MODEST 15
Modelling and Observing Dense Stellar Clusters in Chile

Abstract Booklet

Universidad de Concepción, Chile

March, 2nd-6th, 2015

1 Schedule

Sunday, March 1st

18.00 - 21.00	Welcome Cocktail and Registration, Hotel Araucania

Monday, March 2nd

8.30 - 9.00	Late Registration
9.00 - 9.30	Welcome Adresses
Topic:	**Initial Mass Function**
9.30 - 10.00	Pavel Kroupa Is the IMF a probability density distribution function?
10.00 - 10.30	Mark Gieles What does the mass-to-light ratio of globular clusters tell us about the IMF?
10.30 - 11.00	Coffee Break
Topic:	**Merging Sub-Systems**
11.00 - 11.30	Juan Pablo Farias Osses Can we predict the survival of an hierarchical formed star cluster?
11.30 - 12.00	Elena Gavagnin Star cluster formation through merger of sub-clusters
12.00 - 12.30	Alison Sills Dynamical Evolution of Very Young Stellar Sub-Clusters
12.30 - 14.30	Lunch Break

Topic:	**Mass Segregation**
14.30 - 15.00	Sambaran Banerjee Very young massive clusters: formation and activity
15.00 - 15.30	Nathan Leigh The Properties of Galactic Globular Clusters at Birth
15.30 - 16.00	Jincheng Yu Mass Segregation of Young Star Clusters
16.00 - 16.30	Coffee Break
16.30 -17.00	Hossein Haghi Possible smoking-gun evidence for initial mass segregation in re-virialized post-gas expulsion star-burst clusters
17.00 - approx. 18.00	Poster Presentation
approx. 18.00 - 19.00	Poster Viewing

Tuesday, March 3rd

Topic:	**Multiple Stellar Populations**
9.00 - 9.30	Steven McMillan Evolution of Binary Stars in Multiple-Population Globular Clusters or Simulating Young Star Clusters with AMUSE
9.30 - 10.00	Richard de Grijs Massive cluster defies multiple stellar population concept in apparent paradigm reversal
10.00 - 10.30	Ivan Cabrera-Zini Constraining globular cluster formation through studies of young massive clusters
10.30 - 11.00	Coffee Break
11.00 - 11.30	Douglas Geisler Uncovering Multiple Populations in Globular Clusters with Washington Photometry
Topic:	**Binaries**
11.30 - 12.00	Hans Zinnecker The orbital evolution of close binaries near the Galactic Center (Kozai effect)
12.00 - 12.30	Emanuele Dalessandro The primordial binary fraction in low-density Galactic globular clusters
12.30 - 14.30	Lunch Break

Topic: **Rotation, High Velocity Stars and Kicks**

14.30 - 15.00 Anna Lisa Varri
Early evolution of rotating star clusters

15.00 - 15.30 Sverre Aarseth
Velocity kicks and mass segregation

15.30 - 16.00 Roberto Capuzzo-Dolcetta
High velocity stars from galactic centers

16.00 - 16.30 Coffee Break

Topic: **Star and Globular Cluster General**

16.30 -17.00 Licai Deng
Time-domain studies of star clusters using 50BiN

17.00 - 17.30 Andrea Dieball
Hunting for Brown Dwarfs in Globular Clusters: M4

17.30 -18.00 Sandro Villanova
Chemical constrains for Modeling Dense Stellar Systems

18.00 - 19.00 Visit to the new Astronomy Building at UdeC

Wednesday, March 4th

Topic:	**Star and Globular Cluster General**
9.00 - 9.30	Alessio Mucciarelli Rotational Velocities in Globular Cluster Blue Straggler Stars
9.30 - 10.00	Francesco Ferraro An empirical clock to measure the dynamical age of stellar systems
10.00 - 10.30	Edwin van der Helm Creating Arches
10.30 - 11.00	Coffee Break
11.00 - 11.30	Alice Zocchi Pressure anisotropy in globular clusters
11.30 - 12.00	Paolo Bianchini From models to observations: understanding IFU observations of globular clusters
Topic:	**VVV**
12.00 - 12.30	Sebastian Ramirez Alegria Young clusters with massive stellar population in the VVV-survey
12.30 - 14.30	Lunch Break
14.30 - 20.30	Conference Excursion to Lota Chiflon del Diabolo and Parque Lota

Thursday, March 5th

Topic:	**Computational Methods**
9.00 - 9.30	Mirek Giersz The newest developments of the MOCCA code and the Astro-data tools
9.30 - 10.00	Abbas Askar Simulating Observations of MOCCA Star Cluster Simulations with COCOA
10.00 - 10.30	Graeme Candlish Putting MOND to the test
10.30 - 11.00	Coffee Break
11.00 - 11.30	Yohei Meiron Expansion Techniques for Collisionless Stellar Dynamical Simulations
11.30 - 12.00	Rainer Spurzem Astrophysical N-body and other computer models on the path to Exascale
12.00 - 12.30	Long Wang The million-body problem: hybrid parallel direct NBODY6++ simulations of globular clusters
12.30 - 14.30	Lunch Break

Topic: **Elliptical Orbits**

14.30 - 15.00 Douglas Heggie
Dynamics of star clusters on elliptical orbits

15.00 - 15.30 Andreas Kuepper
The Influence of Eccentric Orbits on Cluster Evolution

Topic: **Planets**

15.30 - 16.00 Thijs Kouwenhoven
The formation and dynamical evolution of free-floating planets in star clusters

16.00 - 16.30 Coffee Break

Topic: **UCDs**

16.30 -17.00 Steffen Mieske
UCDs

17.00 - 17.30 Joerg Dabringhausen
Low-mass X-ray binaries as tracers for a varying stellar initial mass function in ultra-compact dwarf galaxies

17.30 -18.00 Jarrod Hurley
TBD

20.00 - 24.00 Conference Dinner Hacienda Patagonia

Friday, March 6th

Topic:	**Globular Cluster Systems**
9.00 - 9.30	Thomas Puzia The Scale Sizes of GCs in NGC 1399
9.30 - 10.00	Richard Lane Dwarf companions and globular cluster systems of isolated elliptical galaxies
10.00 - 10.30	Matthew Taylor Observational Evidence for a Dark Side to NGC 5128's Globular Cluster System
10.30 - 11.00	Coffee Break
11.00 - 11.30	Jeremy Webb The Orbital Anisotropy and Tidal Filling Profiles of Globular Clusters in Giant Galaxies
11.30 - 12.00	Florent Renaud Star cluster evolution in the cosmological context
12.00 - 12.30	Juan Madrid Coevolution of Globular Clusters and Host Galaxies
12.30 - 14.30	Lunch Break

Topic: **Black Holes**

14.30 - 15.00	Barbara Lanzoni Searching for IMBHs in globular clusters through the radial velocity of individual stars
15.00 - 15.30	Nora Luetzgendorf Testing black-hole accretion from stellar winds in star clusters using AMUSE
15.30 - 16.00	Danor Aharon Formation and evolution of nuclear star clusters with in-situ star-formation: Nuclear cores, age segregation and TDEs history
16.00 - 16.30	Coffee Break
16.30 - 17.00	Peter Berczik Galaxy collsion simulations with central Post Netwonian Binary Black Hole
17.00 - 17.30	Shuo Li Tidal disruption evolution of supermassive black holes in merging stellar system
17.30 -18.00	Paulina Assmann Post-Newtonian Dynamics of Black Holes with spin in star clusters simulations with NBody6 ++

2 Posters

1. Ahmed Abdullah: The specific frequency of globular clusters in elliptical galaxies
2. Angela Adamo: Probing the role of galactic environment during cluster formation: a link between young star clusters and ancient globular clusters
3. Matthew Benacquista: Extragalactic Black Hole Binaries as Low-frequency Gravitational Wave Sources
4. Clio Bertelli Motta: Chemical abundances of open clusters in the Sloan Digital Sky Survey
5. Jura Borissova: Star clusters in VVV
6. Michael Brewer: Investigating the Spitzer Instability Using AMUSE Codes
7. Maxwell Xu Cai: Simulations of planetary systems in star clusters
8. Julio Carballo-Bello : Stellar clusters as tracers of the formation and structure of the Milky Way
9. Nelvy Cristina Choque Challapa: Pre- and postprocessing of galaxies
10. Chul Chong: The evolutionary population synthesis model for calcium infrared triplet of simple stellar populations
11. Filippo Contenta: Neutron star natal kicks and the long-term survival of star clusters
12. Raul Esteban Dominguez Figueroa: Finding a progenitor of Segue 1
13. Heinz Frelijj Rubilar: TBD
14. Akram Hassani Zonoozi: Did violent early residual-gas expulsion play a dynamical role for Pal 14 and Pal 4?
15. Jongsuk Hong: Evolution of binary stars in multiple-population globular clusters
16. Nataly Nicole Ibarra Vara: Which gravitational waves we should expect from a Globular Clusters?
17. Yara Jaffe: A phase-space view of gas stripping and galaxy quenching in clusters
18. Christian Knigge: Multiple options – (1) Cataclysmic Variables in – – Globular Clusters; (2) Blue Stragglers in – – Open and Globular Clusters; (3) – – Far-ultraviolet Surveys of Globular – – Clusters
19. Michael Kuhn: Mass Segregation in Star-Forming Regions with Subclustered Stellar Populations

20. Dongwook Lim: Low resolution spectroscopy for the Globular Clusters with Signs of Supernova Enrichment
21. Alessandra Mastrobuono Battisti: A primordial origin for the composition similarity between the Earth and the Moon
22. Nicolas Medina: Variability of YSOs in BRC 89
23. Bryan Miller: The Stellar Populations of Nuclei and Globular Cluster Clusters in dE Galaxies in Virgo and Fornax
24. Cesar Munoz: TBD
25. Claudio Navarro: A search for YSO in the Galactic center using VVV data
26. Christian Nietschelm: Study of the duplicity and the multiplicity in the Sco-Cen Complex (Sco OB2)
27. Alexander Rassakazov: Rotational Brownian Motion of a Supermassive Binary in a Rotating Galactic Core
28. Tom Richtler: TBD
29. Jenna Ryon: Sizes and Shapes of Star Clusters in Nearby Galaxies
30. Sara Saracino: GEMINI observations reveal the structure of Liller 1
31. Mirco Simunovic: CMD Properties of Blue Straggler Stars in Globular Clusters from HST Survey Data
32. Anna Sippel: Slicing and dicing globular clusters
33. Margaryta Sobolenko: Merging time for interacting galaxies with central post-Newtonian black holes
34. Piera Andrea Soto King: Tau-square fitting the Age and Distance of the Blanco 1 Open Cluster
35. Maria Tiongco: Lifetimes and kinematics of rotating star clusters in a tidal field
36. Rodrigo Adolfo Vejar Asem: Properties of Tidal Tails in a NFW potential
37. Joshua Wall: Modelling Massive Cluster Formation with Stellar Feedback using Flash and AMUSE
38. Peter Zeidler: A Hubble Space Telescope multi-band survey with WFC3 and ACS of the young massive star cluster Westerlund 2

3 Abstracts

In alphabetical order:

Sverre Aarseth
Institute of Astronomy, University of Cambridge
talk
Title: Velocity kicks and mass segregation
Abstract: We present results of N-body simulations containing neutron stars and black holes. The mass segregation of light and heavy stars is compared for different values of the kick velocity. Models of star clusters with large kicks show a preference for enhanced central concentration with respect to the case when there is a significant retention of neutron stars and black holes which are the first to experience mass segregation. The latter systems also show evidence of black hole binaries which may experience post-Newtonian effects before being ejected in sling-shot events.

Ahmed Abdullah
Argelander Institute for Astronomy, University of Bonn.
poster
title: The specific frequency of globular clusters in elliptical galaxies
Abstract: Globular clusters (GC) are important objects for tracing the early evolution of a galaxy. We study the relation between the properties of globular cluster systems and properties of their host galaxies. In order to understand the origin of the 'U' -shape relation between the GC specific frequency (S_N) and their mass, the high value of S_N occurring at low and high galaxy masses, while low values of S_N are found for intermediate mass galaxies ($\approx 10^{10} Msun$), we derive a theoretical model of specific frequency (S_{Nth}). We construct a model depending on the minimum star cluster mass ($M_{ecl,min}$) and the slope of the embedded cluster mass function (β). A model is suggested according to which a population of young cluster is formed following a cluster mass function which depend on the star formation rate (SFR). The agreement is good between the primordial value of the specific frequency (S_{Ni}) and our model at a certain value of $M_{ecl,min}$ and β. The model is able to reproduce S_{Ni} with β=1.7, and the model with a higher minimum mass limit $M_{ecl,min} = 10^5 Msun$ can match the S_{Ni} for elliptical galaxies while for dwarf elliptical galaxies are explain with $M_{ecl,min} = 5 Msun$, this difference is likely due to the different formation mechanism of dwarf and elliptical galaxies.

Angela Adamo
Stockholm University, Oscar Klein Centre
poster
Title: Probing the role of galactic environment during cluster formation: a link between young star clusters and ancient globular clusters
Abstract: Our understanding of star formation on galactic scales has been fairly grasped (e.g. the rate at which stars form scales proportionally to the molecular gas content) both in the local and high redshift universe. However, our knowledge on how star formation proceeds at small scales (e.g. the fraction of star formation happening in stellar clusters, the time-scales for star-forming regions to dissolve, the impact of the galactic environment on star and cluster formation) remains a challenge. Gravitationally bound young stellar clusters appear to be a commune product of star formation. There are tantalizing similarities between young star clusters and globular clusters, the latter formed by gravitationally bound ancient stellar populations. However, the young and globular cluster populations show statistical properties (mass functions, formation efficiencies, and survival times) that have been claimed incompatible, leaving the two populations being the results of distinct processes of formation. In my contribution, I will discuss the latest results produced with the analysis of the young cluster populations in several nearby galaxies. The use of new statistical methods, higher UV quality data, the access to homogenous datasets, like the HST treasury program LEGUS (legacy extragalactic UV survey), show, for the first time, clear evidence of the influence of the galactic environment in shaping the upper mass end of the mass function of the young star cluster populations. Previous HST studies found that globular cluster mass function have a similar trend, with an upper mass truncation that scales proportionally to the luminosity (mass) of the host galaxy and cannot be explained only by dynamical evolution. After all, the differences between the two cluster populations, may not be so pronounced, suggesting that the same physical formation process but under different environmental condition has been (and currently is) at work at high redshift (when globular clusters were formed) and in the local universe.

Danor Aharon
Technion Israel Institute of Technology
talk
Title: Formation and evolution of nuclear star clusters with in-situ star-formation:Nuclear cores, age segregation and TDEs history.
Abstract: Nuclear stellar cluster (NSCs) are known to exist around massive black holes (MBHs) in galactic nuclei. Two formation scenarios were suggested for their origin: (1) Build-up of NSCs from consecutive infall of stellar cluster and (2) Continuous in-situ star-formation following gas inflow into the galaxy nucleus. Though the cluster-infall scenario has been extensively studied in recent years, the in-situ formation, and in particular the role of star-formation in the long-term build-up of NSCs and their evolution have been hardly studied. In our work we use Fokker-Planck calculations to study the effects of star formation on the build-up of NSCs and its implications for their long term evolution and their resulting structure. We use the Fokker-Planck equation to describe the evolution of several stellar populations, and add appropriate source terms to account for the effects of newly formed stars. We show that continuous star-formation even 1-2 pcs away from the MBH can lead to the build-up of an NSC with properties similar to those of the Milky-way NSC We also find that the in-situ star formation processes affect the final structure of NSCs in unique ways; though the general structure of the old stellar population in the NSC is very similar to the steady-state Bahcall-Wolf cuspy structure, its younger stellar population do not yet achieve a steady state. In particular, formed/evolved NSCs with in-situ star-formation contain differential age-segregated stellar populations which are not yet fully mixed. Younger stellar populations formed in the outer regions of the NSC have a cuspy structure towards the NSC outskirts, while showing a core-like distribution inwards, with younger populations having larger core sizes. In principal, such a structures can give rise to an apparent core-like radial distribution of younger (up to 2-3 Gyrs) stars, as observed in the Galactic center, while still contain an underlying stellar cusp of older stars, that can be potentially be missed by current observations of red-giants, which might be biased towards younger stellar populations. In addition, we simulate the rates of tidal disruption of stars by MBHs during the evolution of the clusters. By that, we provide a prediction model of the history of tidal disruption events (TDEs). We find the TDE rates in several scenarios grow in time as the number density in the NSCs increase.

Abbas Askar
Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences, Poland
talk
Title: Simulating Observations of MOCCA Star Cluster Simulations with COCOA
Abstract: The MOCCA (MOnte Carlo Cluster simulAtor) code developed in NCAC can simulate the evolution of realistic star clusters and can provide full dynamical & stellar evolutionary history of all objects in the cluster. In order to properly and automatically analyze results of simulation data, it is important to develop effective tools for working out extremely large amounts of data and to be able to compare simulated models of star clusters with observations and other types of simulations. For this purpose, we are developing the COCOA (Cluster simulatiOn Comparison with ObservAtions) code that can quickly and automatically apply observational techniques to simulated clusters and conduct comparisons of star cluster simulation results with observational data. COCOA results can help in estimating accuracy of cluster parameters obtained from observations and incorporating the observer's view of numerical simulations of the evolution of star clusters can be very valuable. In this talk, I will present initial results from the COCOA and will discuss its various functional components which include (but are not limited to) various ways of projecting numerical data on to the plane of the sky, simulating observations of stars in binary systems, generating FITS and photometric data in different bands, computing surface brightness profile, velocity dispersion profile and luminosity functions.

Paulina Assmann
Universidad de Chile, Chile / NAOC, Beijing
talk
Title: "Post-Newtonian Dynamics of Black Holes with spin in star clusters simulations with NBody6 ++"
Abstract: Globular clusters are believed to be breeding grounds for the sources of gravitational waves that advanced detectors such as LIGO and Virgo aim to detect. In this work, we sim- ulate, using an NBODY6++ code, a realistic dense star cluster where stellar evolution and primordial binaries are included, in order to study relativistic mergers of compact binaries in this object. This theoretical work will give critical information that can help observations aimed to study the dynamics of globular clusters and the detection of gravitational waves.

Sambaran Banerjee
Argelander-Institut fr Astronomie, University of Bonn, Germany
talk
Title: Very young massive clusters: formation and activity
Abstract: The ways in which near-spherical, gas-free, massive star clusters of very young age come into existence is among the most widely debated topic in astronomy. Once formed, one of the widely raised issue is their dynamical implications. In the first part of this talk, I discuss the formation channels of the well observed Galactic NGC 3603 young cluster (HD 97950), based on our recent studies. I demonstrate that the notion of monolithic cluster formation out of dense gas clumps remarkably reproduces HD 97950 cluster. Next, I explore the possibility of formation of the same cluster via hierarchical merging of subclusters. Unlike the episodic model that well reproduces HD 97950, the same is found to be practically impossible with hierarchical assembly alone. Only those systems which assemble promptly into a single cluster (in ¡ 1 Myr) from a close separation (all within approx. 2 pc) can reproduce the observed density profile of HD 97950, but only after approx. 70% gas removal. These results therefore suggest that NGC 3603 young cluster has assembled essentially in an episodic fashion followed by a substantial gas expulsion. In the second part, I discuss the role of the young "super" star cluster R136, in the Tarantula nebula of the LMC, in generating runaway massive stars, based on our recent studies. In particular, I show that the existence of massive "slow runaway" stars like VFTS 682, in the vicinity of R136, can be easily explained by dynamical ejections from R136 cluster. We also quantify the general properties of runaway massive stars from an R136-like young massive cluster.

Matthew Benacquista
University of Texas at Brownsville
poster
Title: Extragalactic Black Hole Binaries as Low-frequency Gravitational Wave Sources
Abstract: The eLISA gravitational wave observatory will be sensitive to low frequency gravitational wave in the mHz band. Black hole binaries born in globular clusters will be particularly strong sources in this band and can be detected from Mpc distances. We will discuss the prospects for detection of dynamically formed binaries from the nearby universe.

Peter Berczik
National Astronomical Observatories of China, Chinese Academy of Sciences
talk
Title: Galaxy collsion simulations with central Post Netwonian Binary Black Hole.
Abstract: We present the set of direct N-body numerical simulations (up to N=1M particles) with the large scale different mass galaxy-galaxy collisions. The central Black Holes (BH) are simulated as a special particles with the Post Newtonian (PN) force corrections (up to PN3.5 terms) implemented only for the BH interactions. We prove that the Binary BH merging time scale for the different mass mergers are significantly smaller compare to the similar mass galaxy merging cases.

Clio Bertelli Motta
University of Heidelberg, ZAH, ARI
poster
Title: Chemical abundances of open clusters in the Sloan Digital Sky Survey
Abstract: Stars are known to form in clusters that, in the case of open clusters, will eventually dissolve due to gravitational interactions and release their stars into the field population, thus playing an essential role in the evolution of the Galactic disc. The number of identified open clusters in the solar neighbourhood is constantly increasing, counting 3006 Milky Way clusters in 2013. This list has been recently updated with 139 further open clusters having in common a large height above the Galactic plane (b ¿ 20 deg) and an age ¿ 1 Gry. We cross-matched the list of known open clusters with the SDSS database in order to retrieve spectra of stars that have been observed by the Sloan SEGUE Survey or by the Sloan main Survey and that are, with high-probability, cluster members. We analysed a sample of about 30 open clusters in order to infer their Fe abundance as well as their composition in several alpha elements, together with the equivalent width of the CN bands of the stars involved. We discuss the results in terms of the degree of chemical homogeneity among stars belonging to the same cluster, which may yield information about the initial conditions leading to the cluster formation and indicate the presence of multiple stellar populations. Besides, we correlate the average metallicities and chemical compositions of the clusters with their position in the disc in order to gain insight into the spatial variations of the Galactic star formation history.

Paolo Bianchini
Max-Planck-Institut fr Astronomie
talk
Title: From models to observations: understanding IFU observations of globular clusters
Abstract: Even though globular clusters (GCs) have long been considered prototypical simple spherical systems, their origin is still strongly debated. Internal kinematics, acting as fossil record of the formation processes, can help us unravel their origin as well as to search for the presence of exotic objects such as intermediate mass black holes (IMBHs) in their central regions. Two main strategies are employed in studies of the internal kinematics of GCs: 1) measurements of velocities of resolved stars (line-of-sight velocities or proper motions) 2) integrated kinematic measurements with IFU spectroscopy. Unsettlingly, these different methods can give significantly different observational outcomes when applied to the same object. Therefore, we have developed a procedure to simulate IFU observations of GCs, starting from realistic Monte Carlo or N-body cluster simulations. Using these mock observations we are able to determine several effects that lead to the profound differences between the observational methods, such as a stochastic scatter introduced by the presence of a few bright stars. We will describe these effects and propose procedures to mitigate them. Finally, we will show that these effects must be fully taken into account to correctly interpret subtle kinematic signatures usually ascribed to the presence or absence of IMBHs.

Michael Brewer
Drexel University, Department of Physics
poster
title: Investigating the Spitzer Instability Using AMUSE Codes
abstract: The AMUSE codebase is a modular package of codes for astrophysical research simulations. Intended to replace traditional kitchen sink types of codes, which require that the end-user accept all of the code creators choices for implementations of multiple different types of physics, the modular structure of AMUSE allows users to easily select which codes are desired for each type of physics required, and because the modules share a common interface, this allows users to change their choices of modules without significant changes to their code. Here, we examine the behavior of a new module called, multiples, designed for detailed handling of binary stars and other few-body systems within large N-body codes, applying the module to the study of mass segregation in two-component globular clusters and begin a numerical investigation of the Spitzer mass segregation instability. We find that, for systems of total size N = 5000 and a number fraction for the heavy population of 0.01, the timescale for the segregation of a small population of heavy objects within a background population of lighter objects scales as approximately 1/, where is the ratio of the mass of the heavy population to the lighter, background population. This scaling is in agreement with theoretical predictions and published results from other numerical simulations. The Spitzer instability is a phenomenon that occurs in globular clusters where, if a small population of heavy objects is sufficiently massive relative to the background population of lighter objects, the heavy population will become dynamically decoupled from the background and evolve independently leading to a small number of dominant hard binaries which through close encounters are expected to eject the other heavy objects from the system core. We begin an exploration of the threshold for instability by evolving a series of globular clusters of size 32,000 particles with King model initial conditions, varying W0, the King Model core concentration parameter, Q, the number fraction of the heavy population, and , the mass ratio of the heavy population to the background population. The scale of this survey provides an excellent opportunity to stress test the multiples module to find bugs and benchmark performance.

Jura Borissova
Institute of Physics and Astronomy, Universidad de Valparaiso
poster
Title: Star clusters in VVV
Abstract: TBD

Ivan Cabrera-Ziri
LJMU, ESO
talk
Title: Constraining globular cluster formation through studies of young massive clusters.
Abstract: Currently there are two competing scenarios to explain the origin of the stellar populations in globular clusters (GCs). The main difference between them is whether or not multiple events of star formation took place within GCs. Some of these formation scenarios predict that young massive clusters (YMCs) should be spawning new generations of stars within them. Here we will present the constraints on several GCs formation scenarios gathered so far through observations of YMCs.

Maxwell Xu Cai
National Astronomical Observatories of China (NAOC) / Kavil Institute for Astronomy and Astrophysics (KIAA)
poster
Title: Simulations of planetary systems in star clusters
Abstract: It has been widely accepted that star clusters are the building blocks of galaxies. Over the time they get tidally disrupted and their member stars contribute to the galaxy popula- tion. Since the formation of the Solar System can be dated back for more than 5 billion years, this naturally brings up the question that whether or not the Solar System was ini- tially part of the star cluster. In fact, recent observation suggest that planetary systems have difficulty surviving in the star cluster environment, mainly due to the frequent close encoun- ters. In order to investigate the puzzle of planetary system survival rate within star clusters, it is necessary to build up a hierarchical structure of simulation, where planetary systems are embedded in the star cluster. In this poster the modeling of the hierarchical system is presented, discussion of the preliminary results is covered.

Candlish, Graeme
UdeC
talk
title: Putting MOND to the test
abstract: The LCDM standard cosmological model is strongly supported by multiple lines of evidence, particularly from observations at large scales such as the CMB and large scale structure. There are some indications, however, of problems at smaller scales. An alternative to the CDM approach is to modify the gravitational force, as exemplified by the MOdified Newtonian Dynamics (MOND) idea. While evidence suggests MOND cannot account for dynamics at all scales without dark matter, it has been successful at galactic scales. Due to the complexity of the theory, however, most tests of MOND have extended no further than using a simple scaling relation to determine rotation curves or velocity dispersions. Therefore, to test the concept more thoroughly we require numerical simulations. In this talk I will discuss the development and testing of a new N-body solver, using two distinct formulations of MOND, that is incorporated into the RAMSES code. I will briefly summarise the theory of MOND, and how it is implemented in the code. I will then demonstrate the effectiveness of the code in various test cases and discuss scientific applications.

Roberto Capuzzo-Dolcetta
Dep. of Physics, Sapienza, Univ. of Roma, Italy
talk
title: High velocity stars from galactic centers R. Capuzzo Dolcetta, Dep. of Physics, Sapienza, University of Roma, Italy
abstract: There is evidence of the existence of stars moving at very high velocities (greater than 1000 km/s) especially when looking toward the Galactic center. All the reasonable mechanisms require the extraction of energy in some multiple body system involving a massive or super massive black hole. One of such possibilities, that here I present and discuss, is that of the extraction and acceleration of stars from a globular cluster during one, or more than one, close encounter with the massive black hole in the galactic center. The probability of such close encounters is high for massive globular clusters whose orbits have had time to deeply decay around the galactic center due to dynamical friction.

Carballo-Bello, Julio
Universidad de Valparaiso
poster
title: Stellar clusters as tracers of the formation and structure of the Milky Way
abstract: tbd

Choque, Nelvy
UdeC
poster
title: TBD
abstract: TBD

Chul Chung
Center for Galaxy Evolution Research, Dept. of Astronomy, Yonsei University, Republic of Korea
poster
title: The evolutionary population synthesis model for calcium infrared triplet of simple stellar populations
abstract: Here we present the evolutionary population synthesis model for calcium infrared triplet (CaT) of simple stellar populations. We have adopted the empirical spectral libraries of Cenarro et al. (2001) and INDO-US (Valdes et al. 2004), and constructed CaT models with the same input physics and stellar evolutionary tracks used in the models of Chung et al. (2013a, b). Our new CaT-metallicity relations show non-linear correlations when the metallicity of stellar population is greater than [Fe/H] -0.5. This is because cool stars in metal-rich stellar populations hinder the formation of calcium II ionised lines. This new relation shows good agreements with the observed CaT of globular clusters in early-type galaxies. Additionally our models also confirm that the effects of blue horizontal branch stars and the age (¿10 Gyr) of stellar populations on the integrated CaT are almost negligible. Based on our new models, we suggest that CaT is not a good metallicity indicator for metal-rich stellar populations.

Title: Neutron star natal kicks and the long-term survival of star clusters
Authors: Filippo Contenta (University of Surrey, UK), Anna Lisa Varri (University of Edinburgh, UK), Douglas C. Heggie (University of Edinburgh, UK)
Abstract: We investigate the dynamical evolution of a star cluster in an external tidal field by using N-body simulations, with focus on the effects of the presence or absence of neutron star natal velocity kicks. We show that, even if neutron stars typically represent less than 2% of the total bound mass of a star cluster, their primordial kinematic properties may affect the lifetime of the system by up to almost a factor of four. We interpret this result in the light of two known modes of star cluster dissolution, dominated by either early stellar evolution mass loss or two-body relaxation. The competition between these effects shapes the mass loss profile of star clusters, which may either dissolve abruptly ("jumping"), in the pre-core-collapse phase, or gradually ("skiing"), after having reached core collapse.

Dabringhausen, Joerg
UdeC
talk
title: Low-mass X-ray binaries as tracers for a varying stellar initial mass function in ultra-compact dwarf galaxies
abstract: Ultra compact dwarf galaxies (UCDs) are dense stellar systems at the border between massive star-clusters and small galaxies. Recent research has shown that their average optical mass-to-light (M/L) ratio cannot be explained by stellar populations with a canonical initial stellar mass function (IMF). This can be understood if UCDs represent a case of rapid star formation in an extremely dense environment, leading to a top-heavy IMF. A top-heavy IMF implies a high number of neutron stars (NSs) in an aged stellar population, which could provide the unseen mass in UCDs. The NSs can form binary systems with a evolving low-mass stars and thereby become visible by X-ray emission. The frequency of such so-called low-mass X-ray binaries (LMXBs) depends on the frequency of NSs and thus on the IMF. The notion of a top-heavy IMF in UCDs can therefore be tested by modelling the frequency of low-mass X-ray binaries (LMXBs) in UCDs and globular clusters (GCs) and comparing it to the observed frequency of LMXBs in those stellar systems. The observed frequency of LMXBs in UCDs in the Virgo Cluster does indeed support a top-heavy IMF in those UCDs. Further information will come from Monte-Carlo simulations of the LMXB-populations of UCDs and GCs in other galaxy clusters.

Emanuele Dalessandro
Department of Physics & Astronomy, University of Bologna
talk
title: The primordial binary fraction in low-density Galactic globular clusters
abstract: Binary stars play a crucial role in the formation and evolution of dynamically active stellar systems. While many details are still missing, the general idea is that the binary fraction in the core of globular clusters (GCs) increases because of dynamical processes, while in the outskirts it remains roughly constant with time thus bringing direct information about its primordial value. We have used a proper combination of high-quality deep HST and ground based data to derive the absolute binary fraction both in the core and in the most external regions of a properly selected sample of GCs. In this way we have been able to constrain the original binary stars content at the early formation stages of the analysed GCs. In addition, we have compared the binary system radial distributions with those observed for exotic objects in GCs all over the entire cluster extensions. These studies allow us to shed new light on the dependency of binary properties on the host cluster characteristics, on the link between the binary fraction and the peculiar population properties and to provide us with invaluable constraints to the models of GC formation and evolution.

Richard de Grijs
Kavli Institute for Astronomy and Astrophysics, Peking University
talk
title: Massive cluster defies multiple stellar population concept in apparent paradigm reversal
abstract: Until about a decade ago, massive star clusters were considered "simple" stellar populations: it was generally thought that all of their member stars had formed at approximately the same time from the same progenitor molecular gas cloud. All stars would thus have similar ages and only a very narrow range in chemical composition. Over the past decade, this concept has changed dramatically, and massive star clusters are no longer considered single-generation stellar populations. Here we highlight a discovery associated with a 2 billion-year-old cluster in the Large Magellanic Cloud which, at first sight, appears to comply with the multiple stellar population dogma, but whose stellar content beyond the main sequence can only be reconciled with a truly single stellar population. We invoke a distribution of stellar rotation rates to resolve this apparent conundrum. This places the multiple populations theory as a general concept on loose footing. It is thus clear that existing theories of star cluster formation and evolution are in need of a fundamental overhaul. Since star clusters are among the brightest stellar population components in any galaxy, understanding their composition in detail is indeed imperative for understanding galaxy evolution as a whole.

Licai Deng
National Astronomical Observatories, Chinese Academy of Sciences talk
title: Time-domain studies of star clusters using 50BiN
abstract: 50BiN is a ground-based global network aimed at surveying variable objects in galactic open clusters. In this talk, I am going to present the scientific goals, site plan and instrument setup, together with the early science from the prototype node in west-China. As 50BiN is sub-net of SONG, current status of SONG will also be presented.

Andrea Dieball
University of Bonn, Germany
talk
title: Hunting for Brown Dwarfs in Globular Clusters: M4
abstract: Observational studies of globular clusters have always shaped our understanding of stellar systems, and also of the structure and evolution of individual stellar types. One of the remaining challenges in globular cluster research is to explore and go beyond the end of the hydrogen-burning main sequence to the sub-stellar brown dwarf (BD) regime. BDs represent a link between very low mass stars (VLMSs) and giant planets, and thus are important for our understanding of stellar structure and evolution, and star and planet formation. However, determining the physical parameters of field BDs is extremely difficult and the major hurdle in BD research. Observations of globular clusters that reach beyond the H-burning limit can significantly improve the situation and will provide the much needed metal-poor benchmark VLMSs and BDs that are crucial if we are to test and improve theories for their formation, evolution and structure. Here we present first results from our deep IR survey with HST of the globular cluster M4. The data reach about 3 magnitudes below the predicted H-burning limit, and several BD candidates can be clearly identified.

Dominguez, Raul
UdeC
poster
title: TBD
abstract: TBD

Farias Osses, Juan Pablo
UdeC
talk
title: Can we predict the survival of an hierarchical formed star cluster?
abstract: We examine the effects of substructure and pre-gas expulsion virial ratio in the survival of young embedded star clusters. We perform N-body simulations of equal mass fractal distributions under the influence of three different shapes of background potentials to mimic native gas. We found that if we know the percentage of stellar mass inside the half mass radius of the stars and the virial ratio of the cluster both when gas expulsion begins, it is possible to know with certain confidence what minimum fraction of stellar mass the cluster will retain after gas is gone. We show that a simple theoretical model can fit all our simulations considerably well. However we still wonder if gas dynamics could affect our predictions and we show the first comparsons with simulations that use SPH particles to model gas background.

Francesco Ferraro
Department of Physics and Astronomy, University of Bologna
talk
title: An empirical clock to measure the dynamical age of stellar systems
abstract: The definition of reliable clocks able to measure the age of cosmic structures is a crucial task in Astrophysics, but only a few chronometers are currently known in the Universe. The most famous is the luminosity of the main sequence turn-off point, to measure the chronological age of stellar aggregates. However, this quantity alone is unable to fully characterize the global evolution of a system: indeed, stellar clusters with the same chronological age can have experienced quite different levels of dynamical evolution. By using the radial distribution of Blue Straggler Stars in a sample of 20 Galactic globular clusters, we recently defined the first empirical clock able to measure the dynamical age of stellar aggregates from pure observational properties (Ferraro et al. 2012, Nature, 492, 393). A crucial role in the derivation of these results has been played by the HST: high-resolution imaging, especially in the near-ultraviolet, has been crucial to properly obtain complete samples of Blue Straggler stars in the central regions of even the most concentrated globular clusters. We present the state of the art results about Blue Straggler stars in Galactic globular clusters and their crucial role in clarifying the internal dynamical processes occurring in these highly collisional stellar systems.

Frelijj Rubilar, Heinz
UdeC
poster
title: TBD
abstract: TBD

Elena Gavagnin
University of Zurich, Switzerland
talk
title: Star cluster formation through merger of sub-clusters
abstract: Young star clusters (YSCs) are a keystone for star formation, because they are the nursery of stars and the building blocks of galaxy discs. YSCs are thought to form from the collapse of molecular cloud cores, but the details of this complex process are still an open question. The main models that have been proposed are the monolithic scenario and the sub-cluster merger scenario. The 'monolithic scenario', which predicts the formation of a YSC from the collapse of a single cloud core, is unable to explain several recent observational facts (e.g. the existence of multiple populations), which could be likely accounted by the 'sub-cluster merger scenario', in which the cluster builds up from the early merger of sub-clusters that form in different cores of the same molecular cloud. Whether a YSC forms monolithically or from the merger of sub-YSCs is crucial, because it might affect not only the mass segregation, but also the structural parameters, the morphology of the SC, and the formation of blue straggler stars from stellar collisions. In my talk I will present the results of direct Nbody simulations (making use of the STARLAB public software environment) of YSCs mergers, including both an accurate integration of the dynamical processes and advanced stellar evolution models. I will discuss how core collapse and mass segregation depend on the time when the merger occurs and on the properties of the merging sub-clusters. The simulations were performed at different metallicity, and I analysed how mass-loss by stellar winds and supernovae (at different metallicity) affect the core-collapse and the development of mass segregation.I will compare my simulations with recent observations of YSCs in which the existence of non-coeval stellar populations has been claimed (e.g. NGC 602). I will also show how my results can explain the distinct kinematic populations that have been recently observed in the Gamma Velorum cluster by the Gaia ESO survey.

Geisler, Doug
UdeC
talk
title: Uncovering Multiple Populations in Globular Clusters with Washington Photometry
abstract: Globular Clusters (GCs), long considered as ideal Simple Stellar Populations, are now known to harbor a wide variety of chemical inhomogeneities. Multiple populations (MP) are being found in a growing number of Galactic GCs via both photometric and spectroscopic techniques. However, most studies employ either high resolution spectroscopy, HST photometry or inefficient filters from the ground. A ground-based photometric system which is both efficient and effective would be especially excellent for uncovering MP. We demonstrate that the Washington system meets these goals. Our analysis of the well-studied GC NGC 1851 shows indeed that the C filter is both very efficient and effective at detecting its previously discovered MPs in the RGB and SGB, using relatively little telescope time on only a 1-meter telescope. Remarkably, we have also detected an intrinsically broad MS best characterized by two distinct but heavily overlapping populations that cannot be explained by binaries, field stars, or photometric errors. This is the first time MPs in a MS have been discovered from the ground, and just as strikingly, using only a 1-meter telescope. The Washington system thus proves to be a very powerful tool for investigating MPs, and holds particular promise for extragalactic objects where photons are limited and for the future after the unique UV capabilties of HST are gone.

Mark Gieles
Department of Physics, University of Surrey
talk
title: What does the mass-to-light ratio of globular clusters tell us about the IMF?
abstract: A fundamental observable that can be determined for globular clusters (GCs) up to large distances is the mass-to-light ratio, which can be used as a proxy of the stellar initial mass function (IMF). Recent studies of M/L of Local Groups GCs have found M/L values that were factors of a few off the predictions from single stellar population (SSP) models. These differences were explained by variations in the IMF. In this contribution I discuss to what extent these anomalous M/L values can be explained by systematic biases because most GCs have evolved towards equipartition as the result of two-body relaxation.

Mirek Giersz
Nicolaus Copernicus Astronomical Centre, Polish Academy of Sciences, ul. Bartycka 18, 00-716 Warszawa, Poland
talk
Title: The newest developments of the MOCCA code and the Astro-data tools.
Abstract: I will discuss the newest developments of the MOCCA code. The developments are connected with full implementation of triple and quadruple treatments into the MOCCA logic and the code flow. This work was done actually by Arek Hypki. The first results of simulations with hierarchical systems will be presented. I will also present information about the Astro-data tools developed under AstroGrid-PL project implemented within PLGrid-Plus infrastructure. Under the Astro-data framework a special tool for storing, searching and comparing simulations done by different stellar dynamical code is implemented. This can be regarded as a data base very useful for various project conducted by dynamicists and observers.

Hossein Haghi
Institute for Advanced Studies in Basic Sciences(IASBS)
talk
title: Possible smoking-gun evidence for initial mass segregation in re-virialized post-gas expulsion star-burst clusters Colaborators: Pavel Kroupa, Akram Hasani Zonoozi, Sambaran Banerjee
abstract: In the present study, we have carried out a series of direct N-body calculations to investigate the effect of residual-gas expulsion from the globular clusters' embedded progenitors on the stellar mass function of different models on circular orbits, starting either tidally filling or underfilling, and either with or without primordial mass segregation. We covered the first 100 Myr of the evolution of modeled clusters and showed for the first time that the expulsion of residual gas from initially mass-segregated models leads to the significantly shallower slope of the stellar mass function in the low- ($M \leq 0.5M_{\odot}$) and intermediate-mass ($\simeq 0.5 - 0.8M_{\odot}$) regime. Therefore the imprint of residual gas expulsion, as a direct evidence of primordial segregation, might be visible in the present day MF. We also found that the strength of the external tidal filed, as an essential parameter, influences the degree of flattening in the intermediate-mass range, such that the MFs of primordially mass-segregated tidally-filliing clusters with r_h/r_t values larger than 0.1 show a strongly depleted mass function in the intermediate stellar mass range, while the slower mass-loss rate of clusters initially lying inside their tidal radii, takes a longer time to lose a given amount of mass. Therefore, the shape of present day MF in intermediate stellar mass range probes the birth place of clusters in Galactic environment.

Akram Hassani Zonoozi
Institute for Advanced Studies in Basic Sciences(IASBS)
poster
title: Did violent early residual-gas expulsion play a dynamical role for Pal 14 and Pal 4?
abstract: Recently Zonoozi et al (2011, 2014) presented direct N-body simulations of two remote halo globular clusters Pal 4 and Pal 14 to specially address the question whether or not primordial mass segregation is necessary to reproduce the shallow present-day mass function slope. They found that the current state of Pal 4 can be reproduced either by assuming primordial mass segregation, or alternatively, by assuming an IMF already depleted in low-mass stars (i.e. initially flattened IMF) in the early gas-expulsion phase, compared to the Kroupa IMF. This seems curios since such flattened IMF is less likely to be reproduced for such distant, tidally-underfilling clusters if they lie on a circular orbits with radius of present day Galactocentric distance. We showed that this flattened MF in the observed mass range $\simeq 0.5 - 0.8 M_{\odot}$ can be explained by residual-gas expulsion from primordially mass-segregated, initially tidally-filling models. If Pal 4 and 14 has always been on the circular orbit with a radius of present day galactocentric distance, it is hard to imagine that the tidal field would have played a role during the cluster response to gas expulsion. We then concluded that the cluster may have formed in a tidal dwarf galaxy or within the inner part of our Galaxy, and then moved to a larger galactocentric distance owing to orbiting on the eccentric orbit and we provided a priliminary estimate of cluster birth site.

Douglas Heggie
University of Edinburgh, Scotland
talk
title: Dynamics of star clusters on elliptical orbits
abstract: While this problem is easy to simulate, it is hard to understand. For clusters on circular orbits we have an energy integral, zero-velocity surfaces, Lagrange points, and so on. Most of this machinery does not exist for the case of an elliptical galactic orbit. In this talk I describe results of a project (in collaboration with B Bar-Or and A L Varri) aimed at the theoretical understanding of the escape rate in the elliptical case.

Jongsuk Hong
Indiana University, USA
poster
title: Evolution of binary stars in multiple-population globular clusters
abstract: Simulations of the formation of multiple stellar populations in globular clusters predict that second-generation stars form in a compact subsystem in the cluster central regions. Previous studies have suggested that the initial differences in the structural properties of first- and second-generation stars can have significant implications for the evolution of the binary star population. We have performed a survey of N-body simulations to explore the evolution of binary stars in multiple-population globular clusters. We will presents results concerning the differences in the evolution of the global fraction of first- and second-generation binaries, the evolution of the binary spatial distribution, and of the binary binding energy distribution for clusters with different initial structural properties.

Jarrod Hurley
Swinburne University of Technology
talk
title: TBD
abstract: TBD

Nataly Nicole Ibarra Vera
UdeC
poster
title: Which gravitational waves we should expect from a Globular Clusters?
abstract: Due to new developments in the code Nbody6++, it is now possible to simultaneously model globular clusters with a realistic number of stars, star formation, and primordial binaries. Here we will use Nbody6++ simulations to study the relativistic mergers of compact objects in an realistic environment, and define the physical properties of gravitational waves that can be generated in such system. We will discuss how to include relativistic corrections to the orbit simulations and how to extract from them the predicted gravitacional wave amplitudes, using the formalism of post-newtonian expansion. Our results should be relevant for ground-based gravitational wave detectors.

Yara Jaffe
Universidad de Concepcion
poster
title: A phase-space view of gas stripping and galaxy quenching in clusters
abstract: I will present recent results from a study of gas stripping and galaxy quenching in cluster galaxies from the Blind Ultra Deep HI Environmental Survey (BUDHIES). We use cosmological simulations to infer the orbital histories of the observed cluster galaxies in phase-space. We further exploit our multi-wavelength data to distinguish between the different physical processes that affect galaxies in clusters. Our results strongly support a scenario in which ram-pressure by the intra-cluster medium strips away the HI gas in disk galaxies as they first fall into the cluster. After complete gas removal, the galaxy eventually ceases to form stars and becomes red and "dead". I will also discuss the need of other mechanisms such as group pre-processing to explain the large fraction of quenched galaxies in the infall regions of clusters.

Christian Knigge
University of Southampton
poster
title: Multiple options – (1) Cataclysmic Variables in Globular Clusters; (2) Blue Stragglers in Open and Globular Clusters; (3) Far-ultraviolet Surveys of Globular Clusters
abstract:TBD

Thijs Kouwenhoven
Kavli Institute for Astronomy and Astrophysics, Peking University talk
Title: The formation and dynamical evolution of free-floating planets in star clusters
Abstract: The recent discovery of a large population of exoplanets in the Galactic field has provided a wealth of information that helps us understand how planetary systems form and evolve. Exoplanet surveys targeting star clusters, on the other hand, have been less successful: only a hand full of exoplanets have been discovered in these regions. This may be attributed to the frequent encounters experienced by star cluster members, and possibly by a difference in the formation process. The presence of multiple planets in a system (such as our own Solar system) can substantially increase the possibility of planet ejections, which may explain the absence of close-in planets, such as hot Jupiters, that would normally be unaffected by stellar encounters. This talk focuses on the dynamical fate of multi-planet systems in dense stellar systems and on the evolution of the free-floating planet population in star clusters resulting from destabilized planetary systems. Since most of the planet-hosting stars in the Galactic field (and probably even our own solar system) are thought to have formed in clustered stellar environments, this places limits on the properties of the star clusters they may have formed in.

Pavel Kroupa
University of Bonn
talk
title: Is the IMF a probability density distribution function?
abstract: The stellar initial mass function (IMF) is usually assumed to be a probability density distribution function. Recent data appear to rule out this interpretation though, and I will discuss alternative more realistic applications and results concerning the possibly true nature of the IMF. Empirical evidence has emerged that the IMF becomes top-heavy in intense star bursts and at low metallicity. Related to the IMF are binary star distribution functions, and these evolve through dynamical processes in embedded star clusters. The insights gained from these considerations lead to a mathematically computable method for calculating stellar populations in galaxies, with possibly important implications for the matter cycle in galaxies. It turns out that the galaxy-wide IMF, the IGIMF, becomes increasingly top-heavy with increasing galaxy-wide star formation rate, while at the same time the binary fraction in the galactic field decreases.

Andreas Kuepper
Columbia University
talk
title: The Influence of Eccentric Orbits on Cluster Evolution
abstract: A good fraction of the globular clusters in the Milky Way show large half-mass radii and flat stellar mass functions, depleted in low-mass stars (the so-called de Marchi relation). This is contrary to expectations since the driver of low-mass star depletion, two-body relaxation, should be least efficient in these clusters. Using a comprehensive set of direct N-body simulations of globular clusters on various eccentric orbits within a Milky-Way-like potential, we show how a clusters half-mass radius and its mass function develop over time. The slope of the stellar mass function flattens proportionally to the amount of mass a cluster has lost into the tidal field, and the half-mass radius grows to a size proportional to the apogalactic distance of the clusters orbit. We conclude that the extended, depleted clusters observed in the Milky Way must have had small half-mass radii in the past, and that they expanded due to the weak tidal field they spend most of their lifetime in. Moreover, their mass functions were likely canonical in the past but flattened significantly as a cause of strong mass loss.

Michael Kuhn
Universidad de Valparaiso
poster
title: Mass Segregation in Star-Forming Regions with Subclustered Stellar Populations
abstract: Recent X-ray/infrared/optical surveys of high- and low-mass stars in nearby star-forming regions (e.g., MYStIX; Feigelson et al. 2013), provide useful datasets to study mass segregation. For young stars in 17 MYStIX regions, we infer stellar masses from JHK photometry combined with spectroscopic classifications from the literature. Mass segregation of the stellar population is measured using Schlather's E-mark statistic. Most of these regions exhibit significant global mass segregation, including cases where stars are spatially centrally concentrated and cases where stars are distributed in subclusters. Nevertheless, a few regions, including DR 21 and the Rosette Nebula, do not show global mass segregation. We discuss influences of star-forming region morphology, stellar ages, and stellar subcluster properties on the presence or absence of mass segregation and implications for theories of primordial vs. dynamic mass segregation in star-forming regions.

Richard Lane
Universidad de Concepcion
talk
title: Dwarf companions and globular cluster systems of isolated elliptical galaxies.
abstract: Isolated elliptical galaxies are interesting creatures. Despite their isolation, many isolated ellipticals have tidally interacting dwarf companions, with obvious tidal tails. We recently uncovered a dwarf companion exhibiting both tidal tails and multiple cores, evidence for hierarchical merging at two different scales in the same system. The lower mass merger is apparently occuring at a smaller mass scale than anything previously observed. What does this mean in terms of LCDM? What does this mean in terms of the evolution of the host galaxies? Furthermore, the globular cluster systems of isolated ellipticals can tell us much about the history of the host galaxy. Are all isolated ellipticals really fossil groups?

Barbara Lanzoni
Department of Physics and Astronomy, University of Bologna
talk
title: Searching for IMBHs in globular clusters through the radial velocity of individual stars
abstract: An intermediate-mass black hole (IMBH) hidden in a globular cluster (GC) is predicted to produce a steep central cusp in the velocity dispersion (VD) profile. Observationally detecting such a signature is indeed very challenging. While many claims of IMBH detection have been made from integrated light spectroscopy studies, I will show that this approach can be severely biased by the presence of a few dominant bright stars and that the safest way to measure the line-of-sight VD is through the radial velocities of individual stars. In the framework of a dedicated campaign, I will discuss the results obtained so far for a few GCs, among which NGC 6388 where the radial velocities of individual stars bring to the conclusion that no IMBH is hidden in this system (Lanzoni et al. 2013, ApJ 769, 107), while integrated light spectroscopy suggests a 10^4 Msol BH.

Nathan Leigh
American Museum of Natural History/University of Alberta
talk
title: The Properties of Galactic Globular Clusters at Birth
abstract: In this talk, we present the results of a suite of Monte Carlo and N-body simulations for globular cluster (GC) evolution. The models are used to constrain the parameter space relevant to the formation of the Milky Way GC population. That is, the set of initial conditions that will evolve dynamically over 10-12 Gyr to reproduce the presently observed parameters for the bulk of the Galactic GC population. We assume an universal initial binary fraction near unity with a significant soft component, combined with initial densities in the range $10^4 - 10^6 M_\odot$ pc^{-3} and an initial mass-density relation corresponding to higher densities in initially more massive clusters. These initial conditions are able to simultaneously reproduce the present-day observed structural parameters (concentration, mean density, total cluster mass, etc.), stellar mass functions and binary fractions (both inside and outside the half-mass radius) for most Galactic GCs.

Shuo Li
National Astronomical Observatories, Chinese Academy of Sciences
poster
title: Tidal disruption evolution of supermassive black holes in merging stellar system.
abstract: Supermassive black hole binaries (SMBHBs) are the products of frequent galaxy mergers. The evolution of SMBHBs is very important because the supermassive black holes (SMBHs) in active galactic nuclei (AGNs) play a key role on the formation and the evolution of their host galaxies through feedback. Moreover, before and during the coalescence of the SMBHB, very strong gravitational waves (GWs) are emitted, which may be observable in the near future and will help us to open a completely new astrophysical window into the evolution of galactic nuclei, black holes and their spins, and directly into general relativity. Thus, the detections of the strong GW radiation and their possible electromagnetic counterparts are essential. By using one million particle direct N-body simulations on special many-core hardware (GPU cluster), we study the dynamical co-evolution of SMBHB and its surrounding stars in gas poor environment, specially focus on the evolution of stellar tidal disruption rates in the galactic nuclei during the merger of galaxies. We find that, due to triaxial stellar distribution and strong interaction of two SMBHs, the tidal disruption rate in merging galaxies will be boosted during the formation of bound SMBHB system. Besides, the disrupted stars have different orbital characteristics before, during and after the formation of SMBHB. We also investigate the dependence of the results on the SMBH mass and density slope of the galactic nuclei.

Dongwook Lim
Center for Galaxy Evolution Research and Department of Astronomy, Yonsei University, Korea
poster
Title: Low resolution spectroscopy for the Globular Clusters with Signs of Supernova Enrichment
Abstract: Recent observations have provided evidence for the multiple stellar populations in most of globular clusters (GCs). In particular, some of these GCs show clear separation of red giant branches (RGBs) in Ca narrow-band photometry. This would suggest that the later generation stars in these GCs were affected by supernovae (SNe) enrichment. In order to clarify this situation, we have performed the low-resolution spectroscopy for the RGB stars in these GCs. Consequently, we confirm the significant differences in calcium abundance between two RGBs from the spectroscopic HK' index, and also find interesting differences in CN-CH correlations among these GCs. In this talk, we will present our spectroscopy for the GCs with signs of SNe enrichment.

Nora Luetzgendorf
European Space Agency (ESA/ESTEC)
talk
title: Testing black-hole accretion from stellar winds in star clusters using AMUSE
abstract: In the past decades massive black holes in star clusters have drawn the attention of observers and theorists in equal measure. Many detections, however, stand in contrast with results from different techniques. Especially the discrepancy between kinematic black-hole measurements and the absence of strong X-ray and radio emission from the centres of globular clusters remain an unsolved mystery. The main uncertainty when translating X-ray and radio flux measurements to black-hole masses is the amount of gas that is accessible for the black hole to accrete. We set out to investigate the effect of stellar winds on the accretion flow of the black hole. By using the Astrophysical Multipurpose Software Environment (AMUSE) we combine gravitational physics, stellar evolution and hydrodynamics to a single simulation of stars interacting with the black hole in the centre of a globular cluster. I present new results of this code by determining the accretion rate of the supermassive black hole in our galaxy from stellar winds of the surrounding S-Stars. From this, we will be able to extend the simulations to actual star cluster sizes and to pin down accretion rates expected from such a system.

Juan Madrid
Gemini Observatory
talk
title: Coevolution of Globular Clusters and Host Galaxies
abstract: We quantify the effects that galaxy evolution has on the lifespan of globular clusters through the analysis of direct N-body simulations. Large, multimass N-body simulations of globular clusters in a realistic Milky-Way-like potential, allow us to determine the impact of the host galaxy mass and geometry on the survival time of star clusters. Different geometries in a disk of identical mass can determine either the survival or dissolution of an orbiting star cluster. The evaporation rate of globular clusters evolving in a strong tidal field is also derived using these N-body simulations. The evolution of the evaporation rate is estimated for a globular cluster that decays into the center of the galaxy due to dynamical friction. We show how the evaporation rate has been underestimated in previous analytical studies. We discuss the findings of this work in relation to the formation of nuclear star clusters and super-massive black holes by inspiraling globular clusters.

Alessandra Mastrobuono-Battisti
Technion-Israel Institute of Technology
poster
title: A primordial origin for the composition similarity between the Earth and the Moon
abstract: Methods developed to study dense stellar systems are often applied to smaller scale problems. A perfect example of this natural continuity is the study of the formation and evolution of planetary systems, and in particular the origin of the Earth-Moon system. Most of the properties of the Earth-Moon system can be explained by a collision between a planetary embryo and the growing Earth late in the accretion process. Simulations show that most of the material that eventually aggregates to form the Moon originates from the impactor. However, analysis of the terrestrial and lunar isotopic composition show them to be highly similar. In contrast, the compositions of other solar system bodies are significantly dif- ferent than the Earth and Moon. This poses a major challenge to the giant impact scenario since the Moon-forming impactor is then thought to also have differed in composition from the Earth. Here we track the feeding zones of growing planets in a suite of N-body simulations of planetary accretion, in order to measure the composition of Moon-forming impactors. We find that a significant fraction of all planetary impactors could have had similar composition to the planets they impacted, in contrast with the composition of different planets existing at the same planetary system. These findings can resolve the apparent contrast between the observed similarity of the Earth and the Moon composition and its difference from that of other solar system bodies. This primordial composition similarity solution therefore lifts the prime obstruction for the standard giant-impact origin of the Moon, as well as eases some of the difficulties for alternative giant impact scenarios suggested in recent years.

McMillan Steve
Drexel University
talk
title: Evolution of Binary Stars in Multiple-Population Globular Clusters OR Simulating Young Star Clusters with AMUSE
abstract: TBD

Nicolas Medina
Instituto de Fisica y Astronomia, Universidad de Valparaiso, Chile.
poster
title: Variability of YSOs in BRC 89
abstract: We present some recent results of photometric intestigation of VVV variables belonging to young cluster [BDS2003] 2.

Yohai Meiron
KIAA-PKU
talk
title: Expansion Techniques for Collisionless Stellar Dynamical Simulations
abstract: We present graphics processing unit (GPU) implementations of two fast force calculation methods based on series expansions of the Poisson equation. One method is the self-consistent field (SCF) method, which is a Fourier-like expansion of the density field in some basis set; the other method is the multipole expansion (MEX) method, which is a Taylor-like expansion of the Green's function. MEX, which has been advocated in the past, has not gained as much popularity as SCF. Both are particle-field methods and optimized for collisionless galactic dynamics, but while SCF is a "pure" expansion, MEX is an expansion in just the angular part; thus, MEX is capable of capturing radial structure easily, while SCF needs a large number of radial terms. We show that despite the expansion bias, these methods are more accurate than direct techniques for the same number of particles. The performance of our GPU code, which we call ETICS, is profiled and compared to a CPU implementation. On the tested GPU hardware, a full force calculation for one million particles took 0.1 s (depending on expansion cutoff), making simulations with as many as 10^8 particles fast for a comparatively small number of nodes.

Mieske Steffen
ESO, Chile
talk
title: UCDs
I will review the properties of ultra-compact dwarf galaxies, a type of stellar systems intermediate between star clusters and galaxies. One main focus will be on the elevated dynamical mass-to-light ratios of UCDs. Those elevated M/L may indicate that UCDs harbour supermassive BHs in their very center, unnoticed up to now in our census of SMBHs in the nearby universe. I will report on the first, and spectacular, result of an observational campaign aimed at finding such SMBHs in UCDs. I may also touch briefly on the stellar populations and specific frequencies of UCDs.

Bryan Miller
Gemini Observatory
poster
title: The Stellar Populations of Nuclei and Globular Cluster Clusters in dE Galaxies in Virgo and Fornax
abstract: We present ages and metallicities for nucleated dwarf elliptical galaxies (dE,N) in the Virgo and Fornax Cluster based on Lick/IDS index measurements and SSP models. Gemini/GMOS spectroscopy shows that the globular clusters are mostly old and metal-poor, very similar to the globular clusters in the Milky Way halo. The nuclei tend to be more metal-rich than the globular clusters and have a wider range of ages. The [alpha/Fe] ratio appears to be solar for the globulars, but the nuclei may be slightly alpha-enhanced. Formation scenarios for globular clusters and nuclei will be discussed.

Alessio Mucciarelli
Department of Physics & Astronomy, University of Bologna, Italy
talk
title: ROTATIONAL VELOCITIES IN GLOBULAR CLUSTER BLUE STRAGGLER STARS
abstract: Blue Straggler stars (BSSs) are brighter, bluer and more massive than the main sequence turnoff stars. They are thought to form by direct collisions, or through mass-transfer activity between binary companions. High rotational velocities are expected for both types of BSSs but, until a few years ago, information about BSS rotational velocities were available for a few objects only, on the basis of low resolution spectra. Moreover, the link between BSS formation mechanisms and rotational velocities is not clear yet. In order to investigate this issue, we performed a spectroscopic survey of BSSs in a sample of six Galactic Globular Clusters by using the high-resolution spectrograph FLAMES@VLT. Here we presents the results obtained from this survey: the rotational velocity distribution observed in each cluster will be discussed in light of the possible BSS formation mechanisms and the cluster parameters.

Munoz, Cesar
UdeC
poster
title: TBD
abstract: TBD

Claudio Navarro
Universidad de Valparaiso poster
title: A search for YSO in the Galactic center using VVV data
abstract: The nature and incidence of eruptive variability in Young Stellar Objects is widely recognized as one of larger gaps in our understanding of the pre-main sequence evolution of normal low mass stars. It is thought that large variations in the accretion rate cause the sudden changes in brightness of several magnitudes, with lingering effects on the star's location in the HR diagram for greater than 1 Myr. This has major implications for studies of the Initial Mass Function. The VVV public survey has now provided the base for search for variability in YSO around young clusters and star-forming regions near the Galactic center. In this talk we present some preliminary results for the first of our fields, located around the Quintuplet cluster.

Christian H. R. Nitschelm
Unidad de Astronomia, Facultad de Ciencias Basicas, Universidad de Antofagasta
poster
title: Study of the duplicity and the multiplicity in the Sco-Cen Complex (Sco OB2)
abstract: The Sco-Cen Complex is composed of three nearby southern OB associations: Lower Centaurus Crux,Upper Centaurus Lupus and Upper Scorpius. Each of these contains more than one hundred and fifty stars, supergiants as well as giants, bright early-type as well as fainter late-type, main sequence as well as pre-main sequence. Using the literature, the Simbad database, the results from the Hipparcos astrometry satellite and our own research programme, we have created a catalogue of secure and possible members of the Sco-Cen Complex, in the framework of a more specific study of the binary population in nearby OB associations. During this talk, we present our new catalogue and some results we were able to derive from it, mainly about the present knowledge of the duplicity and the multiplicity throughout the Sco-Cen Complex. After explaining the selection process of the members, we are presenting some already known and yet unknown interesting spectroscopic binaries in the Sco-Cen Complex, SB1 and SB2, and proposing a few of them (mainly SB2) for a further disentangling study.

Thomas H. Puzia
Institute of Astrophysics, Pontificia Universidad Catolica, Santiago, Chile
talk
title: The Scale Sizes of GCs in NGC 1399
abstract: Globular cluster sizes are good probes of the dynamical environment they live in. Based on HST imaging, we have obtained half-light radius measurements of GCs in the central regions of Fornax with some surprising results, which I will discuss in this talk.

Sebastian Ramirez Alegria
Universidad de Valparaiso / MAS
talk
title: Young clusters with massive stellar population in the VVV-survey
abstract: Near infrared all-sky surveys such as 2MASS (Skrutskie et al. 2006), GLIMPSE (Benjamin et al. 2003), and UKIDSS (Lawrence et al. 2007) were key in the discovery of young and very obscured stellar clusters in our Galaxy. But the census is still far from complete. For example, in the case of the massive clusters census, up to 100 clusters with a mass greater than 10.000 solar masses may still remain hidden (Hanson & Popescu 2008). In this talk I will present the last clusters discovered using the ESO public survey Vista Variables in the Via Lactea (VVV; Minniti et al. 2010, Saito et al. 2012), particularly the new clusters with massive stellar population (Wolf-Rayet and OB-stellar populations). These objects are part of our long-term program dedicated to build an database of a great number of open clusters with an homogeneously derived physical characterization.

Alexander Rasskazov
Rochester Institute of Technology
poster
title: Rotational Brownian Motion of a Supermassive Binary in a Rotating Galactic Core
abstract: The subject of our study is a binary supermassive black hole in the center of a galactic nucleus. We model the evolution of its orbit due to interactions with the stars of the galaxy by means of 3-body scattering experiments and Fokker-Planck formalism. The main result is the following: when the nucleus possesses some degree of rotation, there's a significant change in the orbital orientation of a supermassive binary towards alignment with the plane of rotation of the nucleus. Knowing the orbital orientation of a supermassive binary is important because it is related to the orientation of the accretion disk and to the spin of the black hole which would be the result of merger of the binary components.

Florent Renaud
University of Surrey
talk
title: Star cluster evolution in the cosmological context
abstract: Because of their old ages, the dynamical evolution of globular clusters must be considered in a cosmological context. In the lambda-CDM paradigm, galaxies grow significantly (in mass and size) over such timescales, by accretion of gas and mergers. It is however challenging to simultaneously consider the internal cluster forces and the external galactic forces, due to the large range of scales involved (10 orders of magnitude in space and time). Indeed, Nbody simulations of star clusters often consider a static galactic tidal field, but the errors (on the global and structural properties of the clusters) coming from this simplification have never been quantified. Using a new method to integrate tides from any functional form of the galactic potential in Nbody6 simulations, we compared the evolution of a star cluster orbiting in a galaxy which grow with cosmic time, to that of a cluster in a static version of such galaxy. Both the direct effect of an increasingly massive galaxy and the indirect effect of an inspiral orbit affect the mass-loss of the cluster as well as the properties of its tidal tails.

Richtler, Tom
UdeC
poster
title:tbd
abstract: tbd

SARA SARACINO
Department of Physics and Astronomy (University of Bologna)
poster
title: GEMINI observations reveal the structure of Liller 1
abstract: By exploiting the exceptional high-resolution capabilities of the Multi-Conjugate Adaptive Optics System at Gemini South, we are carrying on project aimed at probing the nature of a selected sample of globular clusters in the Galactic bulge. Here we present the first results, consisting in the deepest and most accurate near-IR color-magnitude diagram ever obtained for Liller 1. We used these data to build new star density and surface brightness profiles for the cluster, and to re-determine its main structural parameters (center of gravity, density profile, scale radii, concentration parameter, etc). We found that Liller 1 is significantly less concentrated and less extended than previously thought. Still it has one of the largest collision rates (the second after Terzan 5) among all star clusters in the Galaxy, thus confirming that it as an ideal environment for the formation of collisional exotic objects (such as millisecond pulsars).

Alison Sills
McMaster University
talk
title: Dynamical Evolution of Very Young Stellar Sub-Clusters
abstract: Recent observations of massive, young, nearby star-forming complexes are starting to probe the detailed structure of newly-forming star clusters. In particular, the MYStIX collaboration (Feigelson et al. 2013) have an extensive census of stars in 20 such regions, probing down to low masses and through significant extinction. Early results suggest that most star clusters form from a number of distinct subclusters, and that those subclusters themselves have interesting stellar age and mass distributions. In this talk, I will discuss results from a project to dynamically model very young, embedded subclusters, using initial conditions based on the MYStIX observations of their youngest clusters.

Mirko Simunovic
Instituto de Astrofisica, PUC poster
title: CMD Properties of Blue Straggler Stars in Globular Clusters from HST Survey Data.
abstract: We have combined HST/ACS optical and HST/WFC3 near-UV photometric archival data of the inner regions for over 50 galactic globular clusters (GC). Using proper motion cleaning of the color-magnitude diagrams (CMD) we have constructed a large homogenous catalog of Blue Straggler Stars (BSS) and studied their CMD location properties. We further use a set of isochrones to find stellar mass and age estimates for the BSS populations in all GCs. Different mass and age distributions can be used to constraint the conditions of BSS formation for varying cluster parameters such as metallicity. Ultimately, our goal is to use multiple parameters such as the binary fraction, binary mass ratio and stellar collision rate to explore the resulting BSS mass and age distributions, and this way accurately determine their progenitors and formation scenarios.

Anna Sippel
Swinburne University
poster
title: Slicing and dicing globular clusters
abstract: We use direct models of GCs and analyze them with observational tools as far as possible, with a particular focus on the colour evolution during cluster evolution. Using this approach, we find that the change of integrated cluster colour is driven by the brightest stars rather than the removal of low-mass stars.

Rainer Spurzem
National Astronomical Observatories of China, Chinese Academy of Sciences and Kavli Institute for Astronomy and Astrophysics, Peking Univ.
talk
title: Astrophysical N-body and other computer models on the path to Exascale
abstract: The use of accelerated computing (currently: GPU) for astrophysical computations in China and other countries is presented. Current and future hardware (including a few preliminary experiments with Intel Xeon Phi) and international collaborations are discussed. We show many-core accelerated particle- and mesh-based simulation algorithms for astrophysics, some of them using hundreds to thousands of GPUs (approaching a million GPU cores) for one single application run in a parallel message passing environment, and give detailed timing models. Future perspectives for accelerated computing towards the Exaflop/s scale will be discussed. In some more detail our two main parallel GPU N-body codes using high order Hermite schemes (NBODY6++/GPU and phiGPU) will be presented and their future evolution (as far as not covered by individual contributions from our Silk Road team members in this conference). As astrophysical application some new results on the dynamics of multiple black holes in galactic nuclei and of central gaseous and stellar disks there will be shown.

Margaryta Sobolenko
Main Astronomical Observatory NASU, Ukraine
poster
title: Merging time for interacting galaxies with central post-Newtonian black holes
abstract: We present a set of, state of the art, large scale direct N-body simulations of the galaxy collision with the central Supermassive Black Hole system (SMBH). Each galaxy is represented as a set of particles (up to N=1M). The SMBH system is decribed using the two high mass special, i.e. "relativistic", particles. The interaction between these two particles have an extra post-Newtonian correction terms (PN) up to PN3.5 level. We conclude that our code correctly describes the behavior of the SMBHs mergers in galaxies. The obtained results are quite comparable with simplified method which include only the analytic description of Peters and Mathews (just 2.5PN term). We obtained the merging time upper bound for interacting galaxy NGC 6240.

Piera Soto King
Universidad de La Serena
poster
title: Tau-square fitting the Age and Distance of the Blanco 1 Open Cluster
abstract: In this work we seek to derive the age of the nearby and young open cluster Blanco 1. This solar metallicity cluster, is located far from the Galactic plane making it quite unusual and astrophysically interesting. The methods that we used to determinate the age of Blanco 1 employed color magnitude diagrams and various flavors of stellar evolution models. Initially, the data that we used are a suite of F- and G-star spectra, which were acquired using the low-resolution cassegrain spectrograph installed on the 1.9m Radcliffe telescope located at the South African Astronomical Observatory. Comparing optical photometry with spectral types, we hoped to derive reddening vectors to help us with the isochrone fitting of Blanco 1. However, magnetic activity on our target stars prevented us from completing this analysis. We instead used hot, higher-mass, early-spectral type stars in the cluster to derive its reddening vectors. To fit the distance we tried with the HIPPARCOS (209 pc) distance, that have no a good fit in the main sequence. On the other hand we found that the best fit is 240 pc by isochrones D'Antona & Mazzitelli (1997). Finally, isochrones generated from theoretical stellar models were compared to the clusters color magnitude diagrams, allowing us to estimate the distance-dependent age of Blanco 1. We find that its photometric age is 150 Myr, comparable to its lithium and gyrochronology age.

Matthew Taylor
Pontificia Universidad Catolica de Chile/ESO Santiago
talk
title: Observational Evidence for a Dark Side to NGC 5128's Globular Cluster System
abstract: Evidence for a new type of star cluster from the dynamical mass scaling relations of compact stellar systems (CSSs) will be presented, based on a study of 125 CSSs around the nearby giant elliptical galaxy NGC 5128, using high resolution spectra (R26000) obtained with VLT/FLAMES. All radial velocity (v_r) and line-of-sight velocity dispersion (σ_{los}) measurements are performed with the penalized pixel fitting (ppxf) technique. The (σ_{los}) estimates are corrected to the 2D projected half-light radii, ($\sigma_{1/2}$), as well as the cluster cores, (σ_0), accounting for observational/aperture effects and are combined with structural parameters in order to derive dynamical half-mass estimates ($M_{1/2}$), and total dynamical masses (M_{dyn}), for 116 CSSs around NGC 5128. In total, 93 CSSs have M_dyn measured for the first time along with the corresponding dynamical mass-to-light ratios (dyn). We find two distinct sequences in the dyn-Mdyn plane, which are well fit by power laws of the forms dyn $\propto M^{(}0.330.04)$ and ${}_dynM^{(}0.910.04)$. The shallower sequence corresponds to the very bright tail of the globular cluster luminosity function (GCLF), with indications for angular momentum content that increases with M_dyn. The steeper relation appears to be populated by a distinct group of objects with significant dark gravitating mass components, such as central massive black holes and/or exotically compact dark matter distributions. This result would suggest that the formation and evolution of these CSSs is markedly different from the classical globular clusters in NGC 5128 despite the fact that they have luminosities similar to the GCLF turn-over magnitude. After a thorough discussion of myriad factors potentially influencing our results, we also present evidence for a hyper-compact stellar system, consisting of an intermediate-mass black hole surrounded by a compact stellar population, similar to those that have been suggested to form in galaxy mergers. Lastly, we find three objects that show evidence of being, young, massive, open star cluster candidates, that are consistent with being formed in the last merging event of its host galaxy.

Maria Tiongco
Indiana University
poster
title: Lifetimes and kinematics of rotating star clusters in a tidal field
abstract: We have carried out a large survey of N-body simulations aimed at exploring the effects of rotation on the long-term dynamical evolution of star clusters in the tidal field of a galaxy. In this contribution we will present the results concerning the dependence of the cluster lifetime and the evolution of the cluster kinematical properties on the cluster structural properties and the strength of its initial rotation.

Edwin van der Helm
Leiden Observatory
talk
title: Creating Arches
abstract: I use AMUSE to simulate an embedded star cluster in a tidal potential, including stellar evolution and feedback, to investigate the creation and evolution of the Arches cluster near the Galactic center.

Anna Lisa Varri
University of Edinburgh, School of Mathematics
talk
title: Early evolution of rotating star clusters
abstract: An increasing number of young and intermediate age star clusters are being observed to have significant internal rotation. In this respect, it is crucial to understand the role of angular momentum during the initial stages of star cluster dynamical evolution. Driven by these motivations, I explored the dynamics of dissipationless collapse in the presence of non-vanishing initial angular momentum. I will present the results of an extended survey of N-body simulations, designed to investigate the early dynamical evolution of stellar systems starting from homogeneous and inhomogeneous initial density distributions with different amounts of total angular momentum. The structural, kinematical, and phase space properties of the systems resulting from such violent relaxation scenario will be described, with emphasis on the dynamical interplay between internal rotation and pressure support.

Vejar, Rodrigo
UdeC
poster
title:tbd
abstract:tbd

Villanova, Sandro
UdeC
talk
Title: Chemical constrains for Modeling Dense Stellar Systems
Abstract: Globular Clusters are recognized to host multiple stellar populations that were formed during the first millions of years of the cluster life. The exact mechanism that generated such a phenomenon is still debated, but detailed chemical abundances of the individual stars couppled with state-of-the-art evolutionary models can help to find an aswer. In this talk I will give a review ot the chemical patterns found in Galactic Globular Clusters, including Ruprecht 106, a relativelly massive cluster that show no presence of multiple populations, and Omega Centauri, the most complex cluster in the Milky Way, that shows many generations of stars with an age-spread of several Gyrs.

Joshua Wall
Drexel University
title: Modelling Massive Cluster Formation with Stellar Feedback using Flash and AMUSE.
abstract: We are developing a simulation of massive cluster formation using Flash and the AMUSE software environment. Flash handles the hydrodynamics of the gas and star creation through cloud collapse, and then the stellar dynamics are integrated with a fourth order Hermite scheme in AMUSE. Further stellar evolution is computed in AMUSE, and then radiative and SNE feedback information is computed in FLASH based on the stellar evolution. Gravitational interaction between the gas and the stars is handled via a symplectic gravity bridge between the codes in AMUSE.

Long Wang
Department of Astronomy at Peking University, Beijing, China
talk
Title: The million-body problem: hybrid parallel direct NBODY6++ simulations of globular clusters
Abstract: NBODY6 and NBODY6++ are well-known direct N-body codes for studying the dynamics of star clusters. In order to understand the evolution of massive globular clusters, it is important to study these objects the direct N-body method and to perform a comparison with theoretical models, Fokker-Plank methods, and Monte-Carlo methods. We have optimized the NBODY6++ code with hybrid parallel methods (MPI, GPU, OpenMP, and AVX/SEE) to solve the million-body problem. Here, we present the new features of the NBODY6++ code, benchmarks, as well as our initial simulation results of realistic globular clusters containing over a million particles.

Jeremy Webb
McMaster University
talk
title: The Orbital Anisotropy and Tidal Filling Profiles of Globular Clusters in Giant Galaxies
abstract: We compare the relationship between globular cluster effective radii rh and projected galactocentric distance Rgc for the cluster populations of M87, NGC 1399, and NGC 5128. Observations of all three galaxies find a shallower increase in rh with Rgc then predicted by basic tidal theory. To reproduce the relationship, we first model a globular cluster population in each galaxy that has an isotropic distribution of orbits and is tidally filling at all Rgc. We then explore the effects of either cluster orbits becoming more radial or clusters becoming less tidally filling with Rgc. Finally, we determine the combination of orbital anisotropy and tidal filling profiles that best reproduce the observed relationship between rh and Rgc in each galaxy and compare the results. We also explore the effects of orbital anisotropy and tidal filling on the metal-rich and metal-poor sub-populations of each galaxy.

Jincheng Yu
Pontificia Universidad Catlica de Chile
talk
title: Mass Segregation of Young Star Clusters
abstract: Mass segregation of the young star cluster is one of the dynamical properties which is an important tool to investigate the star forming process and dynamical evolution of star clusters. The origin of this mass segregation has been suggested as either primordial, that is, it is a result of the star formation process in which stars form mass segregated from their parent molecular cloud, or dynamical, i.e., resulting from fast dynamical evolution. Recent N-body simulations suggest initially dynamically cool and sub-structured star clusters can be mass segregated within very short timescale. However, the effects of different initial conditions are still not well understood. Therefore, we investigate the influence of different initial parameters to further constrain our theoretical model for young star clusters. We will show rapid dynamical mass segregation exist not only in low-mass star clusters but also the massive star clusters. In particular, we focus on the correlation between the fractality and the degree of mass segregation of the early evolution of young star clusters.

Peter Zeidler
ZAH/ARI, University of Heidelberg
poster
title: A Hubble Space Telescope multi-band survey with WFC3 and ACS of the young massive star cluster Westerlund 2
abstract: Westerlund 2 is one of the most massive compact young Galactic star clusters. It is the central ionizing cluster of the giant HII region RCW 49. The winds and energetic radiation of its more than eighty O-type stars have created a cavity around the cluster and are eroding the surrounding giant molecular cloud, creating complex structure of pillars and bright-rimmed filaments whose tails point away from Westerlund 2. We recently obtained deep broad- and narrowband Hubble Space Telescope ACS and WFC3 images of Westerlund 2 to explore the evolutionary history of the starburst cluster and its surroundings. Our spatially resolved extinction maps permit us to obtain color-magnitude diagrams with indvidual stellar dereddening, allowing us to infer the distance, age, and age spread of Westerlund 2 with unprecedented accuracy and to constrain the anomalous extinction in the region. We trace the prominent pre-main-sequence population of Westerlund 2 across a mass range of 0.5-11 solar masses. Some of those stars, including massive Herbig Ae/Be stars, exhibit considerable H alpha excess. The broad turn-on region towards the main sequence suggests an age spread of up to three Myr in Westerlund 2. Moreover, subclustering is visible in the region, and the data suggest a core-halo age gradient as found in other young clusters. We also analyze the mass function of Westerlund 2 and note that, just as in other similarly young massive compact clusters, mass segregation is already noticeable.

Zinnecker, Hans
SOFIA
talk
title:tbd
abstract: I think I was considering to discuss the orbital evolution of close binaries near the Galactic Center (Kozai effect). This could trigger a merger of the binary components.

ALICE ZOCCHI
UNIVERSITY OF SURREY
talk
title: "Pressure anisotropy in globular clusters"
abstract: Pressure anisotropy plays an important role in the dynamics of globular clusters, and it should be taken into account to properly describe these systems. To determine its importance in the different phases of the evolution of globular clusters, we analysed the results of numerical simulations, by means of isotropic and anisotropic dynamical models, with a discrete MCMC fitting technique (Zocchi et al., in preparation). Our results show that anisotropy originates in the early phases of the life of globular clusters, independently of their initial conditions, and for clusters located in an external tidal field it is erased completely in the final stages, just before the complete dissolution of the systems. We also show that it is crucial to consider the correct dynamical model, by taking into account the appropriate amount of anisotropy, in order to accurately determine the mass of the clusters and their structural properties. Moreover, we discuss the degeneracy between the feature generated by pressure anisotropy in the projected velocity dispersion profile and the one due to the presence of an intermediate-mass black hole in the center of the system.