age/mass combination is unheard-of for the MW star clusters, but rather common in the Magellanic Clouds. Additionally, I will present first results about the cluster proper motion and orbit based on further FourStar data, plus the first abundances study using IGRINS high resolution NIR spectra. This aggregate dataset will tell us whether GLIMPSE-C01 is disc-borne of halo-borne cluster crossing the disc, together with exploring for the first time the age threshold for self-enrichment in our Galaxy, only studied in detail so far in star clusters in the MCs
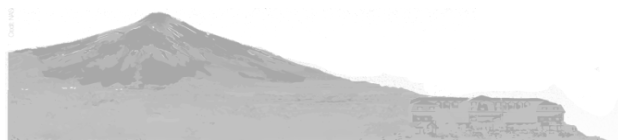
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The mass and stellar populations of the Galactic bulge

Manuela Zoccali, PUC, Chile

ABSTRACT

I will present the results of the GIRAFFE Inner Bulge Survey, with particular emphasis on the spatial distributions of the two metallicity populations, and their contribution to the total stellar mass budget of the Galactic bulge. I will also show the results of a follow-up MUSE programme aimed at characterizing the velocity dispersion peak found within 2 degrees (~280pc) from the Galactic center.

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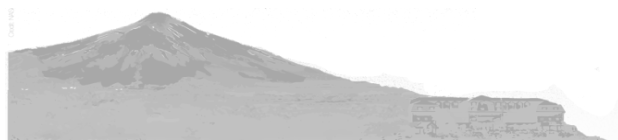
The **Galactic Bulge**
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Assembling Galactic globular clusters using orbital criteria

Angeles Perez-Villegas, IAS-USP, Brazil

ABSTRACT

The globular clusters (GCs) are the most ancient stellar systems in the Milky Way. Therefore, GCs play a key role in the understanding of the early chemical and dynamical evolution of our Galaxy. Around 40 % of GCs are placed within ~ 4 kpc from the Galactic center. In that region, all Galactic components overlap, making their disentanglement a challenging task. With Gaia DR2, we have accurate absolute proper motions (PMs) for the sample of known GCs that have been associated with the bulge/bar region. Combining the PMs with homogeneous distances from RR Lyrae and red clump stars, as well as radial velocities from spectroscopy, we can perform an orbital analysis of this GC sample, employing a steady Galactic potential with bar. We use a clustering algorithm on the orbital parameters such as the perigalactic distance, the apogalactic distance, the maximum vertical excursion from the plane and eccentricity to identify the GCs that belong to the bulge/bar, thick disk, thin disk or halo.

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The **Galactic Bulge**
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The Nuclear Star Cluster

Mathias Schultheis, Obs. de la Cote d'Azur, Nice, France

ABSTRACT

The Nuclear Star Cluster in the Milky Way is the only one we can study in detail, and as a benchmark object for large spiral galaxies, it provides a vital link to theories of galaxy evolution in general. This makes it very special and fundamental to explore. In many ways an extreme environment and embedding the super-massive black hole, the Nuclear Star Cluster lies at the centre of the Milky Way and extends a few 10 light-years across. With high-IR facilities, it is possible to get details chemical abundances of late type giants but it is also possible to trace the young stellar population in the Nuclear cluster. I will discuss our latest results

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The **Galactic Bulge**
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Near-Infrared Study of the Galactic Bulge X-ray Emission

Kumiko Morihana, Nagoya Univ., Japan

ABSTRACT

Apparently diffuse X-ray emission has been known to exist along the Galactic Plane, which is referred to as the Galactic Diffuse X-ray Emission (GDXE). The GDXE is composed of the Galactic Center X-ray Emission (GCXE), Galactic Ridge X-ray emission (GRXE), and Galactic Bulge X-ray Emission (GBXE), and its energy spectra are characterized by ionized Fe-K emission lines. A deep exposure by Chandra on the GBXE resolved >80% of the Fe-K lines into many faint X-ray sources. However, nature of these faint sources is poorly understood due to a lack of X-ray photon statistics. We carried out NIR imaging and spectroscopy of the Chandra field by Subaru/MOIRCS. Consequently, we found that there seems to be an unexpected stellar population constituting the GBXE, rather ordinary in NIR and unexpectedly shining in X-rays. In this talk, we present these NIR results and discuss nature of the new population in the Galactic bulge.

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The **Galactic Bulge**
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Bulge formation scenarios

Sandro Tacchella, HS CfA, USA

ABSTRACT

I will start by reviewing bulge formation scenarios that have been put forward. I will then present theoretical works on bulge formation in galaxies at redshifts of 1-3 based on state-of-the-art IllustrisTNG cosmological simulations and VELA zoom-in simulations, showing that typical galaxies on the star-forming main sequence can form a bulge component through rapid gas inflows to their central cores, triggered by mergers, counter-rotating accretion streams, or violent disk instabilities. In the final part, I will compare these theoretical ideas with current observations. Specifically, I will focus on the synergies from the ground (e.g., ALMA, SINFONI, MANGA) and space (HST, Spitzer, Herschel) to derive stellar mass and star-formation rate profiles.

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The **Galactic Bulge**
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The Galactic bulge as seen by the OGLE survey

Igor Soszynski, Warsaw University Obs., Poland

ABSTRACT

The Galactic bulge has been continuously observed by the Optical Gravitational Lensing Experiment (OGLE) since 1992. Currently, the OGLE project monitors the brightness of about half a billion stars in this region of the sky. These data provide us with a tool to study the structure of the bulge, to describe the star formation history, to measure the distance to the center of the Milky Way, to trace the metallicity distribution, and to map the interstellar extinction. Gravitational microlensing events have been used to probe the chemical composition of dwarfs in the central regions of the Galaxy and to detect exoplanets. Hundreds of thousands of new variable stars have been identified, including objects of previously unknown classes.

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The **Galactic Bulge**
at the crossroads

New Cepheids identified towards the Galactic bulge: Does the disk extend for more than 80 kpc?

Annalisa Calamida, STScI, USA

ABSTRACT

We report the detection of 2,521 previously uncatalogued variables towards the Sagittarius Window Eclipsing Extrasolar Planet Search field in the Galactic Bulge, using VIMOS@VLT time-series photometry, including 11 Cepheids and a further 88 potential Cepheid candidates, and many contact binaries. The analysis of the light curves showed that Cepheids are located up to distances larger than 80 Kpc from the Galactic center, thus indicating that the young stellar disk may extend much farther out than previously thought. We now have DDT planned observations with X-Shooter@VLT to collect spectra for the 3 brightest candidate Cepheids: these data will allow us to confirm these stars as Cepheids and characterize their dynamics and composition to further support their membership to the disk. If the classification is confirmed, this would be the first empirical evidence that the disk extends for more than > 80 Kpc.

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The **Galactic Bulge**
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RR Lyrae stars as Reddening Probes: Calibration in the DECam Optical Bandpasses

Kathy Vivas, CTIO, Chile

ABSTRACT

RR Lyrae variable stars are not only a well established standard candle of old stellar populations, but also, they are extremely good standard colors. These properties make RR Lyrae stars valuable tools in high extinction regions, such as the Galactic Bulge, since it is possible to obtain the line-of-sight reddening if multi-band photometry is available. We present preliminary results of an ongoing project that aims to derive calibrated Color-Period relationships in the optical filters (ugrizY) used by the Dark Energy Camera (DECam) on the Blanco Telescope at CTIO. We obtained multi-band, multi-epoch observations of 12 galactic globular clusters with known populations of RR Lyrae stars, spanning a range of metallicities, location in the Galaxy and Oosterhoff type. The color at minimum light - period relationship is expected to have little or no dependence on metallicity for colors made with the reddest filters (riz), but it may be important for colors containing the bluer bands u or g.
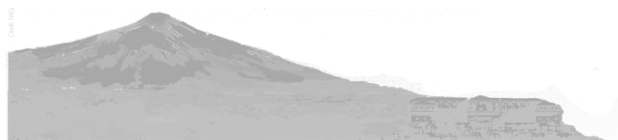
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The **Galactic Bulge**
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Predicting physical parameters of RR Lyrae based on the light curve morphology : Bulge variables

Anupam Bhardwaj, Peking University, China

ABSTRACT

We present an application of non-linear optimization to RR Lyrae variables in the Galactic bulge to estimate their physical parameters using a comparison of theoretical and observed light curve structure at multiple wavelengths. The multiband light curves for RR Lyrae are taken from the OGLE and VVV survey and theoretical light curves are generated from the stellar pulsation models. We adopt the Fourier amplitude and phase parameters together with observed period and mean-light properties as independent variables to perform one-to-one linear regression and predict the mass-luminosity, temperature, radius etc. from the models for the observed stars. Our results suggest a smoother grid in all the input parameters to the pulsation models can provide accurate and precise estimate of physical parameters generated from the best-fit model to the observed light curves.

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The **Galactic Bulge**
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Classical Cepheids in the direction of the Galactic bulge

Javier Minniti, PUC / ESO, Chile

ABSTRACT

Classical Cepheids are among the most useful Galactic and nearby extragalactic distance tracers because of their well-defined period luminosity relations. Moreover they are young stars, with ages ranging 20-300 Myr. Using data from the VVV survey we are now able to study these young standard candles in highly reddened regions of our Galaxy that were previously hidden to us. We have discovered several Cepheid candidates close to the Galactic plane. Population I Cepheids must compose an important fraction of our sample. In this talk, I will show the results of a NIR spectroscopic follow-up of 24 Cepheid candidates in the direction of the bulge and 22 in the southern disk, together with the results of a variability search towards the inner region of the bulge (|L|<5∞) using VVV multi-epoch PSF photometry to find new Cepheid candidates.

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The **Galactic Bulge**
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Near-IR variability of the bulge stellar population

Dante Minniti, UAB, Chile

ABSTRACT

Variable stars in the near-IR can be used to characterise in detail the composite stellar populations of the Galactic bulge. Pulsating variable stars in particular (RR Lyrae, Miras, and classical Cepheids), are excellent distance indicators, as well as reddening probes. They sample the extremes of the Milky Way stellar populations: from the very old and metal-poor to the very young and metal-rich, passing through the intermediate-age stars. Their study has an impact on the fields of Galactic structure, stellar evolution, star clusters, and the interstellar medium, among others. I will cover the results on the pulsating variable stars in the complex environment of the Galactic bulge, concentrating mostly on the VISTA Variables of the Via Lactea Survey (VVV), that is a large ESO Public near-IR survey of the Southern Milky Way (http://vvvsurvey.org). In the first part of the talk I will describe the design, observations, data processing, and current status of the VVV Survey and its on-going extension VVVX. In the second part I will summarize the discoveries and latest results enabled by this and other large near-IR variability surveys of the Milky Way.

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The **Galactic Bulge**
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Unleashing the inner Galaxy: the proper motion revolution

Felipe Gran, PUC, Chile

ABSTRACT

The Galactic bulge is usually avoided by wide-field surveys due to the stellar crowding and the dust and gas in the line of sight that covers the heart of the Milky Way. Within this framework, and taking advantage of the near-IR multi-epoch observations of the VVV survey towards the Galactic bulge, we aim to characterize in full detail the innermost part of the Galaxy in terms of its stellar populations, globular clusters, variable stars, and most importantly the individual proper motion of the stars. Here we show the first glimpse of the results of this study, in which we are able to recover the entire sample of known globular clusters within the analyzed area and also find new ones due to the derived proper motion information. We also explore the variable stars present in the area, specifically, RR Lyrae stars which are perfect distance indicators, to give clues about its cluster membership.

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The **Galactic Bulge**
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The VVV & VVVx survey - Status Report

Maren Hempel, Univ. Andres Bello, Chile

ABSTRACT

Since October 2009 the VISTA Variables in the Via Lactea Survey (VVV) and its extension (VVVx) have been collecting near-infrared imaging data of the inner galactic bulge and its adjacent disk area. VVVx will continue for approximatelly 2 more years, extending its predecessor VVV not only in area, but also in time-baseline. This meeting is the perfect occation to give an overview of the two surveys, their science goals, observing strategy, progress of the observations, data access and some of the results. The latter are manyfold, but here I will focus for one on the photometric completeness and its effect on the stellar density distribution across the survey area. Second I will include our study og the integrated near-infrared luminosities of selected galactic Globular Clusters. They are excellent probes of major star formation events and studying them within the Milky Way is essential for extragalactic studies, where resolved photometry or spectroscopy is not feasible.

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The **Galactic Bulge**
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The structure of the old Galactic Bulge revealed by Type II Cepheids

Vittorio Francesco Braga, UNAB, Chile

ABSTRACT

In the Galactic Bulge, metal-rich Red Clump stars, trace an X-shaped structure (Zoccali & Valenti 2016). However, the spatial distribution of old and more metal-poor Bulge stars, as traced by RR Lyrae (RRLs), is still under discussion (DÈkany et al. 2013; Pietrukowicz et al. 2015; Kunder et al. 2016). Type II Cepheids (T2Cs) are old, low-mass post-Horizontal Branch stars. Like the RRLs, T2Cs trace old stellar populations, but they are 1-3 mag brighter. T2Cs are distance indicators that obey a Period-Luminosity relation which is more accurate in the NIR, and practically metallicity-independent (Di Criscienzo et al. 2007). We use the Ks-band VVV light curves of 894 T2Cs in the OGLE IV catalog (Soszynski et al. 2017) to inspect the structure of the Bulge. We find a distance of the Galactic Center of 8.46 kpc, which is larger than estimates obtained with similar tracers (RRLs, 8.30 kpc). The difference is due to the fact that we used a new reddening law (Alonso-Garcia et al. 2017) and a 3D, distance-dependent reddening map (Schultheis et al. 2014). We also find, as in Pietrukowicz et al. (2015), a tilted ellipsoid, with stars at positive Galactic longitude (l) closer than stars at negative l. We use VVV and Gaia proper motions to show that Bulge T2Cs have the properties an old, kinematically hot population, as expected. Finally, we find that the average difference between VVV and Gaia proper motions of T2Cs is similar to the proper motion of Sgr A*, in the Galactic Center.

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The **Galactic Bulge**
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A billion-source atlas of the inner Milky Way

Javier Alonso-García, Univ. de Antofagasta, Chile

ABSTRACT

Our knowledge of the innermost Milky Way is seriously hampered by the dust and gas present at low latitude lines of sight. The VVV and the VVV-X surveys can beat these difficulties by observing the Galactic Bulge and inner Disk at near-infrared wavelengths were extinction is highly diminished. In addition, the high resolution of the VVV/VVV-X images and the use of PF-fitting techniques allow us to deal with the elevated crowding at these low-latitude regions. In this contribution, I will present the billion-source catalog we have generated for these regions. I will show the near-infrared CMDs that we have built, and which allow for a more precise definition and a better characterization of the different stellar populations located in the Galactic Plane. I will also talk about the non-canonical reddening law towards these low latitude lines-of-sight, and how we can use the information provided by our color-magnitude diagrams to constrain it.

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The **Galactic Bulge**
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Bulge structure and kinematics

Andrea Kunder, Saint Martin's Univ., USA

ABSTRACT

The internal kinematics of the bulge using a statistical sample of stars was first analyzed by the BRAVA survey, which showed that the bulge is in cylindrical rotation. Kinematic models allow at most only ~10% of the original model disk mass to be in the form of a "classical" spheroid formed by dissipational collapse. Subsequent kinematic bulge surveys, probing closer to the plane and/or different stellar populations, have confirmed this result. However, a more complicated kinematic view of the bulge than was first able to be disentangled by the original BRAVA results has emerged. In particular, the ARGOS, GIRAFFE and APOGEE survey's have combined elemental abundances with kinematics to reveal that the bulge has several populations coexisting within it. Perhaps the most striking example of this is the kinematically distinct rotation curves exhibited by the bulge RR stars and the red clump stars. An overview of the current status of the bulge structure and kinematics is given.
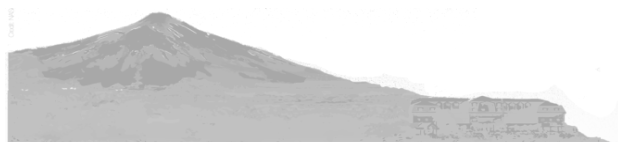
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The **Galactic Bulge**
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Correlations between kinematics and metallicity of bulge stars

Alvaro Rojas-Arriagada, PUC/MAS, Chile

ABSTRACT

Our understanding of the rather complex nature of the Galactic bulge has substantially increased in the last decade, mainly driven by the data provided by recent large scale photometric and high-resolution spectroscopic surveys. The picture that has emerged from this very active research made evident that the Galactic bulge cannot longer be considered as a simple homogeneous structure. As already suggested from the bimodal nature of the metallicity distribution function, the bulge seems to be the product of the spatial coexistence of two groups of metal-rich and metal-poor stars, with different spatial distributions, alpha-enhancements, and seemingly, different ages. In this context, kinematic information for bulge stars of different metallicity provides a fundamental ingredient to disentangle their eventual different origin by revealing their different dynamics. In this talk, I will briefly review the lessons learned from correlating radial velocity with metallicity, as sampled across.

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The **Galactic Bulge**
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Stellar Chemodynamics in the Inner Milky Way and Beyond

Gail Zasowski, University of Utah, USA

ABSTRACT

Galactic bulges contain dense fossil records of star formation and galaxy assembly encoded in the chemodynamical patterns of the stars. The Milky Way's bar/bulge is the only one in which we can resolve the chemistry/kinematics of individual stars, but despite sophisticated models that can reproduce the bulk stellar patterns, we have not fully mapped the evolution of our bar/bulge's numerous populations. Recent surveys, particularly in the infrared, are providing opportunities to characterize ever-finer details of the inner Milky Way's velocity and chemical distributions, which are critical discriminants among models with different star formation and evolutionary histories. Using APOGEE data, we will present an analysis of chemodynamical patterns observed in thousands of inner Galaxy stars, discuss implications for tracing the co-evolution of stellar morphological, dynamical, and chemical properties in external galaxies, and highlight future prospects for improvements in the 2020s.
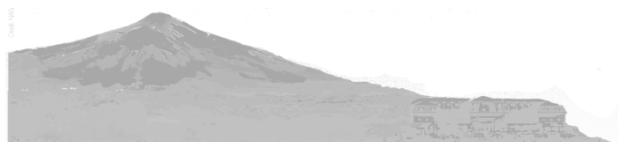
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Chemical and Kinematic Analysis of CN-strong Metal-poor Field Stars in LAMOST DR3

Baitian Tang, Sun Yat-sen Univ., China

ABSTRACT

The large amount of chemical and kinematic information available in large spectroscopic surveys have inspired the search for chemical anomaly stars in the field. Though these metal-poor stars ($[Fe/H]<-1$) are commonly enriched in nitrogen, their detailed spatial, kinematic, and chemical distributions suggest that various groups of chemical anomaly stars may exist, thus their origin is still a mystery. To study these N-rich stars statistically, we show our effort of increasing the sample size by identifying new CN-strong stars with LAMOST DR3. We use CN-CH bands around 4000 A to find CN-strong stars, and further separate them into CH-normal stars and CH-strong stars. The chemical abundances from our data-driven software and APOGEE DR 14 suggest that most CH-normal stars are N-rich, while CH-strong stars may be carbon stars. The kinematics of our CN-strong CH-normal stars indicate a substantial fraction of these stars are retrograding, poin pointing to a possible extragalactic origin.
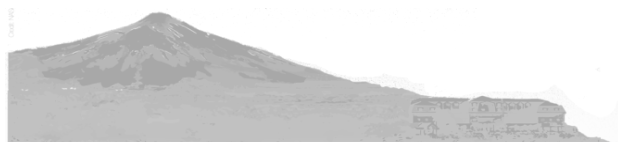
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Chemical abundances and ages of the bulge stars in APOGEE high-velocity peaks

Yingying Zhou, Shanghai Astronomical Observatory, China

ABSTRACT

A cold, high-velocity (HV, ~200 km/s) peak was first reported in several Galactic bulge fields based on the Apache Point Observatory Galaxy Evolution Experiment (APOGEE) commissioning observations. Both the existence and the nature of the HV peak are still under debate. Here we revisit this feature with the latest APOGEE DR13 data. We find that most of the low latitude bulge fields display a skewed Gaussian distribution with an HV shoulder. However, only 3 out of 53 fields show distinct HV peaks around 200 km/s. The velocity distribution can be well described by Gauss$-$Hermite polynomials, except for the three fields showing clear HV peaks. We find that the correlation between the skewness parameter h3 and the mean velocity, instead of a distinctive HV peak, is a strong indicator of the bar. It was recently suggested that the HV peak is composed of preferentially young stars. We choose three fields showing clear HV peaks to test this hypothesis using the metallicity, [alpha/M] and [C/N] as age proxies. We find that both young and old stars show HV features. The similarity between the chemical abundances of stars in the HV peaks and the main component indicates that they are not systematically different in terms of chemical abundance or age. In contrast, there are clear differences in chemical space between stars in the Sagittarius dwarf and the bulge stars. The strong HV peaks off-plane are still to be explained properly and could be different in nature. Note that APOGEE1 only covers the positive longitude side of the bulge. Nowadays APOGEE2 covers the whole bulge and the data of some negative fileds are available. We will show some preliminary results on velocity distributions in the negative longitude side of the bulge.

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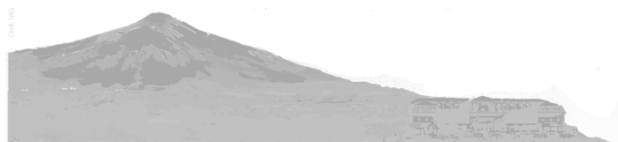
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Chemically-dissected rotation curves of the inner Galactic bulge

Will Clarkson, University of Michigan-Dearborn, USA

ABSTRACT

I will report results from an ongoing study using archival Hubble Space Telescope imaging observations in seven filters over a multi-year time-baseline, for several fields towards the inner Galactic bulge. Thanks to the broad wavelength coverage of the WFC3 Bulge Treasury Survey, we can chart for the first time the proper motion-based rotation curves of the inner Milky Way as traced separately by relatively metal-rich and metal-poor main sequence tracer samples. While the velocity dispersion behavior is qualitatively in line with some previous spectroscopic indications at similar Galactic latitudes, the metallicity-difference in rotation curves has not previously been observed, probably because ours is the first study to break down chemo-dynamical indications by distance along a single line of sight.
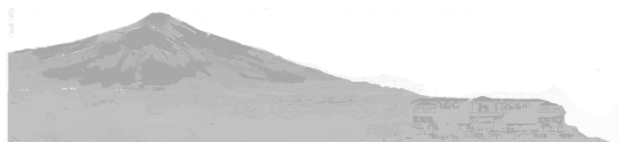
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The **Galactic Bulge**
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Interstellar extinction toward the Galactic bulge

Noriyuki Matsunaga, Univ. of Tokyo, Japan

ABSTRACT

The past decade has seen rapid progress in studies on the Galactic bulge thanks to many large-scale surveys in both photometric and spectroscopic approaches. However, interstellar extinction has limited observations of objects in low-latitude regions of the bulge. Optical observations are affected more significantly, but sensitivity and interpretation of infrared observations are also disrupted because of strong and patchy extinction towards the bulge. Detailed mapping of the extinction including distribution of absorbing clouds along the line of sight is an important task in Galactic astronomy. Determination of the extinction law, i.e. wavelength dependency of the extinction is also an important and unavoidable task, and many studies have been published in a recent few years. In this talk, I'll review previous studies on the interstellar extinction and discuss new approaches including usage of spectroscopic or astrometric data.
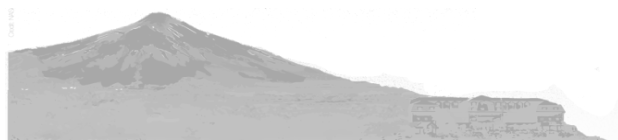
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The **Galactic Bulge**
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The star formation history and metallicity in the galactic inner bulge revealed by the RGBB

Francisco Nogueras Lara, IAA-CSIC, Granada, Spain

ABSTRACT

Observations of the innermost kiloparsec of the Milky Wayís bulge are affected by extreme interstellar extinction and source crowding which have posed serious obstacles to the study of its stellar population up to now. Using the 0.2íí angular resolution JHKs data from the new GALACTICNUCLEUS survey, we overcome these challenges and study the stellar population within two fields, about 0.6∫ and 0.4∫ to the Galactic north of the Milky Wayís centre. We find that the stellar population is old, similar to the one at larger distances from the Galactic plane, and that its metallicity is twice solar, which is consistent with a flat metallicity gradient within about 500 pc of the Galactic centre.

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Exploring windows of low extinction in the Galactic plane with VVV

Roberto Saito, Univ. Federal de Santa Catarina, Brazil

ABSTRACT

High extinction towards the Galactic plane is a major obstacle to study the far side of the Milky Way. In order to explore the Galaxy low extinction windows such as the Baade's window in the bulge have been used to study its stellar content and structure. We present now the analysis of recently discovered windows of low extinction by the VVV Survey towards the Milky plane. These windows at Galactic longitudes |b|<1 deg allows one to explore the far side of the Milky Way right in the plane and to study the structure of Galaxy by analyzing the distribution and proper motion of their stellar content. VVV red clump stars within these windows are used to map the far side of the disk and present evidences of the the spiral arms across the Milky Way.

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Extinction corrected CMDs of bulge stars from multiband (ugriz) light curves of RR Lyrae stars

Abhijit Saha, NOAO, USA

ABSTRACT

Minimum light colors of RR Lyrae stars (which are both standard color markers as well as standard candles) measured with the DECam imager on the Blanco 4m telescope at CTIO in select fields in the Galactic bulge are used to independently derive the extinction law in these visible passbands. Variations in the color-color diagrams on sub-arc-minute scales allow the construction of reddening maps that can be anchored to the RR Lyrae color scale, yielding reddening and extinction corrected color-magnitude diagrams of unprecedented clarity that reveal interesting features and characteristics of stellar populations in the bulge, including a very blue horizontal branch and surprisingly young stars with super-solar abundance. The extinction corrected RR Lyrae stars also trace the density distribution of the ancient stars, and structure in the reddening maps show remnants from the past.

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Dynamical models of the Galactic bulge

Juntai Shen, Shanghai Astronomical Obs., China

ABSTRACT

I review the recent progresses on the properties of the Galactic bar and bulge, and the major theoretical models and techniques to understand the Milky Way bulge. Despite these recent advances, a complete bulge formation model that explains the full kinematics and metallicity distribution is still not fully understood. Upcoming large surveys are expected to shed new light on the formation history of the Galactic bar and bulge.

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The **Galactic Bulge**
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Understanding the chemodynamics of the Bulge

Victor Debattista, Univ. of Central Lancashire, UK

ABSTRACT

I will present the results of simulations and careful comparisons with observations that allow us to determine the formation of the bulge. The bulge is to a large extent part of the bar. It formed in a buckling instability which resulted in many of the trends observed, including the chemical dependence of the X-shape, the vertical gradient and the kinematics. Gaia DR2 gives us additional insight into the bulge and I will present some results from comparison with our simulations.

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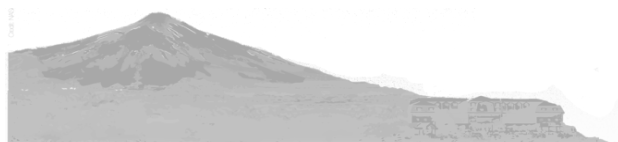
Assembling the Milky Way bulge from globular clusters: Evidence from the double red clump

Young-Wook Lee, Yonsei Univ., South Korea

ABSTRACT

Two red clumps (RCs) observed in the color-magnitude diagram of the Milky Way bulge are widely accepted as evidence for a giant X-shaped structure originated from the bar instability. We suggested, however, a drastically different interpretation based on the He-enhanced multiple stellar population phenomenon as is observed in globular clusters (GCs). Here we report our discovery that the stars in the two RCs show a significant (> 5.3 sigma) difference in CN-band strength, in stark contrast to that expected in the X-shaped bulge scenario. Because CN-strong stars trace a population with enhanced N, Na, and He abundances that originated in GCs, this is direct evidence that the double RC is due to the multiple population phenomenon, and that a significant population of stars in the Milky Way bulge were assembled from disrupted proto-GCs as supported by recent cosmological simulations. Our result also calls for the major revision of the 3D structure of the MilkyWay bulge.
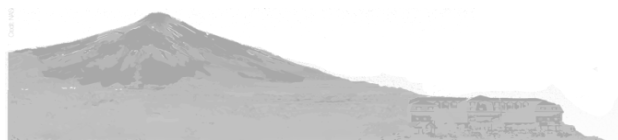
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The **Galactic Bulge**
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No X-shape in the Milky Way bulge

Martín López Corredoira, IAC, Spain

ABSTRACT

X-shape in the bulge of our Galaxy is based on the analysis of red clump star counts in the region |l|<10 deg., 5<|b|<10 deg., where a double peak in the star counts along the line of sight is found, but contamination of a secondary red clump might produce the artifact of the second peak in the density. X-shape was also observed in the projected images of the bulge, although it depends on its processing with the subtraction of some particular disc model or it may be an artefact due to a subtraction of the bulge as an ellipsoid instead of a boxy bulge. Moreover, stellar density of bulge stars in the same regions using different stellar populations with different ages (young F0-F5V from VISTA-VVV data; or intermediate age O-rich Miras variables from OGLE and other surveys; or very old RR-Lyrae) only show a single peak in the density distribution along the lines of sight. This may indicate that X-shape structure is not there and a boxy bulge better represents the bulge.

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Bulge and Globular Cluster Connection: Evolutionary Population Synthesis with Multiple Populations

Chul Chung, Yonsei University, South Korea

ABSTRACT

Recently, Lee et al. (2018) have reported the observational evidences that Galactic bulge consists of stellar populations originated from Milky Way globular clusters (MWGCs). Motivated by this, here we present the evolutionary population synthesis (EPS) for Galactic bulge with the realistic treatment of individual variations in light elements observed in the MWGCs. We have tested our integrated absorption-indices model for the age dating of bulge GCs and the results show remarkable agreements with those derived from the isochrone-fitting in color-magnitude diagrams. We further apply our model to estimate the age of early-type galaxies (ETGs), which are considered as good analogues for the MW bulge. We find that, without the effect of our new treatments, EPS models will almost always underestimate the true age of ETGs. The implication of this result will be discussed in detail.
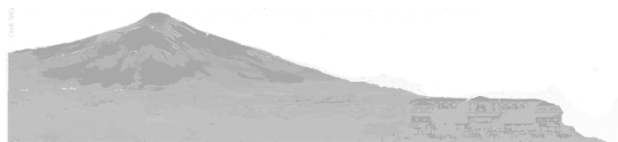
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The **Galactic Bulge**
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Bulges in nearby galaxies

Oscar Gonzalez, UK Astronomy Technology Centre, UK

ABSTRACT

Recently, Lee et al. (2018) have reported the observational evidences that Galactic bulge consists of stellar populations originated from Milky Way globular clusters (MWGCs). Motivated by this, here we present the evolutionary population synthesis (EPS) for Galactic bulge with the realistic treatment of individual variations in light elements observed in the MWGCs. We have tested our integrated absorption-indices model for the age dating of bulge GCs and the results show remarkable agreements with those derived from the isochrone-fitting in color-magnitude diagrams. We further apply our model to estimate the age of early-type galaxies (ETGs), which are considered as good analogues for the MW bulge. We find that, without the effect of our new treatments, EPS models will almost always underestimate the true age of ETGs. The implication of this result will be discussed in detail.

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The **Galactic Bulge**
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Shape of LOSVDs in Barred Disks: Implications for Future IFU Surveys

Zhao-Yu Li, Shanghai Astronomical Observatory, China

ABSTRACT

The shape of line-of-sight velocity distributions (LOSVDs) carries important information about the internal dynamics of galaxies. The skewness of LOSVDs represents their asymmetric deviation from a Gaussian profile. Correlations between the skewness parameter h_3 and the mean velocity $\overline{V}$ of a Gauss–Hermite series reflect the underlying stellar orbital configurations of different morphological components. Using two self-consistent N-body simulations of disk galaxies with different bar strengths, we investigate $h_3 - \overline{V}$ correlations at different inclination angles. Similar to previous studies, we find anticorrelations in the disk area, and positive correlations in the bar area when viewed edge-on. However, at intermediate inclinations, the outer parts of bars exhibit anticorrelations, while the core areas dominated by the boxy/peanut-shaped (B/PS) bulges still maintain weak positive correlations. When viewed edge-on, particles in the foreground/background disk (the wing region) in the bar area constitute the main velocity peak, whereas the particles in the bar contribute to the high-velocity tail, generating the $h_3 - \overline{V}$ correlation. If we remove the wing particles, the LOSVDs of the particles in the outer part of the bar only exhibit a low-velocity tail, resulting in a negative $h_3 - \overline{V}$ correlation, whereas the core areas in the central region still show weakly positive correlations. We discuss implications for IFU observations on bars, and show that the variation of the $h_3 - \overline{V}$ correlation in the disk galaxy may be used as a kinematic indicator of the bar and the B/PS bulge.

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The **Galactic Bulge**
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Bulges in high redshift galaxies

Natascha M. Forster Schreiber, MPI f. extratarrestrische Physik, Germany

ABSTRACT

I will review insights on bulge formation, including in Milky-Way mass progenitors, from spatially-resolved in-situ observations of galaxies at redshifts z ~ 1 - 3. These include VLT/SINFONI + KMOS near-IR integral field spectroscopy, HST imaging, and more recently NOEMA + ALMA millimeter interferometry, mapping the all of the gas kinematics, molecular gas reservoirs, star formation, and stellar mass on scales down to ~ 1 kpc. I will also outline prospects in this area with JWST and E-ELT.

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The **Galactic Bulge**
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Formation and properties of galactic bulges in MW-sized haloes in the AURIGA simulations

Ignacio Gargiulo, Univ. de La Serena, Chile

ABSTRACT

We study the formation and properties of galactic bulges in the Auriga simulations, a suite of forty cosmological magneto-hydrodynamical zoom-in simulations of late-type galaxies in MW-sized Dark Matter haloes performed with the moving-mesh code AREPO. We aim to characterize the formation mechanisms of bulges of an unprecedented large number of galaxies simulated with high levels of resolution in a cosmological context. The bulges of the Auriga galaxies show variety in their shapes, sizes and formation histories. A few of them resemble the X-shape of the MW bulge. Most of the Auriga bulges have less than 25% of accreted stellar particles. We search for correlations between bulge properties such as major-to-minor axis ratios, metallicities, ages, and accretion fraction to define observable properties that will help constraining bulges' origins. Our results are well-suited to compare with current observations of the Milky Way bulge and shed light into its formation.

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The **Galactic Bulge**
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Chemical tagging of stars based on low-resolution spectroscopy

Bruno Dias, ESO/UNAB, Chile

ABSTRACT

In the era of large surveys it is crucial to find the best compromise between telescope and instrument requirements and scientific goals. Photometric surveys deliver numerous targets for spectroscopic follow-up. High-resolution spectroscopy is focused on detailed chemical abundances of stars, but faint stars in the bulge demand a lot of telescope time to get enough signal-to-noise for this type of analysis. Therefore, low-resolution spectroscopy seems to be the most suitable choice in the case of the bulge, because it provides spectra for a large number of faint bulge stars with enough signal-to-noise and resolution to derive radial velocities, atmospheric parameters (Teff, logg, [Fe/H]), and chemical abundances for a few key elements, such as [alpha/Fe]. This set of parameters can already describe the big picture of bulge chemical evolution history and stellar populations, not to mention the selection of chemically interesting targets for high-resolution follow-up. In this talk I will describe the current (e.g. FORS2, MUSE, Gaia) and future instruments (e.g. 4MOST) that deliver low-resolution spectra of bulge stars, their respective surveys, and some results.
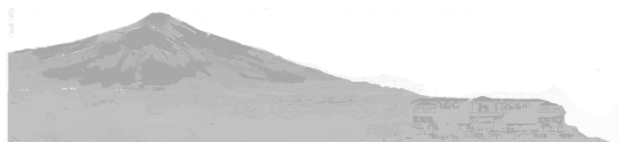
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Yonsei Spectroscopic Survey for Bulge Red Clump Stars

Dongwook Lim, Yonsei Univ., South Korea

ABSTRACT

In the era of large surveys it is crucial to find the best compromise between telescope and instrument requirements and scientific goals. Photometric surveys deliver numerous targets for spectroscopic follow-up. High-resolution spectroscopy is focused on detailed chemical abundances of stars, but faint stars in the bulge demand a lot of telescope time to get enough signal-to-noise for this type of analysis. Therefore, low-resolution spectroscopy seems to be the most suitable choice in the case of the bulge, because it provides spectra for a large number of faint bulge stars with enough signal-to-noise and resolution to derive radial velocities, atmospheric parameters (Teff, logg, [Fe/H]), and chemical abundances for a few key elements, such as [alpha/Fe]. This set of parameters can already describe the big picture of bulge chemical evolution history and stellar populations, not to mention the selection of chemically interesting targets for high-resolution follow-up. In this talk I will describe the current (e.g. FORS2, MUSE, Gaia) and future instruments (e.g. 4MOST) that deliver low-resolution spectra of bulge stars, their respective surveys, and some results.
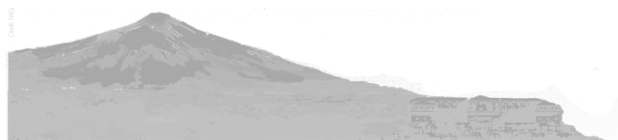
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The **Galactic Bulge**
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Accuracies of abundance determinations in large spectroscopic surveys

Oleksiy Ivanyuk, National Academy of Sciences of Ukraine

ABSTRACT

Along with our own results from the high resolution spectral analysis of the 107 metal rich F, G, K stars from the Calan-Hertfordshire Extrasolar Planet Search program (CHEPS) we discuss differences in the abundances of Na, Mg, Al, Si, Ca, Ti, Cr, Mn, Fe, Ni, Cu, and Zn between a number of large spectroscopic surveys. Most authors tend to use stellar spectra to determine virtually all fundamental parameters including effective temperature and surface gravity. We attempted to recreate results for a dozen of common stars using available input parameters to highlight the real scale of errors this approach might induce. We confirm overabundance and light decline of α-elements versus metallicity in the metal-deficient domain from -0.4 to -0.2 dex. This trend changes for the metal-rich stars between 0.0 and 0.4 dex, but among α-elements only Na follows positive trend - along with Mn, Ni, Cu and Zn. Slight increase is also visible for Al. Ca continued to show a negative trend.

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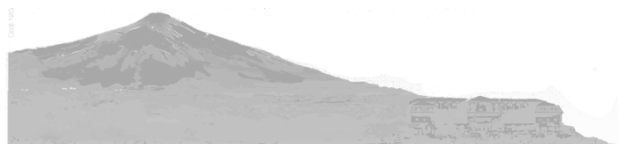
The **Galactic Bulge**
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Future surveys of the bulge stellar populations

Livia Origlia, IANF-OAS, Italy

ABSTRACT

In this talk I will highlight open questions and future observational perspectives to unveil the chemical, kinematic and evolutionary properties of the complex stellar populations of the barred Bulge and towards the Galactic center.
Their comprehension is of fundamental importance to interpret and model formation and evolution of the nuclear region of galaxies at large, and the assembling process of massive bulges at high redshift.

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The **Galactic Bulge**
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Building sets of reference stars for current and future spectroscopic survey stellar parameters

Marcelo Tucci Maia, Univ. Diego Portales, Chile

ABSTRACT

One of the main deliveries of spectroscopic surveys are the stellar parameters and abundances that are determined from automatic pipelines. In this talk I will present 2 important sets of stars that have been used to validate and calibrate the astrophysical parameters of not only several spectroscopic surveys but also Gaia DR2 parameters from the BP/RP spectra. These are the Gaia benchmark stars and a sample of solar twins, both developed by our group at the Astronomy Nucleus in Chile. I will discuss our current activities and future plans for the next generation of spectroscopic surveys and further data releases of Gaia.

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The **Galactic Bulge**
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The Extremely Large Telescope: the future of European ground-based astronomy.

Michele Cirasuolo, ESO, Germany

ABSTRACT

The European Extremely Large Telescope (ELT) is a revolutionary scientific facility that will allow the ESO astronomical community to address many of the most pressing unsolved questions about our Universe. The ELT is now under construction and with its 39-metre primary mirror it will be the largest optical/near-IR telescope in the world. I will present an overview of the ELT Programme, focusing on the latest status of the telescope and its instrumentation, and highlight the key science drivers.

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The WFIRST Microlensing Survey: Symbiosis with Galactic Bulge studies

Matthew Penny, Ohio State Univ., USA

ABSTRACT

WFIRST, the Wide Field Infrared Survey Telescope, will be NASA's next flagship astrophysics mission, to follow JWST. In addition to a general observer program, and high-latitude survey to study dark energy, WFIRST will conduct a large microlensing survey of fields in the Galactic bulge in order to explore the demographics of exoplanets as small as Mars in orbits beyond 1 AU. I will give an overview of the WFIRST mission and its microlensing survey, as well as the efforts under way to maximize the return of the microlensing survey. These efforts include a large microlensing survey of the Galactic center using UKIRT, and the development of a new modular population synthesis Galactic model code to keep up with the rapid developments in the understanding of the Galactic bulge.

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Imaging the Event Horizon in the Galactic Center and M87

Heino Falcke, Radboud Univ., The Netherlands

ABSTRACT

When illuminated by ambient light, the event horizon of black holes will cast a dark shadow. For the supermassive black holes in the Galactic center and in M87 this shadow is detectable with the ìEvent Horizon Telescopeî (EHT), a global mm-wave very long baseline interferometry experiment. The Galactic Center hosts a compact radio source, Sgr A*, with a mass of only 4 Million solar masses, determined precisely from stellar orbits. This gives a robust prediction for a shadow size, allowing detailed tests of general relativity there. However, the imaging is challenging due to rapid source variability and image blurring in the interstellar medium. Imaging of M87 is not affected by these effects, but the black hole mass is more uncertain. With advanced computer simulations the appearance of the sources and their shadows can be modeled and predicted in detail. A first global campaign of the EHT was successfully conducted in 2017 and the data are currently being analyzed.

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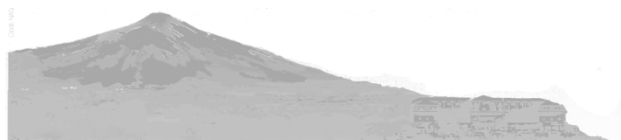
The **Galactic Bulge**
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Is the Galactic Bulge Shining in Gamma Rays

Chris Gordon, University of Canterbury, New Zealand

ABSTRACT

Data from the Fermi Large Area Telescope indicates that there is an extended source of GeV gamma-ray photons coming from the Galactic Centre. Initially, it was thought that this could be due to self-annihilating dark matter. However, recent work shows that the spatial morphology better matches the shape of the Galactic bulge rather than a spherically symmetric shape that would be expected from a dark matter signal. I will discuss this result and also give details on the evidence that the source of the excess is due to an unresolved population of millisecond pulsars in the Galactic bulge.

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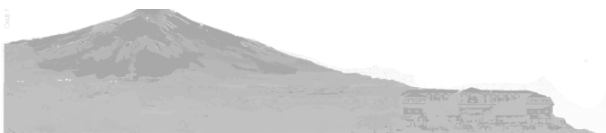at the crossroads

POSTER CONTRIBUTIONS

Search for Exoplanet Transits in the Galactic Bulge

Caddy Cortés, U Concepcion, Chile

ABSTRACT

The study of exoplanets provides us with a greater understanding of planetary system formation, what are their structures and compositions. In this project, our aim is to search and characterize extrasolar planets in the Galactic Bulge and to establish whether there is a relationship with existing exoplanets in the Disk of the Milky Way. This will be done using photometric catalogs through the K2 mission and VVV survey. With these data, we will search for exoplanets in this field using the transit technique. We present the discovery of five exoplanet candidates, in which three warm Jupiters and two hot Jupiters detected in the Galactic Bulge with K2 data. Our candidates have a period between 3.6 and 35.2 days. One of them is a planet orbiting a variable star. Here, we will report preliminary planet catalogs and their properties.

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The **Galactic Bulge**
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A MUSE analysis of inner bulge globular cluster Terzan 9

Heitor Ernandes, IAG-USP, Brazil

ABSTRACT

Moderately metal-poor inner bulge globular clusters should be relics of an early generation of long-lived stars formed in the proto-Galaxy. aims heading (mandatory) Terzan 9, projected at only 4.12 degrees, and with an orbit remaining confined in the inner 1 kpc of the Galaxy center is among the most central globular clusters in the Milky Way. Given its compactness, Terzan 9 was observed with the Multi Unit Spectroscopic Explorer (MUSE), at the Very Large Telescope. Extraction of several hundreds of cluster spectra allow to derive metallicities and [Mg/Fe] based on the Mg2 feature. (cf. Dias et al. 2015), as well as other strong features such as NaD, Na819nm, Ca, Ba, and molecular lines. Low resolution spectra obtained with MUSE were analysed through full spectrum fitting, with the code ETOILE.
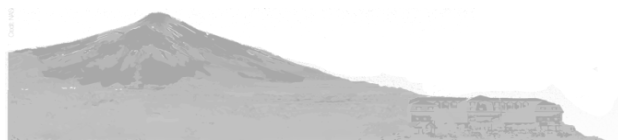
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The **Galactic Bulge**
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Terzan 5, a fossil relic of the galactic bulge

Vanessa Gotta, UCN, Chile

ABSTRACT

Terzan 5 is a globular cluster-like system located at just 2.1 [Kpc] away from the Galactic center (l=3.84°, b=1.69°) that has been commonly cataloged as a Globular Cluster (GC) since its discovery. The high extintion (E(B-V)=2.38) and the strong differential reddening (ΔE(B-V)≈0.7mag) that characterize the area, in addition to the contamination from field stars, limited a deep photometric study of the stellar system.

Recently (Ferraro et al. 2009), it has been discovered that this system is even more complex than previously thought, having two Horizontal Branches (HBs) separated by ~0.3 [mag] in the Ks band. This offset is explicable considering the presence of two population with a difference in metallicity and age of 0.5 [dex] and ~7 [Gyr], respectevely. Later studies (Origlia et al. 2011; Ferraro et al. 2016) confirmed the presence of two population, classifying Terzan 5 as a candidate for the building blocks of the Galaxy. Hence, it is so important to find the properties of this system in a precise way to elucidate the formation and the evolution history in the earliest time of the Milky Way. Recently we obtain new data in J and Ks bands with the near-infrared adaptive-optics camera GeMS/GSAOI of the inner part of this stellar system. In this work we will present the last results of the photometric analysis.

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The **Galactic Bulge**
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New near-IR curves modelling of newly discovered BHB binary stars

Luciana Gramajo, OAC, Argentina

ABSTRACT

We present new results in the study of selected Blue Horizontal Branch binary systems recently detected in the VVV Survey images in the Galactic bulge. For the analysis of the Ks band light curve we used the "Physics Of Eclipsing Binaries" (PHOEBE 1.0) interactive code. The selected sample consists of five Detached, Contact and Semi-detached candidates of eclipsing binaries. The systems discovered present orbital inclinations close to 80∫, and have low eccentricities with surface temperatures range between 7000 and 12000 K.

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The **Galactic Bulge**
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Visual - near-infrared properties of the interstellar extinction towards the Galactic bulge with RR Lyrae stars

Gergely Hajdu, PUC/MAS, Chile

ABSTRACT

Towards the bulge, studies of interstellar extinction are generally limited by uncertainties in the individual distances, magnitudes, and colors of the most commonly utilized stellar tracers. RR Lyrae stars, however, have well known absolute magnitudes and colors; furthermore, their distribution is known to be strongly centered around the Galactic center, easing the problem of unknown individual distances. We exploit these properties of RR Lyrae variables with large samples derived from wide-area surveys (OGLE, VVV) to study the interstellar extinction in optical and near-infrared wavelengths towards the Galactic bulge.

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The **Galactic Bulge**
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Discovery of a significant population of CN-enhanced stars with globular cluster origin in the Milky Way

Seungsoo Hong, Yonsei Univ., South Korea

ABSTRACT

Two scenarios have been suggested to explain the double red clump (RC) phenomenon observed in the Milky Way bulge. One is the X-shaped bulge model, and the other is multiple population model as is observed in globular clusters. In order to investigate the origin of the double RC, we performed low-resolution spectroscopy for stars in the two RC regimes, and measured CN, CH, and Ca band strengths. We found that the stars in the two RCs show (1) a significant (> 5.3 sigma) difference in CN strength, but (2) negligible differences in CH and Ca abundances. This chemical pattern is in contrast to that expected in the X-shaped bulge scenario, but is fully consistent with the behavior predicted in the multiple population m
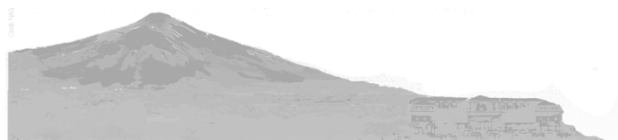
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The **Galactic Bulge**
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Common origin of two RR Lyrae populations and the double red clump in the Milky Way bulge

Sohee Jang, Yonsei Univ., South Korea

ABSTRACT

The OGLE survey has recently discovered two populations of RR Lyrae stars in the Milky Way bulge on the period-amplitude diagram. These two sequences of RR Lyrae stars can be reproduced by our synthetic horizontal-branch models with a small difference in He abundance between the two populations. When these models are extended to solar metallicity following $\Delta Y/\Delta Z \approx 6$ for second generation stars, as predicted from chemical evolution models, the observed double red clump (RC) in the bulge is also naturally reproduced. Therefore, the two populations of RR Lyrae stars and the double RC observed in the bulge appear to be different manifestations of the same multiple population phenomenon in the metal-poor and metal-rich regimes, respectively.

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The **Galactic Bulge**
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Accurate Ages of Bulge Globular Clusters from Deep and Proper-motion-cleaned HST and Gemini CMDs

Leandro Kerber, UESC, Brazil

ABSTRACT

Alpha-enhanced ([alpha/Fe] >~ +0.3) and moderately metal-poor ([Fe/H] <~ -1.0) bulge globular clusters (GCs) with blue horizontal branches are probable relics of the early star formation in the innermost Galactic regions. To determine the ages of such stellar systems, normally suffering by severe extinction and strong field contamination, we have employed multi-epoch photometry from HST (optical) and Gemini (near-infrared, using GSAOI+GeMS) to build proper-motion-cleaned and deep colour-magnitude diagrams (CMDs). By means of Bayesian isochrone fits, we have confirmed that NGC6522, NGC6626 and HP1 are among the oldest GCs in the Galaxy, with ages between 12.5 and 13.0 Gyr. Metallicities from high-resolution spectroscopy and distances from RR Lyrae stars allowed us to better constraint the ages and the helium abundance. Orbital analysis of these clusters suggest that the early fast chemical enrichment in the bulge can be imprinted in stars at Galactocentric distances of ~ 3.0 kpc.

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The **Galactic Bulge**
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Kinematic study of the bulge globular cluster NGC6528

Edoardo Lagioia, University of Padua, Italy

ABSTRACT

Precise estimates of the properties of the metal-rich globular NGC6528 are hampered by significant contamination of bulge stars across the field of view of the cluster. Thanks to HST observations, spanning a time interval of ~10 yr, we performed a kinematic separation of cluster and field stars in the central region of NGC6528. Comparison of observed color-magnitude diagrams with theoretical models in optical bands allowed us to determine the main parameters of the cluster stars as well as the properties of the bulge population in the Baade's Window.

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The **Galactic Bulge**
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Unveiling the RR Lyrae population of bulge globular clusters

Francisco Maia, U. Sao Paulo, Brazil

ABSTRACT

Significant observational efforts have been carried out in the last decades to characterize the bulge globular clusters (GC). However, the strong field contamination, extinction, and crowding still severely hampers the investigation of these targets. Particularly, the RR Lyrae population in metal-poor GC ([Fe/H <~ -1.0]) is crucial to provide accurate distances and to constrain the helium abundances. In this context, we present the early results of an ongoing survey aimed at unveiling the missing RR Lyrae population in the core regions of metal-poor bulge GCs, by making use of AO-assisted photometry obtained with SAM@SOAR telescope. Light curves of hundreds of prospect stars in two such targets (HP1 and NGC6723) were built and the new RR Lyrae candidates identified. Their spatial distribution and properties will be presented, thus providing important constraints to study these GCs.

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The **Galactic Bulge**
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SkZpipe: A Python3 module to produce efficiently PSF-fitting photometry with DAOPHOT, and much more

Francesco Mauro, UCN, Chile

ABSTRACT

In an era characterized by big sky surveys and the availability of large amount of photometric data, it is important for astronomers to have tools to process their data in an efficient, accurate and easy way, minimizing reduction time. We present SkZpipe, a Python3 module designed mainly to process generic data, performing point-spread function (PSF) fitting photometry with the DAOPHOT suite (Stetson 1987). The software has already demonstrated its accuracy and efficiency with the adaptation VVV-SkZ_pipeline (Mauro et al. 2013) for the ``VISTA Variables in the Via Lactea'' ESO survey, showing how it can replace the users, avoiding repetitive interaction in all the operations, retaining all of the benefits of the power and accuracy of the DAOPHOT suite, detaching them from the burden of data precessing. This software provides not only a pipeline, but also all the tools to run easily each atomic step of the photometric procedure, to match the results, and to retrieve information from fits headers and the internal instrumental database. We plan to add the support to other photometric softwares in the future.

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The **Galactic Bulge**
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Chemical analysis of the Bulge Globular Cluster NGC 6553

Carolina Montecinos, U Concepcion, Chile

ABSTRACT

The study of the stellar abundances in the Galactic Bulge is of great importance to understand the chemical evolution that occurred in our galaxy. Within this context, the Multiple Populations (MPs) found in the Globular Clusters (GCs) play a fundamental role. The purpose of this study is to perform a detailed analysis of chemical abundances of a large number of elements to a sample of stars belonging to the bulge globular cluster NGC 6553. In order to determine chemical patterns that allow us to appreciate if the phenomenon of MPs takes place in one of the most metal-rich GCs in the galaxy. This analysis is being carried out with a sample of spectroscopic data obtained by the FLAMES/GIRAFFE spectrograph mounted on the Kueyen VLT-UT2 telescope of the Paranal Observatory (Chile) and with photometric data obtained by Variables in the Vīa Láctea Survey (VVV). This study will also allow us to compare chemical patterns of this GC with others Bulge GCs, as well as with field stars belonging to this one.
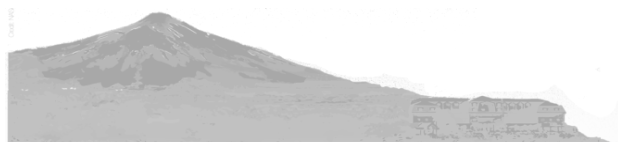
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The **Galactic Bulge**
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Abundances in the globular cluster NGC 6558

Leonardo Muniz, IAG - University of Sao Paulo, Brazil

ABSTRACT

NGC 6558 is a bulge globular cluster with a blue horizontal branch (BHB), combined with a metallicity of [Fe/H]~-1.0. It is similar to HP 1 and NGC 6522, which could be among the oldest objects in the Galaxy. We analysed high-resolution spectra of four members stars observed with FLAMES-UVES@VLT. We find low abundances of the odd-Z elements Na and Al, and of the explosive nucleosynthesis alpha-elements Si, Ca, and Ti. The hydrostatic burning alpha-elements O and Mg are normally enhanced as expected in old stars enriched with yields from core-collapse supernovae, and the iron-peak elements Mn, Cu, Zn show low abundances, which is expected for Mn and Cu, but not for Zn. Finally, the cluster trio NGC 6558, NGC 6522, and HP~1 show similar abundance patterns.

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The **Galactic Bulge**
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The first spectroscopic analysis of the newly discovered VVV-CL001 cluster with MUSE

Julio Olivares, PUC/MAS, Chile

ABSTRACT

We present the first results of an ongoing analysis of MUSE observations of the VVV-CL001 cluster. This is the first cluster discovered by the VVV, and is located at only 8 arcmin away from the known globular cluster UKS-1. The final goal is to obtain the first kinematics and metallicity study of its stellar content. Given its small projected distance from UKS-1, a similar measured radial velocity might argue in favor of the plausible scenario of these two clusters being gravitationally bound; the first known binary clusters in the Milky Way. This work is in process. We present here the analysis of radial velocity data, cluster membership for stars in the observed field, and the cluster's mean and dispersion velocity.
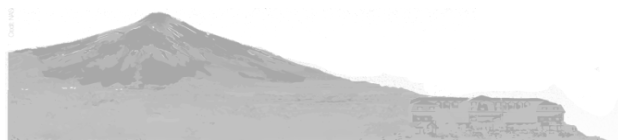
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The **Galactic Bulge**
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Multiple Populations Analysis of Six Bulge Globular Clusters using the HST UV Legacy Survey

Raphael Oliveira, Univ. de Sao Paulo, Brazil

ABSTRACT

The HST UV Legacy Survey of Galactic Globular Clusters (PI: G. Piotto) collected photometric data with UV/blue filters, that are sensitive to variations in CNO abundances. Combined with previous HST optical data, it produces an unprecedented photometric database for GCs. This work presents a study of six bulge GCs, three moderately metal-rich ([Fe/H] ~ -0.5) and three moderately metal-poor ([Fe/H] ~ -1.0). By means of isochrone fitting using a Bayesian approach, we derive self-consistent accurate ages, distances, reddening, and fractions of first-generation stars. We are able to distinguish the multiple stellar populations from the Main Sequence to the Red Giant Branch. Ages are derived for the identified populations, and we investigate whether there occurs any detectable age difference between them.

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VVV Survey and Milky Way Globular Clusters

Tali Palma, OAC, Argentina

ABSTRACT

The VVV NIR Survey has performed time-domain observations in the Ks-band for 6 years and provides an atlas of 562 sq. deg. of the sky in 5 wavebands (ZYJHKs). The VVV data outcome offer a unique dataset to map the stellar populations deeply embedded into highly obscured regions. The recent discovery of a significant number of globular clusters (GCs) distributed in different regions of our Galaxy, achieved by using the VVV data, evidence the incompleteness of the known GC population. The new discoveries are important and have statistic impact on the globally known properties of these objects. In this presentation, we show our latest results of the analysis of a selected sample from the newly discovered low luminosity GCs in the most obscured regions of our Galaxy. We also discuss the requirements or tests which were taken into account to confirm their nature as GCs.
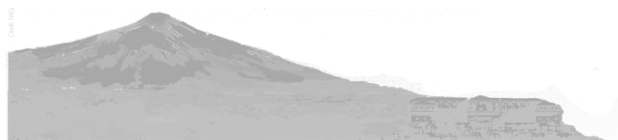
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The **Galactic Bulge**
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CaT study of Bulge Globular Clusters

Celeste Parisi, OAC, Argentina

ABSTRACT

It has been recognized for a long time that our Galaxy contains at least two populations of Globular Clusters: one associated with the halo and the other with Disco/Bulge of the Milky Way (BGC). Both populations strongly trace the chemical and dynamic properties of the respective Galactic components. While the Globular Clusters of the halo have been studied in great detail, the BGC have been relatively neglected, mainly due to the high interstellar reddening. The Vista Variables in the Via Lactea survey (VVV) has been an important advance for the infrared study of the Galaxy's BGC system. However, there are two fundamental parameters of these objects that the VVV cannot provide with the required precision: radial velocities (RV) and metallicities. The most efficient way to derive these important parameters is through the near infrared spectroscopic observation of the Ca II Triplet lines (CaT - $\lambda \approx$ 8500 Å). In this work, we present results of a sample of BGC studied with the CaT technique, through observations obtained with the FORS2 instrument of the VLT (Chile). Our results not only contribute to the understanding of the distribution of metallicities and kinematics of the BGC system, but will also provide information on targets for future high resolution spectroscopic followup studies, e.g. with CAPOS.
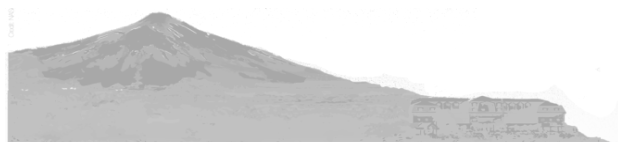
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The **Galactic Bulge**
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The VVV-Gaia catalogue for the Galactic bulge

Roberto Saito, Univ. Federal de Santa Catarina, Brazil

ABSTRACT

In 2016 the ESO VVV Survey completed its observations covering an area of about 562 sq. deg. in the Galactic bulge and southern disk. We present now a catalogue for the VVV bulge region combining near-IR colors from VVV and optical information from Gaia DR2, including distances and proper motions for more than 100M individual sources.

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The **Galactic Bulge**
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The SIRIUS code: Statistical Inference of physical paRameters of sIngle and mUltiple populations in Stellar clusters

Stefano Souza, Univ. de Sao Paulo, Brazil

ABSTRACT

Globular clusters (GCs) are fundamental pieces to understand the formation and evolution of the Milky Way. From the color-magnitude diagrams it is possible to get physical parameters such as age, distance, reddening, proper motions, among others. The wealth of information available in high quality photometric, spectroscopic and/or astrometric data, allows to perform a comprehensive and self-consistent analysis combining different data and techniques. We are developing a python package based on a Bayesian approach, that we named SIRIUS, to extract as much as possible information of a stellar cluster, in general. In addition, SIRIUS can characterize both simple and multiple stellar populations in a stellar cluster. We have tested the SIRIUS validity, analyzing HST, VLT, Gemini, VVV, and Gaia DR2 data of bulge GCs.

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The **Galactic Bulge**
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A new PSF-fitting photometry and reddening map for the VVV bulge area

Francisco Surot, PUC, Chile

ABSTRACT

The VISTA Variables in the Vía Láctea (VVV) is a public ESO survey covering about 300 deg² of the Galactic bulge, and 250 deg² of the southern disk, with the VISTA telescope in near infrared (NIR). We have derived a new point spread function (PSF) fitting photometry for the bulge area of the VVV in JK passbands, with unprecedented depth (down to Ks ~ 19.5 mag) and accuracy (σ < 0.1 mag at Ks = 17.5 mag), including completeness and systematic error estimations based on artificial star injection experiments. This photometric dataset has been used to study the age of the bulge using color magnitude diagrams (CMDs) and to derive a reddening map of the whole VVV bulge area, with higher resolution and performance than ever before. Both the photometric dataset and the reddening map will be made public.