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Concluding remarks

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Abstract. The conference has touched on many aspects of the research of stellar populations both in clusters and galaxies in general, in the Milky Way, nearby galaxies of the Local Group and distant galaxies. I will try to summarize what we learned here.

1. Introduction

Since the historical Vatican Conference on Stellar Populations on 1957, where the foundations of this key subject of Astrophysics were laid down, tremendous developments and achievements have been reached during the past fifty years thanks to the ever growing observational information and theoretical understanding of the whole subject. Going back to those times, I would like to recall here the famous CMD for the stars in the solar vicinity (originally Type I and now Pop I) and Globular Clusters (originally Type II and now Pop II) by Baade (1944), one of the first composite CMD and age ranking of galactic open clusters by Sandage (1957), and the catalog of CMDs of galactic open clusters by Hagen (1970), one of the first systematic collections of photometric data. The situation is nowadays completely different, samples of unprecedented richness are available for cluster and field stars in our own galaxy and in nearby galaxies, surveys like HST, OGLE, SDSS, RAVE, 2MASS, and in the near future GAIA, JWST, ESO-E-ELT to mention a few have provided and will provide data for hundreds of thousands, even millions, of stars with good distances, kinematics, photometry, spectroscopy, chemical abundances, etc. to such a point that even our present day view of stellar populations will be reconsidered. So far, we have got very rich CMDs showing main sequences of unprecedented narrowness, detailed post main sequence stars, down to very narrow White Dwarf sequences, multiple ages in the solar vicinity (Hipparcos CMD), multiple metallicities, complicated star formation histories in nearby galaxies, multiple populations with different age, metallicity and helium content in globular clusters, e.g. lots of blue strugglers, complicated morphologies of the horizontal branch stars, extended, rich tails of AGB stars in the CMDs of field stars in LMC, and many other observational properties. All this seems to suggest that a wide, multi-dimensional space of parameters should be used to define a population of stars. This conference happens to occur at the right time, i.e. at the beginning of the golden era of astronomical research thanks to existing and planned ground and space large scale, very deep, high resolution, telescopes with nearly complete coverage of the spectral energy distribution: the panchromatic view of stellar populations is coming soon.

2. Sessions 1 & 2 – The Milky Way & stellar variability

J. Funes (S.J.): "Welcome address"; B. Barbuy: "The Galactic Bulge"; P. Boyle: "Stellar populations and intermediate-band photometric systems"; K. Freeman: "RAVE and the Galactic halo"; N. Matsunaga: "Cepheids from two stellar populations in the Galactic Bulge"; B. Lemasle: "The Galactic abundance gradients from classical Cepheids"; A. Miglio: "Present and future of asteroseismology"; M. Marconi: "Variables as stellar tracers and distance indicators": G. Pietrzynski: "Eclipsing binaries as fundamental laboratories to improve the precision of stellar parameters; G. Fiorentino: "Variable stars in dwarf Galaxies".

Funes reminds us the great impact of the First Vatican Conference on Stellar Populations and tells us an anecdote about Pius XII writing in the proceedings a thoughtful sentence on the stellar populations that somehow anticipated discoveries made in the recent past. Intuition often proceeds experiments (observations in our case). Coming to more specific questions, it has long been debated whether the Galactic Bulge is the oldest component of the MW. The subject is reviewed by Barbuy who presents current Bulge formation models, recent observational data, the evidence for a X-shape of the Bulge, and the problem of He-enrichment. Census of stars in many regions close to the disc of the MW and suitable calibrations help to reconstruct the stellar populations (Boyle). RAVE data for the Disc and Halo stars allow us to determine the velocity dispersion of thin, thick discs and halo stars, the escape velocity at the position of the Sun, and the potential at large galacto-centric distances (Freeman). Chemical properties are key tools to reconstruct the structure and the past history of star formation. Variables stars are good tracers of this, so Cepheids come to the fore scene as distance indicators, tracers of chemical gradients, etc. In relation to this issue, Marconi reviews the theory of stellar pulsations, Matsunaga discusses type I and II Cepheids, Lemasle deals with the galactic gradients from classical Cepheids. In this context, astero-seismology (Corot & Kepler) becomes an important tool of investigation as a probe of the stellar structure and global stellar parameters. The discovery of solar-like radial oscillations in RGBs is very important as pointed out by Miglio. Variable stars (Cepheids and & RR Lyrae) can be independent estimators of age and metallicity of the parent populations. So why not to use them to constrain distances, past SFR, age, metallicity, etc of nearby dwarf galaxies? (Fiorentino). Needless to say that a good calibration of stellar parameters (mass, luminosity, surface gravity etc) and a comparison with theory of stellar evolution is a preliminary step towards many targets. The ideal labs to do this are the eclipsing binaries for which those basic parameters can be determined with a good precision. A new kind of HB star is found (Pietrzynski).

3. Session 3– Globular clusters

C. Charbonnel: "Theoretical view on multi-populations in Galactic globular clusters"; A. Kunder: "The Horizontal Branch of NGC1851 – Constraints from its RR Lyrae Variables"; J. Alonso-Garcia: "Disentangling multiple stellar populations in globular clusters using the Strömgren system"; C. Cacciari: "Helium abundance difference within globular clusters: NGC 2808"; B. Dias: "Metallicities and Alpha-to-Iron Ratios in GC Stars in a Homogeneous Scale Multiple Populations Searching"; G. Bono: "The galactic bulge: an historical perspective"; M. Marengo "Mass loss in advanced evolutionary phases"; P. G. Prada Moroni "Cumulative propagation of physical uncertainties in stellar models".

Globular Clusters are perhaps the most targeted subject of stellar astrophysics. Since they have been found to have multiple populations, they are under even stronger attack than ever before. We start with mass loss in advanced evolutionary stages and the importance of it in enriching the ISM (Marengo). Kunder examines the HB of NGC1851 with the aid of its RR Lyrae stars discovering at least four components with different chemistry. Multiple stellar populations in GCs are addressed by Charbonnel who presents an overview of the whole subject. She focuses in particular on the striking relationships observed among several important elements: anti-correlation O-Na, C-Mg, constancy of others. She discusses various possible scenarios and highlights the role that rotating massive stars, SN explosion and AGB stars could have played in setting the scene. Recent observational data related to this are presented by Alonso-Garcia who reports on results of a survey of GCS in the Str*ö*mgren photometry to systematically search for multiple populations. It is widely accepted that GCs may host multiple populations with different metallicities and helium content, that are easy and difficult the measure respectively. Using the IR He lines at 1083 Ä in ωCen and NGC 2808, Cacciari measures the helium abundance directly thus empirically setting DY/DZ. The metallicities and alpha to iron ratios are discussed by Dias. Bono reminds us the first determination of the distance to the Bulge, and the Baade-Windows, presenting new studies deep into the crowding of the Bulge. He also rises the question: why the abundance gradient changes the slope at the solar circle and where does the Bulge end and the disk begin? Finally, Prada-Moroni and collaborators investigate the cumulative propagation of physical uncertainties in stellar models. They courageously calculate 3000 stellar models by changing some key parameters and look at the response of several features currently used to study CMDs (TO, RGB tip, ZAHB, lifetimes etc..).

4. Session 4: Dwarf galaxies

M. Mateo: "Formation and evolution of dwarf galaxies"; F. Bresolin: "Metallicity gradients in nearby galaxies"; M. Fabrizio: "The iron content of the Carina dSph galaxy"; A. Del Pino Molina: "Looking for the traces of the early Universe in the Fornax dSph galaxy"; I. Musella: "Variable stars and stellar populations in the MW ultra-faint dwarfs"; M. Cignoni: "Study of Stellar Populations in the lowest luminosity star forming galaxy known today, Leo T"; A. Calamida: "The soundtrack of ωCen variable stars at high frequency".

Mateo introduces the subject reviewing the properties of the dwarf galaxies of the Local Group and lively highlighting their role in the wider context of the nowadays paradigm scenario of galaxy formation and evolution. In particular he addresses the question of star formation in dwarf galaxies and its dependence on the spatial distribution of these latter. Bresolin widens the subject talking about chemical composition gradients across nearby galaxies (and also at high redshift) and in those of low surface brightness. Fabrizio reports on the iron abundance measured in a number of RGs belonging to Carina (dSph) revising the value with respect to previous estimates. Del Pino Molina presents the SFH of the dSpH Fornax together with the spatial distribution of stars. He finds important differences in the stellar content as a function of the galactocentric distance (perhaps dynamical interactions with other systems). The discovery of ultra faint dwarfs (UFDs) in the MW and M31 has opened a new windows on the building up history of the two large spirals. UFDS are suspected to be the genuine building blocks. Musella describes some results about variable stars and stellar content of the UFDs of the MW. Finally, Cignoni reports on the lowest luminosity star forming galaxy known today, Leo T, which shows evidences of perhaps two (maybe three) episodes of SF one about 8-10 Gyr ago (RR-Lyrae) and a recent one at about 3 Gyr ago (Anomalous Cepheids). Calamida investigates the properties of bright and faint variables in ωCen, collecting a large sample of such stars with UltraCam. Some interesting new properties of RR Lyrae in the U-Band are presented for the first time.

5. Session 5: Magellanic Clouds

I. Soszynski: "Magellanic Variables"; R. De Grijs "LMC stellar clusters"; L. Inno "The MC distances using Cepheid NIR PW Relations"; M. Van der Swaelmen "Chemical abundances in the bar population of the Large Magellanic Cloud"; S. Sordo: "Libraries of stellar spectra and SSPs".

Variable stars as tracers of stellar populations and footprints of the SFH are discussed by Soszynski using Ogle-IV data. With the aid of HST data and the VISTA Survey of the MCs, De Grijs investigates the detailed stellar populations in a number of young massive star clusters of the MCs, which do not find their analogs in the MW. Inno presents the largest data set in NIR, JHK for classical Cepheids in the MCs, finding that NIR and optical period-Wesenheit relations are linear over the whole range of periods and the slopes are the same in the MCs. Starting from this, she get the distances to the MCs. Van der Swaelmen studies the bar of the LMC and determines the chemical abundances of the bar population. Anomalies in the Eu abundances are found that cannot be explained by standard nucleosynthesis. The advent of GAIA mission require a preliminary calibration of very extended libraries of stellar spectra and SSPs. Sordo presents the results she has obtained together with her collaborators.

6. Session 6: M31 and beyond

R. Ibata: "Stellar populations in M31"; A. Ferguson: "Stellar populations in the M31 group"; G. Coppola: "Ultra faint dwarf galaxies: the Andromeda satellites"; M. Monelli "Isolated dwarf galaxies in the Local Group"; S. Hidalgo "Star formation history of dwarf galaxies: seeking footprints of the primeval Universe"; F. Annibali "The star formation history of the BCD IZw18"; E. Bernard "A deep, wide-field study of Holmberg II with Subaru/Suprime-Cam"; D. Crnojevic "Resolved stellar populations of dwarf galaxies in the nearby Cen-A group".

Ibata opens the subject presenting recent results on the stellar populations of M31 which permit a global view of the dynamics, structure and stellar content of a giant galaxy from its bulge to the outer halo. The subject is continued by Ferguson discussing the stellar content of M31 and M33. The discovery of a new type of GCs (the extended ones), and the GCs aligned with streams, traces the SFH of the galaxies and chemical enrichment histories. Implications for the history of past interactions are emphasized. This kind of data and companion studies are of paramount importance in discriminating between the two popular galaxy formation scenarios: gradual building up by mergers over the Hubble time or early galaxies assembling followed by quasi quiescence occasionally rejuvenated by minor mergers. Nurture or nature? This is the dilemma! Monelli addresses to the isolated dwarf galaxies of the Local Group (DSpH Cetus and Tucana, LGS3 and Phoenix, dIrr LeoA and IC1613) and discusses their star formation history and early evolution. He summarizes also the properties of their variable stars. Hidalgo studies the star formation history of a group of isolated dwarfs seeking for the footprints of the early universe (UV background, self-shielding, migration and early evolution of these galaxies). Annibali present results for BCD galaxy IZw18 (extremely low metallicity object) to cast light on the question whether this is a genuine primordial galaxy, fossil of the early universe. The long suspected presence of RGB stars, recently confirmed by HST data, rules out this possibility. Ways out for the low metal content are suggested. Bernard presents a deep, wide field survey of Holmberg II of the M81 group. Crnojevic studies the resolved stellar populations in a sample of dwarfs around Cen-A in the M83 group. A survey of Cen-A out to 85 kpc is perhaps indicating that elongation of this galaxy is possible. She compares their properties with those of the Local Group counterpart, highlighting some important differences. The implication on the interplay between nature (mass) and nurture (environment) in shaping the evolution of dwarf galaxies is examined.

7. Session 7: Nearby cosmology

M. Salaris: "Unresolved stellar populations in the Local Volume: Theoretical framework"; E. Peng: "Stellar populations in the Virgo Cluster"; E. Lokas: "Observational parameters of tidally stirred dwarf galaxies"; B. Davies: "Red Supergiants as Cosmic Abundance Probes"; S. Pasetto: "Dwarf galaxies of the Local Group and their synthetic CMDs: the role of the dissipative phenomena".

Stellar populations in galaxies beyond the Local Group can hardly be resolved into single stars. At the distance of the Virgo cluster the smallest unit we can resolve is a star cluster, primarily globular clusters. One needs here integrated magnitudes and colors. The issue is discussed by Salaris who highlights the theory of population synthesis in the case of unresolved stellar populations (need of integrated quantities, SEDs magnitudes, colors) and Peng, who examines the stellar populations in galaxies of the Virgo cluster. What can be detected are star clusters, nuclei of galaxies, and dwarf galaxies. The emphasis is given to the relationship between star clusters and the host galaxies. Lokas presents NB simulations of tidal evolution of rotationally supported dwarf galaxies inside a mother galaxy of the MW dimensions and compares the results with those of the Local Group dwarfs. Davies et al. suggest to use RSG stars to get the chemical abundances of faraway galaxies. Thanks to their luminosity, RSG stars can be used up to 4 Mpc distances. Some results are presented for MW, LMC and SMC. Pasetto studies the dissipative phenomena occurring during the evolution of a dwarf satellite of the MW looking for signatures on the SFH. NB-TSPH simulations and synthetic CMDs are used.

8. Posters

J. Borissova "Star clusters in VVV survey"; D. Crnojevic "A WFCAM near-infrared survey of M31 dwarf elliptical satellites"; S. Degl'Innocenti "The updated Pisa evolutionary model database"; M. Di Criscienzo "NGC 2419: a large and extreme second generation in a currently undisturbed cluster"; N. Drake "Abundance and kinematic analyses of the CH star CD-621346"; F. Fusco "The Local Group Dwarf Irregular Galaxy NGC 6822: new insight on its star formation history"; C. Gud "Age-dating stars from their position in the HR diagram"; N. Kaltcheva "Improved distances and structure of several Galactic star-forming fields"; B. Lemasle "The puzzling chemical evolution of the Carina dwarf Spheroidal galaxy"; M. Mapelli "The joint effect of stellar evolution and dynamics in young star clusters"; B. Pila-Diez "Stellar populations in the Sgr stream"; A. Punanova "CCD BVRI Photometry of the Open Clusters NGC 7142 and NGC2281"; O. Sholukhova "New LBVs in M31"; J. Veljanoski "Kinematic Analysis of the M31 Halo Globular Clusters"; R. Zenoviene "Chemical analysis of a new kinematically identified stellar group".

9. To conclude

In the past the overall pattern of stellar populations and their regular variations in age and metal content were taken as the signature of an ordered, well behaved gran design of the physical processes responsible for the formation and evolution of a galaxy. I am not so sure that the same conviction would hold today. Indeed the more we learn about stellar populations, the more complex seems to be their history and the so-called gran design at work. This is particularly true if galaxies are the results of many mergers each of these bringing their own stellar content and inducing new generations of stars. In other words, are the stellar populations obeying the Nature or Nurture paradigms? The answer may come only from examining vaste populations of stars in the multi-dimensional space of their parameters in order the cast light on underlying schemes. Given the capabilities of the next generations space and ground telescopes, their instrumentation, and better theoretical understanding, large collections of data of unprecedented quality and richness and highly sophisticated theoretical tools of analysis will become everyday practice. Therefore it is easy to anticipate that we are about to witness a quantum jump in the panchromatic view of stellar populations Deciphering the stellar contents of star clusters and galaxies means to trace back the history of their formation and to pin down the physical processes at work.

Finally, we all like to thanks the organisers of this meeting that well continues the tradition initiated with the Vatican Conference and at the same time marks the enormous progress made in more than half a century of continuous dedicated research of many individuals and groups all over the world.

Many thanks Giuseppe! To you and your collaborators!

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