

Meeting id number: IAU Symposium 351

Title: Star clusters: from the Milky Way to the early universe

Coordinating division: H Interstellar matter and local universe

Location: Bologna (Italy)

Dates: 27-31 May 2019

Number of participants: 201

Total amount of IAU Grant funds: 20000 euros

Number of IAU Grant recipient: 44

List of represented countries: a) among participants; b) among IAU grant recipients

- a) Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Czech Rep., France, Hungary, Georgia, Germany, India, Iran, Israel, Italy, Japan, Kazakhstan, Korea, Lithuania, Mexico, Netherlands, Peru', Poland, Russia, South Africa, Spain, Sweden, Switzerland, Thailand, UK, USA (note that ESO people were listed as Germany)
- b) Argentina, Australia, Belgium, Canada, Chile, China, Czech Rep., France, Germany, India, Iran, Israel, Italy, Japan, Lithuania, Peru', Poland, South Africa, Switzerland, Thailand, UK, USA

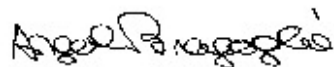
SOC: Angela Bragaglia (co-chair, Italy, F), Enrico Vesperini (co-chair, USA, M), Gary Da Costa (Australia, M), Melvyn Davies (Sweden, M), Michiko Fuji (Japan, F), Mirek Giersz (Poland, M), Young-Wook Lee (Rep. Korea, M), Michela Mapelli (Italy, F), Nadine Neumayer (Germany, F), Genevieve Parmentier (Germany, F), Eric Peng (China, M), Giampaolo Piotto (Italy, M), Thomas Puzia (Chile, M), Maurizio Salaris (UK, M), Alison Sills (Canada, F), Eline Tolstoy (Netherlands, F)

LOC: Emanuele Dalessandro (chair), Angela Bragaglia, Caterina Caravita, Cristiano Fanelli, Alice Minelli, Annalia Piccioni, Antonio Sollima,

Report Submitted by: Angela Bragaglia

Date and place: Bologna, July 5, 2019

Signature of SOC Chairperson:



The IAU Symposium 351 titled “Stellar clusters: from the Milky Way to the early universe” was held in Bologna (Italy) from May 27 to 31, 2019. The Symposium was held in the main conference hall of the C.N.R., in the area where the three local astronomical institutes are located (INAF-Observatory of Astrophysics and Space Science, INAF-Radio Astronomy Institute, Department of Physics and Astrophysics of the Bologna University).

The IAU Symposium 351 was also chosen as MODEST-19 (Modelling and Observing DENSE STellar systems, a meeting series started in 2002). The Symposium was followed on Twitter ([#iaus351](#), [#MODEST19](#)) thanks to many participants.

The IAU Symposium 351 was attended by 201 officially registered participants (125 male, 76 female researchers) coming from 33 different countries. Full information on the participants and the program can be found at the Symposium webpage <http://iausymp351.oas.inaf.it>. Participation to the Symposium was attentive and lively for all sessions.

The Scientific Organizing Committee (SOC) had a hard job in selecting the speakers for the scientific program among the many interesting abstracts which were submitted. Many of the SOC members took part in the Symposium and had an active role, chairing sessions and fostering discussion. Many thanks go to Maurizio Salaris who gave an outreach presentation for the general public on the subject of Globular Clusters and possibility of alien life.

The SOC succeeded in putting together an interesting and stimulating program, well balanced in topics, gender and career level. Young astronomers were given the opportunity to present their results. Beside 12 invited reviews (35 minutes) and 9 solicited talk (25 minutes), we had 52 contributed talks (15 minutes) as shown in the complete program; speakers came from 17 countries. More than 100 posters were also presented, of great value. On the first day we gave the possibility to anyone interested to present a 1-minute highlight of their poster and 65 people did. Posters were visible throughout the entire conference and stimulated conversations and discussions. We wish to thank all participants for their valuable contribution to the success of the Symposium.

We gratefully acknowledge the IAU for providing support for travel. The SOC was able to allocate grants to 44 people, helping them participating to the Symposium. We also acknowledge support from INAF.

We wish to thank the Local Organizing Committee, in particular Emanuele Dalessandro (LOC chair), Caterina Caravita, Cristiano Fanelli, Alice Minelli and Antonio Sollima for their dedication; without their help the Symposium 351 would not have been so successful.

The proceedings will have four editors: A. Bragaglia, M. Davies, Alison Sills, and Enrico Vesperini; we are presently collecting contributions from participants.

The IAU Symposium 351/MODEST 19 was dedicated to stellar clusters across space and time. Topics included:

- Formation and evolution of clusters at present time and at high redshift
- Globular clusters and satellite systems and extragalactic clusters in general
- Multiple stellar populations in stellar clusters, in the Milky Way and in the local Universe
- Dynamics and evolution of stellar content in clusters

- Black holes and other exotic populations in clusters
- Links between globular, open, young massive, nuclear star clusters
- Dwarf/ultra-compact/ultra-faint galaxies and clusters as building blocks of large galaxies
- The Gaia revolution for star clusters
- Galactic archaeology with present and future large surveys

The Symposium clearly showed the complexity of stellar clusters, either at low redshift (e.g. multiple stellar populations, internal dynamics, binary interactions, etc) or at high redshift (formation and early evolution).

The formation mechanisms and sites of stellar clusters of any age and mass were debated, also in the light of multiple populations.

The presence of sessions both on the local and the high-*z* Universe was very useful to establish links between the clusters we see today and their progenitors, using properties both well known or still only partly explored. Researchers were then able to get a broader and more informed vision of the important constraints coming from confronting low- and high-*z* conditions.

Star clusters were not only considered as interesting objects per se, but as probes of larger systems such as galaxies and as contributors to the halo/disc populations.

Stellar clusters internal dynamics and evolution were debated, also in the light of “exotic” objects such as compact binaries, black holes, millisecond pulsars.

The increasing importance of large scale studies and massive datasets and simulations was discussed. Particular mention should be made of the increasing number of theoretical and observational investigations devoted to the study of the internal kinematics of star clusters. Various contributions based on large radial velocity surveys and proper motion studies based on HST and Gaia data were presented. Gaia data and results were widely exploited.

Finally, we very happy to see many young researchers presenting very interesting, clear and informed talks (and posters). This shows that the new generation of scientists promises to bring new highlights in the field of stellar clusters research.

The Scientific Organizing Committee (SOC) selected 12 invited reviews (35 minutes – 7 male, 5 female speakers), 9 invited talks (25 minutes, 5 male, 4 female speakers), and 52 contributed talks (15 minutes, 32 male, 20 female speakers). All times comprise questions & answers.

About 100 posters were shown at the Symposium throughout the week. The SOC organized two poster sessions, where people presented the highlights in 1 minute; this was done on Monday, to encourage poster viewing and 65 people participated.

Chairpersons (10, of which 9 SOC members present): Alison Sills (F), Genevieve Parmentier (F), William Harris (M), Young-Wook Lee (M), Gary Da Costa (M), Angela Bragaglia (F), Melvyn Davies (M), Enrico Vesperini (M), Mirek Giersz (M), Michiko Fuji (F)

Program of the IAU Symposium 351/MODEST 19

MONDAY 27 May

Chair: A. Sills

10:00-10:35 **William Harris - Extragalactic young and old globular cluster systems (Inv.Review, M)**

10:35-10:50 Jean Brodie - Latest results from the SLUGGS Survey

10:50-11:05 Duncan Forbes - Insights from Globular Clusters: Dwarfs to Giant Galaxies

11:05-11:35 coffee break

11:35-10:50 Zara Randriamanakoto – Young massive clusters in the interacting LIRG Arp 299

11:50-12:15 **Charli Sakari – Integrated spectroscopy of extragalactic globular clusters (Inv. Talk, F)**

12:15-12:30 Alejandra Recio-Blanco - The oldest Milky Way accreted population revealed by a chemo-dynamical decryption key of globular clusters

12:30-13:00 1-min poster presentations

13:00-14:30 lunch

Chair: G. Parmentier

14:30-14:45 Eugene Vasiliev - Using Gaia for studying Milky Way star clusters

14:45-15:10 **Ana Bonaca - Uncovering the nature of dark matter with stellar streams in the Milky Way (Inv. Talk, F)**

15:10-15:25 Andres Piatti - Two kinematically different Large Magellanic Cloud old globular cluster populations unveiled from Gaia DR2 data sets

15:25-16:00 1-min poster presentations

16:00-16:30 coffee break

16:30-16:45 Andrea Dupree - Spectroscopy of LMC Cluster Stars

16:45-17:20 **Pascale Jablonka - Dwarf galaxies: formation and chemical evolution (Inv.Review, F)**

17:20-17:35 Pavel Kroupa - A systematically varying stellar IMF from globular cluster and ultra-compact dwarf galaxy data and some implications thereof

17:35-17:50 Melvyn Davies - The Ecology of the Galactic Centre

TUESDAY 28 May:

Chair: W. Harris

09:30-9:55 **Florent Renaud - Formation and evolution of globular clusters and globular cluster systems (Inv. Talk, M)**

09:55-10:20 **Hui Li - Formation and evolution of Globular Clusters in Cosmological Simulations (Inv. Talk, M)**

10:20-10:35 Marta Reina-Campos - Dynamical evolution of stellar clusters in E-MOSAICS

10:35-11:15 coffee break

11:15-11:30 Mike Fall - Formation, Evolution, and Disruption of Star Clusters: A Synoptic Theory

11:30-12:05 **Anil Seth - Nuclear Star Clusters (Inv.Review, M)**

12:05-12:20 Karina Voggel - Using surviving nuclear star clusters and their hidden SMBHs as new tracers of galaxy assembly and SMBH formation

12:20-13:50 lunch

Chair: Y.-W. Lee

- 13:50-14:05 Mayte Alfaro Cuello - A deep view into the nucleus of the Sagittarius dwarf spheroidal galaxy: M54
14:05-14:40 **Simon Portegies Zwart - Young massive clusters in the Milky Way and beyond (Inv.Review, M)**
14:40-14:55 Eros Vanzella - Unveiling forming star clusters in the young universe
14:55-15:10 Michael Grudic - Connecting the ISM to Star Cluster Populations Across Cosmic Time
15:10-15:25 Alison Sills - Formation of Globular Clusters in Radiation Hydrodynamics Simulations
15:25-15:40 Hosein Haghi - The dissolution rate of star clusters starting with a top-heavy IMF
- 15:40-16:10 coffee break
- 16:10-16:25 Susanne Pfalzner - Observations meets theory in clustered star formation
16:25-16:40 Michiko Fujii - Inter-cluster velocity structure of star cluster complexes
16:40-16:55 Tereza Jerabkova - Multiple bursts of star formation in young star clusters: The case of the Orion Nebula Cluster
16:55-17:10 Janet Drew - Tracing O-star runaways from the massive young clusters, NGC 3603 and Westerlund 2
17:10-17:45 **Else Starkenburg - Galactic Archaeology (Inv.Review, F)**

WEDNESDAY 29 May:

Chair: G. Da Costa

- 9:30- 10:05 **Antonino Milone - Photometric studies of multiple stellar populations in Galactic globular clusters and in the young and intermediate-age massive clusters in the Magellanic Clouds (Inv.Review, M)**
10:05-10:40 **Raffaele G. Gratton - Spectroscopic studies of stellar populations in globular clusters and field stars: implications for globular cluster and MW halo formation (Inv.Review, M)**
- 10:40-11:15 coffee break
- 11:15-11:35 **Anna F. Marino - Spectroscopic observations of Multiple Stellar Populations in Star Clusters (Inv. Talk, F)**
11:35-11:50 Francesca D'Antona - "Status update" for the AGB scenario for multiple populations in Globular Clusters
11:50-12:05 Young-Wook Lee - Multiple populations in globular clusters: New insights from chemical evolution & horizontal-branch models
12:05-12:20 Christian Johnson - Light Element Discontinuities in the Globular Cluster NGC 6402 (M14)
12:20-12:35 Chul Chung - Globular Cluster – Bulge Connection: Population Synthesis models with Multiple Populations
- 12:35-13:35 lunch

Chair: A. Bragaglia

- 13:35-13:50 Francesco Calura - Hydrodynamic simulations of second generation star formation in a young globular cluster
13:50-14:05 Mattia Libralato - Internal kinematics of multiple stellar populations in globular clusters: current state of the art, issues, and a way out.
14:05-14:20 Emanuele Dalessandro - Unexpected kinematics of multiple populations in globular clusters
14:20-14:35 Enrico Vesperini - Dynamical Evolution of Multiple-Population Globular Clusters
- 14:35-15:05 coffee break & poster viewing

- 15:05-15:25 Mark Gieles - Supermassive stars as the origin of multiple populations in globular clusters
 15:25-15:40 Silvia Martocchia - Age as a Major Factor in the Onset of Multiple Populations in Stellar Clusters
 15:40-15:55 Steve Zepf - Evidence for Ubiquity of Multiple Populations from Far-Ultraviolet Observations of Extragalactic GCs
 15:55-16:10 Paul Goudfroji - The Impact of Multiple Populations in Globular Clusters to the UV Upturn and Element Abundance Ratios in Massive Early-Type Galaxies
 16:10-16:25 Soeren Larsen - Chemical composition of globular clusters in dwarf galaxies

THURSDAY 30 May:

Chair: M. Davies

- 9:30-9:45 Long Wang - The strong impact of IMFs on the survival of globular clusters
 9:45-10:00 Alessandra Mastrobuono-Battisti - The amazing life of a globular cluster: tidal interactions and mergers in the Galactic disc and nuclear star cluster
 10:00-10:15 Mirek Giersz - MOCCA-SURVEY Database I: Dissolution of tidally filling star clusters harboring BH subsystem
 10:15-10:40 **Anna Lisa Varri - Phase space complexity of star clusters: fresh observables for old and new questions (Inv. Talk, F)**
 10:40-11:05 **Sebastian Kamann - Black holes and rotation: Internal kinematics of star clusters with MUSE (Inv. Talk, M)**
 11:05-11:35 coffee break
 11:35-11:50 Laura Watkins - Imprints of Evolution on the Internal Kinematics of Globular Clusters
 11:50-12:05 Paolo Bianchini - Globular clusters in the era of precision astrometry
 12:05-12:20 Maria Tiongco - Kinematical Evolution of Globular Clusters
 12:20-12:35 Antonio Sollima - The eye of Gaia on globular cluster dynamics

12:35-13:45 lunch

Chair: E. Vesperini

- 13:45-14:10 **Davide Massari - Gaia results for star clusters and dwarf galaxies in the Milky Way (Inv. Talk), M**
 14:10-14:25 Alice Zocchi - Rotating globular clusters in the Gaia era
 14:25-15:00 **Fred Rasio [presented by K. Kremer]- The role of black holes in globular cluster dynamics and gravitational-wave source formation (Inv.Review, M)**
 15:00-15:15 David Pooley - Neutron Star Merger Products in Galactic Globular Clusters
 15:15-15:30 Sara Rastello - Black hole binaries in young star clusters: A dynamical view!

15:30-16:00 coffee break

- 16:00-16:35 **Maureen van den Berg - X-ray sources in Galactic star clusters (Inv.Review, F)**
 16:35-16:50 Abbas Askar - Why Black Holes Matter in Globular Clusters: Dynamical Consequences and Observational Signatures
 17:50-17:25 **M. Ishigaki - Chemical tagging with supernova yield models as a tool to link field stars to their birth clusters (Inv.Review, F)**

FRIDAY 31 May:

Chair: M. Giersz

9:30-9:55 **Francesco Ferraro - Exotic stellar populations, blue stragglers and cluster dynamics (Inv. Talk, M)**
9:55-10:10 Claire Ye - Millisecond Pulsars and Black Holes in Globular Clusters
10:10-10:25 Ugo N. Di Carlo - Young Star Clusters: a Nursery of Merging Binary Black Holes
10:25-10:40 Holger Baumgardt - On the presence of stellar-mass and intermediate mass black holes in globular clusters

10:40-11:20 coffee break

11:20-11:55 **David Yong - Stellar populations in the Milky Way and their link with GCs (Inv.Review, M)**
11:55-12:10 Eduardo Balbinot - Multiple stellar populations in the stellar stream GD1 using Gaia
12:10-12:25 Pete Kuzma - Searching Gaia for Extended Structure in Globular Clusters

12:25-13:45 lunch

Chair: M. Fuji

13:45-14:20 **V. Hill - The innovation of large multi-element high-resolution spectroscopic surveys (Inv.Review)**

14:20-14:35 Ricardo Schiavon - The Contribution of Globular Clusters and Dwarfs as Building Blocks of the Galactic Halo from APOGEE and Gaia

14:35-14:50 David Nataf - The Relationship Between Globular Cluster Parameters and Abundance Variations, and Application to Former Globular Cluster Stars in the Field

14:50. Conference Wrap Up and Goodbye