Abstracts for

The Dance of Stars

Dense Stellar Systems from Infant to Old

MODEST 14

- poster presentations -

Name: Danor Aharon
Institution: Technion – Israel Institute of Technology

Title:

Star formation in nuclear clusters and the origin of the Galactic center apparent core distribution

Authors:

Danor Aharon & Hagai B. Perets

Abstract:

The observed core-like distribution of the old stellar population of red giants near the massive black hole in the Galactic Center (GC) poses a challenge for theories of evolution of stellar population in galactic nuclei. The dynamical relaxation of such systems is expected to give rise to a steep (Bahcall-Wolf) power-law cusp (n~ r^[-7/4]) distribution, inconsistent with the observations. Here we use Fokker-Planck calculations to study the effect of star formation on the evolution of the nuclear cluster stellar distribution. We show that the inclusion of several stellar populations, arising from star formation, could lead to the build up of a stellar core distribution of intermediate age stars (up to a few Gyrs old), similar to that observed for the red giants in the GC, while the older stellar population is relaxed in a typical cusp distribution. These results can reconcile the existence of an apparent core-like distribution, with the possible existence of an underlying cusp distribution for the old stellar population in the GC.

Name: Emiliano Alessandrini
Institution: University of Bologna

Title:

Dynamical Friction in multi-component Globular Clusters

Authors:

E. Alessandrini, B. Lanzoni, P. Miocchi, L. Ciotti

Abstract:

Within the context of the observed radial distribution of Blue Straggler Stars (BSSs) in globular clusters (GCs), we use direct N-body simulations to investigate the behaviour of the dynamical friction (DF) timescale in systems with a mass spectrum. We find that the trend of the DF timescale with distance from the centre is always monotonic. Hence, the observed bomodality in the BSS radial distribution cannot be explained by some non-monotonicity in this quantity. We also find that the presence of a mass spectrum increases the efficiency of segregation via DF, with respect to the case of a background made of equal-mass stars. Thus significant underestimates of DF can be introduced when modeling GCs as one-component systems.

Name: Pia Amigo
Institution: Universidad de Valparaiso

Title:

The G347.6+0.2 star forming region: Revealing starburst episodes beyond the Galactic Center

Authors:

Pia Amigo, Jura Borissova, Radostin Kurtev, Sebastian Ramirez-Alegria

Abstract:

The star forming region G347.6+0.2 is of particular interest because it is located at a distance of 8–9 kpc and may be located beyond the Galactic center. This represents an excellent opportunity to observe star formation at the far side of the bar. The star formation in the region may be triggered by the nearby young massive stellar cluster DBS2003 179. We present here the variability study of this field using near IR images from the Vista Variables in the Via Lactea Survey (VVV) to detect young stellar objects (YSOs) and to characterize the star formation in the region. We also discuss long-term project concerning the new sample of open clusters discovered by VVV, which aim to reveal the physical characteristics of the surrounding gas.

Name: Paulina Assmann
Institution: Universidad de Concepción, Chile

Title:

Post-Newtonian Dynamics of Black Holes with Spin in Star Cluster Simulations with NBODY6++

Author:

Paulina Assmann

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 simulate, 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. We will present results of this project.

Name: Tjarda Boekholt
Institution: Leiden Observatory

Title:

On the reliability of N-body simulations

Authors:

T. Boekholt and S. Portegies Zwart

Abstract:

The general consensus in the N-body community is that statistical results of an ensemble of N-body simulations are accurate, even though individual simulations are not. A way to test this hypothesis is to make a direct comparison of an ensemble of solutions obtained by conventional methods with an ensemble of true solutions. In order to make this possible, we wrote an N-body code called Brutus, that uses arbitrary-precision arithmetic. In combination with the Bulirsch-Stoer method, Brutus is able to obtain converged solutions, which are true up to a specified number of digits.
We perform 3-body simulations with conventional double-precision methods, and with Brutus; both have the same set of initial conditions and initial realisations. The ensemble of solutions from the conventional simulations is compared directly to that of the converged simulations, both as an ensemble and on an individual basis to determine the distribution of the errors.
We find that on average at least half of the conventional simulations diverge from the converged solution. For the solutions which have not diverged significantly yet, we observe that if the integrator is biased in energy and angular momentum conservation, that this will propagate to a bias in the statistical properties of the binaries. In the case when the conventional solution has diverged onto a different trajectory in phase-space, we find that the errors are centred around zero and symmetric; the error due to divergence is unbiased.
Furthermore, the statistics start to become accurate when the time-step parameter is smaller than 0.0625 and when simulations which violate energy conservation by more than 10% are excluded.
For resonant 3-body interactions, we can thus conclude that the statistical results of an ensemble of conventional solutions are indeed accurate.

Name: Lisa-Marie Browne
Institution: Centre for Astronomy, NUI Galway, Ireland

Title:

The Search for Optical Companions of Millisecond Pulsars in the Globular Cluster M22

Authors:

Lisa-Marie Browne, Navtej Singh, Ray Butler, Andy Shearer

Abstract:

To date over 144 pulsars have been found in 28 different globular clusters. The majority of these pulsars are millisecond pulsars (MSP). MSPs can be distinguished from other pulsars by their rapid spin and lower magnetic field strength (Bhattacharya 1996). The dense cores of globular clusters favour the formation of binaries, suitable for the recycling of neutron stars into MSPs through dynamical interactions. These binary systems can be characterised more accurately by searching for their optical companions in very high resolution optical images. Radio observations give information on the MSP, while optical observations of the companion star will provide information on the evolution and nature of the system. From these observations the mass of the companion and the mass of the MSP can also be determined. Such information would help in the understanding of how these systems form in extremely crowded environments. The globular cluster M22 contains two MSPs, PSR J1836–2354A (M22A) and PSR J1836–2354B, discovered by Lynch et al. (2011). M22A has been classified as being a black widow pulsar. Black widows are important as they represent one of the possible evolutionary fates of binaries. They are so named because they gradually destroy their companion; companion masses

Name: Anne Buckner
Institution: University of Kent

Title:

Scale Height Evolution of Open Clusters

Authors:

Anne Buckner, Dirk Froebrich

Abstract:

Star clusters act as tracers of stellar and Galactic evolution and are the building blocks of the Galaxy. As such it is important to determine how gravitational interactions, with e.g. GMCs and the Galactic tidal force (temporally and spatially) affect clusters. It is well documented that these interactions are a primary source for cluster disruption. Coupled with observational limitations, this means that the number of clusters observed in the solar neighbourhood decreases with increasing cluster age. For this reason, it has not been possible observationally to track in detail the evolution of cluster scale height, as restraints on current methods mean that they cannot be applied to small sample sizes. It is therefore desirable to have a reliable and robust method, which allows for a determination of the scale height of small cluster samples. In this talk we present our novel method to determine the scale heights of clusters using modelled distributions, significantly lessening the restraint on sample size. We show that we can determine the scale height with a better than 25% accuracy, for a sample size of 30 or larger. We successfully applied our method to investigate the temporal evolution of cluster scale heights, using data from the Kharchenko et al. (2013), Dias et al. (2002), WEBDA(*) and Froebrich et al. (2007) catalogues. Our detailed analysis establishes a relationship between scale height, Galactocentric distance and age of clusters. We find that scale height increases linearly with the Log(age) of clusters, with a marked change of gradient at 630 Myrs, the implications of which of we will discuss in detail. (*) http://www.univie.ac.at/webda/

Name: Rodrigo Contreras Ramos
Institution: Universidad Católica de Chile

Title:

Variables in the VVV globular clusters

Authors:

Javier Alonso-García, István Dékány, Mácio Catelan, Rodrigo Contreras Ramos, Pía Amigo & Felipe Gran

Abstract:

The VVV survey is observing the central regions of our Galaxy in the near-infrared, where the extinction is highly diminished, in several epochs. Numerous inner Galactic globular clusters fall inside the area covered by the VVV survey. Most of these clusters, especially the faintest ones, have been poorly studied due to the presence of severe extinction and high stellar densities in the field. We will present the first results of a search for variable stars we are conducting in these clusters. Our main aim is to obtain a better determination of the physical parameters of these globular clusters using the information provided by their variables.

Name: Julien Dorval
Institution: Strasbourg Observatory

Title:

Processing binary populations in star clusters

Author:

Julien Dorval

Abstract:

Binary stars play a dominant role in the spectroscopic properties of many systems, such as star clusters, galaxy mergers, starburst galaxies. This kind of population may be subject to internal evolution and to the influence of the surroundings. Recent studies show that binary populations as a whole may evolve through interaction with background stars (singles or binaries: Marks & Kroupa 2012, Kaczmarek et al, 2011). Here we argue that together with this evolution, the fate of the system itself will imprint the binary population. We investigate the influence of the global tidal field during the first million years of the cluster. We present a way to implement a self-consistent fragmented spatial mass distribution, from which we evolve a binary population. We find that tidal field have a stronger impact on wide binaries during the formation of massive clusters.

Name: Elena Gavagnin
Institution: University of Zürich

Title:

A critical look at the scenario of merging to explain the multiple populations

Authors:

Elena Gavagnin (Michela Mapelli and George Lake)

Abstract:

The origin of multiple populations in globular clusters (GCs) is still an enigma. Different scenarios have been proposed but none of them is able to explain all the observed features. In particular, it is not clear why the most metalpoor population is the more centrally concentrated in some GCs (e.g. NGC 1851), while it is the less centrally concentrated in other GCs (e.g. Omega cen). I performed new direct-summation N/body simulations of the merger between two star clusters, using the STARLAB software environment, and I will discuss how these simulations can reproduce some features of the observed radial distribution of multiple populations with different metallicity. The initial conditions were carefully selected to best represent the observed GC properties. The density profile of the merger remnant and the radial distribution of different stellar populations show a strong dependence on the structural parameters of the parent GCs, such as the relative number of stars, the central density and the initial virial radii. In contrast, the different metallicity of the two populations is not responsible for the different radial distribution. Finally, I will discuss the main issues of the merger scenario and whether this could actually represent a realistic perspective, apart from numerical models.

Name: Evert Glebbeek
Institution: Radboud University

Title:

Mergers in binary systems

Author:

Evert Glebbeek

Abstract:

I will present evolutionary calculations of mergers formed in binary systems and highlight how these are similar to mergers formed in direct collisions, and how they differ.

Name: Jaroslav Haas
Institution: Charles University in Prague, Faculty of Mathematics and Physics

Title:

Two body relaxation of stellar disc around a SMBH

Authors:

Jaroslav Haas, Ladislav Subr

Abstract:

Importance of two-body relaxation within a near-Keplerian stellar disc around a supermassive black hole (SMBH) will be discussed. Providing both analytical arguments as well as results from N-body integrations we will show that two-body relaxation may play an important role in formation of the disc radial density profile. Beside the general results, we will discuss this topic in the context of the system of young stars orbitting the SMBH in the Galactic Centre.

Name: Hosein Haghi
Institution: Institute for Advanced Studies in Basic Sciences

Title:

Testing modified newtonian dynamics with velocity dispersion profile of globular cluster NGC 2419

Author:

Hosein Haghi

Abstract:

Several studies have been made to discriminate between Newtonian dynamics and MOND using Galactic globular clusters (GCs) . The globular cluster NGC 2419 has recently taken much attention in this regard. In this presentation, we first investigate the effect of introducing the external field in the MONDian dynamics on the internal dynamics of GCs as a whole. Using N-MODY, which is a parallel particle-mesh code in three dimensions which has been developed by Ciotti et al. (2006) and Nipoti et al. (2007) for the evolution of collisionless N-body systems in either MONDian or Newtonian dynamics, we show that the general effect of the external field for diffuse clusters, which obey MOND in their most parts, is that it pushes the dynamics towards the Newtonian. Then we choose NGC 2419 to check the external field effect by finding the best-fit simulated model, having included the external field. By varying the cluster mass, half-light radius, and mass-to-light ratio we find a model which reproduces the observational data best. We find that even if we take the Galactic external field into account , models evolving on circular orbits and starting from a Newtonian Plummer sphere fit to the observational data better than MOND in terms of the total chi^2 of surface brightness and velocity dispersion.

Name: Seyed Mohammad Hoseini Rad
Institution: University of Birjand

Title:

The impact of galactic halo mass on the size scale of distant globular clusters

Authors:

Mohammad Hoseini Rad, Hosein Haghi, Akram Hasani Zonoozi, Malihe Rabiee

Abstract:

In the present work we show that how the structure of the host galaxy halo has a significant effect on the disruption rate and final size scale of embedded globular clusters using direct N-body modeling with N-body6 code. The aim is to find a relation between the final size scale of remote halo globular clusters as a function of galactic halo mass. All clusters evolve within a Hubble time in a cuspy (NFW) and a non-cuspy (logarithmic) potentials.

Name: Lucie Jilkova
Institution: Leiden Observatory

Title:

Multi-scale interaction in the system HD106906

Authors:

Lucie Jilkova and Simon Portegies Zwart

Abstract:

HD106906 is an unique star possessing both debris disk and planetary-mass companion. With the projected distance of about 650 AU, it is a system with one of the widest separation observed between the parent star and its planet. The system is also a member of the Lower Centaurus Crux stellar association. Using the Astrophysical Multipurpose Software Environment -- AMUSE -- we investigate the survival lifetime of the debris disk in the system and the possibility that the planet was captured from the surrounding stellar association.

Name: Dongming Jin
Institution: University of Texas at Brownsville

Title:

White Dwarf Binary Statistics in Globular Cluster Simulations by MOCCA

Authors:

Dongming Jin, Matthew Benacquista

Abstract:

The MOCCA code is one of the most advanced codes which has the capacity to simulate realistic sized star cluster with full dynamical history of the star evolution using Monte Carlo methods for star cluster evolution and a Fewbody code for scattering. White dwarf binaries are good candidates for a promising gravitational wave sources. Our work uses MOCCA to simulate 90 globular clusters of different number of stars, binary fraction, metallicity and initial mass function slope. After ruling out current non-existent models which evaporate before 9 Gyrs and uninteresting models that have a low number of white dwarf binaries, we do multiple runs of the remaining models for a Hubble time scale to get statistics on overall white dwarf binary populations of different component types and radios & orbital periods at a specified time range from 8 Gyrs to 10 Gyrs. We consider white dwarf binaries which exists within specified time range & Lagrangian radii range and have orbit periods in the scale up to days to be observable. Thus we set up a map of possible white dwarf binary detection rates for different types of globular clusters.

Name: Emil Khalisi
Institution: MPI for Nuclear Physics

Title:

How Simulations Reveal Features in the Rings of Saturn

Author:

Emil Khalisi

Abstract:

High resolution images by Cassini disclose "propeller"-shaped gaps in the rings of Saturn. These features reveal the gravitational influence of very small moonlets which are unresolvable to the camera.
Nbody simulations show that the propellers could be explained by the customary Keplerian shear: Faster particles drift passing the moonlet receive a drag to the moonlet's gravity, while the slower are kicked forward. However, the formation of propellers is prevented when the surface density exceeds a critical value (ca. 300 g/cm^2). For higher values of the surface density, gravitational wakes prevail and no propellers would form.
Such gravitational wakes are transient structures that resemble patterns of star clumps produced in a rotating Galactic disk characterized by the Toomre parameter.
In a forthcoming study our objective will be to perform simulations importing a more general case of the dynamical evolution of planetary rings.

Name: Igor Korsunov
Institution: Saint Petersburg State University

Title:

Evolution of OB associations in the Milky Way

Author:

Igor Korsunov

Abstract:

The evolution and kinematics of OB associations determine the spatial distribution and kinematics of OB stars and their progenies, neutron stars and stellar-mass black holes. Unfortunately, for the lack of observational data related to the low-mass component of OB associations and distribution of associations in the Milky Way, their kinematics is badly known. So, until the new high-precision observational data are obtained, simulation is one of the main sources of knowledge in the field. Our work is focused on the internal kinematics of OB associations in the gravitational field of the Milky Way. The evolution of association is modeled using existing codes for astrophysics simulations, coupled together by the AMUSE (Astrophysical Multipurpose Software Environment) framework. The evolution scenarios for OB associations with different initial conditions (mainly based on data for Sco OB2) are considered. Obtained kinematic and evolutional parameters for model associations are compared with the observational data.

Name: Richard Lane
Institution: Universidad de Concepcion

Title:

Globular clusters: tracers of galactic evolution and Lambda CDM

Authors:

Richard Lane, Ricardo Salinas, Tom Richtler, Lilia Bassino, Juan Pablo Caso

Abstract:

The globular cluster (GC) systems of isolated elliptical galaxies (IEs) have only recently begun to be studied in detail, and may exhibit morphological connections to the evolutionary histories of their hosts. In fact, evidence is mounting that the GC systems of massive galaxies in clusters are largely assembled by infall/accretion processes. IEs are their counterparts in low density environments and a comparison of their GC systems should directly highlight environmental effects. Are GCs the answer to unlocking the evolution of isolated galaxies? In addition, the GC systems of reasonably nearby galaxies are detectable out to large radii, making them useful tracers for producing dynamical models of their hosts. How much dark matter is contained within IEs? Very little it seems, at least in some cases. GCs are, therefore, also one of the most important tools we have for testing Lambda CDM models observationally.

Name: Michael Marks
Institution: Argelander Institut für Astronomie, University of Bonn

Title:

A Binary Population Synthesizer for Star Clusters

Author:

Michael Marks

Abstract:

Multiple stellar systems are a non-negligible constituent of most star clusters. Binary fractions range from below 10% up to 50% for dense globular clusters, and up to 70% for sparser open clusters and associations. While these numbers are comparatively easily accessible, the question of how their orbital parameters in terms of, e.g., their mass-ratio, separation and eccentricity are distributed is, in most cases, less clear. BiPoS1 is a new command-line tool to efficiently synthesize realistic binary populations for star clusters (and the Galactic field, too). It starts using a universal initial binary population, which matches pre-mainsequence constraints, and is then evolved through pre-mainsequence eigenevolution and stellar-density-dependent dynamical binary disruption. BiPoS1 calculates binary fractions and allows the extraction of orbital-parameter distributions for specific mass-ranges or spectral types, as well as for constraints on certain orbital-parameters. This makes straight-forward tests against observations possible. It can further be utilized to synthesize binary and single star populations for later use in numerical simulations of star clusters. The model used in BiPoS1 has been shown to match many constraints for young star formation regions and young clusters as well as the Galactic field. The code will be made publically available in an upcoming contribution (Marks, Pflamm-Altenburg & Kroupa). Contact Michael Marks (mmarks@astro.uni-bonn.de) to obtain your preliminary copy of BiPoS1.

Name: Yohai Meiron
Institution: KIAA, Peking University

Title:

Expansion Techniques for Collisionless Stellar Dynamical Simulations

Authors:

Yohai Meiron, Kelly Holley-Bockelmann, Rainer Spurzem and Baile Li

Abstract:

We present GPU implementations of two fast force calculation methods, based on series expansions of the Poisson equation. One is the Self-Consistent Field (SCF) method, which is a Fourier-like expansion of the density field in some basis set; the other 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 method and optimized for collisionless galactic dynamics, but while SCF is a "pure" expansion, MEX is an expansion in just the angular part; it is thus capable of capturing radial structure easily, where 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 ~ 0.15 seconds (depending on expansion cutoff), making simulations with as many as 10^8 particles fast on a comparatively small number of nodes.

Name: Maria Messineo
Institution: MPIfR, Bonn

Title:

Evolved massive stars in the G23.3-0.3 complex

Author:

Maria Messineo

Abstract:

In giant molecular clouds, the detection and characterization of evolved massive stars are crucial for mapping star formation from 3 to 30 Myr, and to locate stellar clusters and associations. I will give an overview of a multi-wavelength analysis of evolved massive stars discovered in the Galactic giant molecular cloud G23.3-0.3, which is at a likely distance of ~4.5 kpc (Messineo et al. ApJ, 708, 1241, 2010; A&A submitted). A number of 39 early-type stars (mostly evolved), a new luminous blue variable, and a few red supergiants were detected. Some of the massive stars are likely associated with supernova remnants W41, G22.7-00.2,and G22.7583-04917.

Name: Dominique M.-A. Meyer
Institution: Argelander Institut für Astronomie – University of Bonn

Title:

Predictions of the brightness of bow shocks of main sequence runaway massive stars

Authors:

Meyer D. M.-A., Mackey J., Langer N., Gvaramadze V. V., Mignone A.

Abstract:

We study the circumstellar medium of massive stars, and aim particularly at investigating the role and the effects of stellar motion on to the interstellar medium (ISM). The resulting nebulae are bow-shocks with observable characteristics that are determined by stellar properties such as the mass-loss rate and the wind velocity, but also by the ISM parameters such as its density. To this end, we ran a grid of models for 10, 20 and 40 M⊙ stars which move through the ISM and whose properties evolve at the same time. This wind-ISM interaction is modelled with various physical processes such as radiative cooling (Wiersma et al., 2011) and heating as well as electronic thermal conduction (Cowie et al., 1977) using the PLUTO MHD code (Mignone et al., 2006). The treatment of the dissipative processes discriminates fully ionised from partially neutral medium at low temperatures (T

Name: Paolo Miocchi
Institution: Università di Bologna

Title:

On the role of dynamical friction in shaping the BSS radial distribution

Author:

Paolo Miocchi

Abstract:

It was recently shown that Globular Clusters (GCs) can be grouped into different families on the basis of the radial distribution of Blue Straggler Stars (BSS), each family corresponding to increasing degrees of dynamical evolution, as marked by an increasing value of the radial position of the distribution minimum. This feature has been explained as due to dynamical friction (DF) affecting BSSs at progressively larger radial distances from the cluster centre. In this talk I present the results of a set of direct N-body simulations ran to more quantitatively study this phenomenon. I show that bimodal BSS radial distributions, similar to the observed ones, arise in these collisional simulations and I discuss the evolution of their shape in connection with the proposed relationship between the position of the minimum and the cluster dynamical age.

Name: Joel Pfeffer
Institution: University of Queensland

Title:

Contribution of stripped nuclear clusters to globular cluster and ultra-compact dwarf galaxy populations

Authors:

Joel Pfeffer, Brendan Griffen, Holger Baumgardt, Michael Hilker

Abstract:

We use the high-resolution Millennium II cosmological simulation combined with a semi-analytic galaxy formation model to predict the contribution of stripped nuclear clusters formed by the tidal stripping of nucleated dwarf galaxies to globular cluster (GC) and ultra-compact dwarf galaxy (UCD) populations of galaxies. We follow the merger trees of haloes in time and determine the absolute number and stellar masses of merging haloes. We assume at all times that nuclei contain a fixed fraction of the stellar mass of individual haloes and take the nucleation fraction of haloes from observations of galaxies in the present-day universe. Our results show that stripped nuclei follow a mass function N(M)~M^-1.7 in the mass range 2x10^6 < M/M_sun < 10^8, significantly flatter than found for globular clusters. The contribution of stripped nuclei will therefore be most important among high-mass GCs and UCDs. We find the number of stripped nuclei predicted to form for systems with the virial mass of the Milky Way agrees well with the number of massive globular clusters in the Milky Way which have a spread in heavy element abundances and therefore were likely formed inside a dwarf galaxy. In the Fornax cluster the rich globular cluster system of the central galaxy outnumbers the counts of stripped nuclei up to 10^7 M_sun, which is consistent with the notion by other works that most UCDs in clusters have a star cluster origin.

Name: Janati Tjibaria Pijloo
Institution: Radboud University Nijmegen

Title:

The initial conditions of Galactic globular clusters

Authors:

J.T. Pijloo, S.F. Portegies Zwart

Abstract:

We constrain the initial conditions of the Galactic globular clusters in mass and half-mass radius, which provides a starting point for future N-body calculations. To this end we have coupled the fast, parametrized star cluster evolution code EMACSS to a Markov Chain Monte Carlo code, providing a method to determine the distributions of probable initial conditions of observed star clusters.

Name: Sebastian Ramirez Alegria
Institution: Millennium Institute of Astrophysics

Title:

Mapping the young and obscured cluster population in the Milky Way

Authors:

S. Ramirez Alegria, J. Borissova, A. Herrero, A. Marín-Franch, R. Kurtev, A.N. Chené, P. Amigo, K. Rübke

Abstract:

Young massive clusters are key to map the Milky Way's structure, and near-IR large area sky surveys have contributed strongly to the discovery of new obscured massive stellar clusters. In this talk, I will present the latest results of two groups dedicated to the search and characterization of young massive clusters: the MASGOMAS group (IAC, Spain) using 2MASS and the Star Cluster Group at the Astronomy Institute of the Universidad de Valparaiso (Chile), using the ESO public survey VVV. Both groups use near-IR photometry (J, H, and Ks) to select young massive clusters candidates, but with different methods: visual inspection of the VVV false colour images (VVV group) and overdensities detection of OB-type star candidates, using a free reddening index and a searching algorithm (MASGOMAS group). For the most promising candidates, we proceed with a near-IR follow-up spectroscopy, which allow to carry out the spectral classification of the OB-type candidates. The latest cluster discovered by the MASGOMAS group is Masgomas-4, a double core cluster located at a distance of 1.9 kpc. The spectrophotometric data confirm a very young and massive stellar population, with a clear concentration of pre-main sequence massive candidates (Herbig Ae/Be) around one of the cluster cores. The presence of a surrounding H II cloud and the Herbig Ae/Be candidates indicate an upper age limit of 5 Myr. I will also present the physical characterization of VVVCL086 (Ramirez Alegria et al., 2013), discovered by Borissova et al (2011). According to individual distance estimates for two observed stars (spectral types O9 and B0V), this cluster is located at the far edge of the Galactic bar, at a distance of 11 kpc. We estimated a lower limit for the cluster total mass of (2.8*10^3) solar masses and we limited the age between 1.0 and 5.0 Myr.

Name: Steven Rieder
Institution: Kapteyn Instituut

Title:

Evolution of star clusters in an evolving galaxy

Authors:

Steven Rieder, Rob Crain, Tom Theuns, Joop Schaye, Simon Portegies Zwart

Abstract:

We simulate open star clusters embedded in a live galaxy. With AMUSE, we combine the tidal field obtained from an advanced hydrodynamical galaxy simulation to simulations of star clusters. We study the evolution and survivability of these clusters, depending on their location in the galaxy, and compare the results to observed open clusters.

Name: Liliana Elizabeth Rivera Sandoval
Institution: University of Amsterdam

Title:

The Faint Cataclysmic Variable Population of the globular cluster 47 Tucanae

Authors:

Liliana Elizabeth Rivera Sandoval, Maureen van den Berg, Craig Heinke, Adrienne Cool, Haldan N. Cohn, Phyllis M. Lugger

Abstract:

The star density in the cores of globular clusters (GC) can be up to 10 million times higher than the local star density. The resulting high interaction rates in GCs are ideal for studying exotic binary stars, such as cataclysmic variables, low-mass X-ray binaries and milli-second pulsars, and the effects of dynamical encounters on the stellar and binary population. We have obtained near-ultraviolet images of the nearby dense and massive globular cluster 47 Tuc with the Wide Field Camera 3 on the Hubble Space Telescope (HST). In combination with existing deep HST and Chandra X-ray data, we use these images to study the compact binaries in 47 Tuc. In this work we have focused on the population of accreting white dwarfs or cataclysmic variables (CVs). The new data allow us to obtain one of the deepest measurements of the globular-cluster CV luminosity function ever, down to Mv=11.6, and thus identify CVs at very low mass-accretion rates. I will discuss the results in the context of a comparison with the measured CV luminosity function in local space and with those of other GCs, like the core-collapsed globular cluster NGC6397.

Name: Dmitrij Semionov
Institution: Center for Physical Sciences and Technology

Title:

Stellar clusters through the veil of dust

Author:

Dmitrij Semionov

Abstract:

Proper determination of the main parameters of stellar populations is made difficult by intervening interstellar dust which is often interpenetrating young star complexes. We propose a new interactive procedure for gradual refinement of stellar population parameters derived by using synthetic stellar populations and 3D distribution of interstellar dust. We demonstrate capabilities of the method by reconstructing dust cloud structures in front of star clusters observed in the Milky Way.

Name: Alessandro Alberto Trani
Institution: SISSA - International School for Advanced Studies

Title:

The interplay of stellar evolution and dynamics in young star clusters at different metallicities

Authors:

Alessandro Alberto Trani, Michela Mapelli, Alessandro Bressan

Abstract:

We have run direct N-body simulations to investigate the impact of stellar evolution and dynamics on the structural properties of young massive (~10^4 Msun$) star clusters (SCs) with different metallicities (Z=1, 0.1, 0.01 Zsun). Metallicity drives the mass loss by stellar winds and supernovae, with SCs losing more mass as their metallicity increases. We adopt three sets of initial conditions, with different initial relaxation timescale. We find that the evolution of the half-mass radius of SCs depends on the dominant process that heats the SCs. If stellar mass loss is the dominant process, metal-rich SCs expand more than metal-poor SCs. In contrast, when binary hardening is dominant, the half-mass radius of metal-poor SCs grows faster than that of metal-rich SCs. These behaviors depend on how the relaxation timescale and the timescale of stellar evolution compare. In our simulations, we also find core radius oscillations, which grow in number and amplitude as metallicity decreases. We argue that this is due to the higher maximum remnant mass in low-metallicity SCs.

Name: Maureen van den Berg
Institution: University of Amsterdam

Title:

Interacting binary populations in old open and globular clusters as seen by Chandra

Author:

Maureen van den Berg

Abstract:

Chandra observations of globular clusters have uncovered hundreds of interacting binaries. Correlations of the number of binaries of a specific type with cluster parameters (mass, encounter rate) have provided observational keys to their formation history: quiescent low-mass X-ray binaries are created in dynamical interactions, the relatively ordinary magnetically-active binaries (ABs) are thought to be mainly primordial, and cataclysmic variables (CVs) appear to be a mix of primordial and dynamically-formed populations. At the same time, a detailed comparison between the X-ray source populations in a few globular and old (> 4 Gyr) open clusters has shown that there is a relative dearth (per unit mass) in globulars of CVs and ABs. I will review what we have learned from a comparison of open and globular clusters, and show new results from some of the deepest Chandra globular-cluster observations, and from our ongoing Chandra survey of some of the oldest open clusters.

Name: Edwin van der Helm
Institution: Leiden Observatory

Title:

The orbit of HLX-1

Authors:

Edwin van der Helm, Simon Portegies Zwart, Onno Pols

Abstract:

The X-ray source HLX-1 is currently the best intermediate mass black hole candidate. It is often assumed that the black hole accretes gas from a stellar companion orbiting it on a highly eccentric orbit. Using AMUSE, I have coupled stellar evolution and SPH simulations to study the orbital evolution of this system and it's mass transfer. I will present results concerning the (lack of) stability of this system, which trigger exciting questions on the possible origin of the HLX-1 system.

Name: Anna Lisa Varri
Institution: University of Edinburgh

Title:

Dynamical Instabilities in Differentially Rotating Stellar Systems

Authors:

A. L. Varri, E. Vesperini, S. L. W. McMillan, G. Bertin

Abstract:

We present the results of a survey of N-body simulations designed to investigate the stability properties of a family of self-consistent axisymmetric stellar dynamical models, characterized by the presence of differential rotation. Slowly rotating configurations are found to be dynamically stable and they are particularly suited for the description of rotating Galactic Globular Clusters. New dynamical instabilities are observed in equilibria in the strong differential rotation regime. Such instabilities are dominated by coherent global modes with azimuthal number m = 1,2. For the relevant unstable modes, corotation occurs inside the rotating configuration. Such instabilities show striking similarities with the dynamical instabilities observed in differentially rotating fluid polytropes. This result represents a first step in the investigation of the analogies between stellar and fluid rotating spheroidal systems in a regime currently unexplored.

Name: Anna Lisa Varri
Institution: University of Edinburgh/Indiana University

Title:

Early Evolution of Rotating Star Clusters

Authors:

A. L. Varri, E. Vesperini, M. Tiongco, S. L. W. McMillan, C. M. Gosmeyer

Abstract:

An increasing number of young 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, we explored the dynamics of dissipationless collapse in the presence of non-vanishing initial angular momentum. We present here the preliminary 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 and kinematical 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.

Name: Smriti Vats
Institution: Anton Pannekoek Institute for Astronomy, University of Amsterdam

Title:

X-Ray source populations in old open clusters: Collinder 261

Authors:

Smriti Vats, Maureen van den Berg, Rudy Wijnands

Abstract:

We are carrying out an X-ray survey of old open clusters with the Chandra X-ray Observatory. Single old stars, being slow rotators, are very faint in X-rays ($Lx < 1 \times 10^{27}$ erg s^{-1}). Hence, X-rays produced by mass transfer in Cataclysmic Variables (CVs), or by rapid rotation of the stars in tidally-locked, detached binaries (Active Binaries, ABs), can be detected, without contamination from single stars. By comparing the properties of various types of interacting binaries in different environments (the Galactic field, old open clusters, globular clusters) we aim to study binary evolution and how it may be affected by dynamical encounters with other cluster stars. Stellar clusters are good targets to study binaries, as age, distance, chemical composition, are well constrained. Collinder (Cr) 261 is an old open cluster (age ~ 7Gyr), with one of the richest populations inferred, of close binaries and blue stragglers of all open clusters, and is therefore an obvious target to study the products of close encounters in open clusters. We will present the first results of this study, detailing the low-luminosity X-ray population of Cr 261, in conjugation with other open clusters of our survey (NGC 188, Berkeley 17, NGC 6253, M67, NGC 6791), and in comparison with populations in globular clusters.

Name: Kirsten Vincke
Institution: MPIfR

Title:

Influence of the cluster environment on forming planetary systems

Authors:

K. Vincke, A. Breslau, S. Pfalzner

Abstract:

Most stars did very likely not form in isolation, but as part of a stellar cluster. The question arises, how and to what degree such a dense stellar environment might have influenced the protoplanetary disc for those stars. Our own Sun is no exeption, it was very likely born in a stellar cluster and underwent an encounter which changed the properties of the young Solar System. Indications for such an encounter are (i) the highly eccentric orbits of trans-Neptunian objects like Sedna and the recently discovered 2012 VP113 and (ii) the significant drop in surface density outside Neptune's orbit, creating a "sharp edge" of the Solar System. Here we concentrate on the latter, investigating the size of protoplanetary discs after encounter events. We use an extensive data set of disc sizes based on simulations covering a wide space of encounter parameters. This is applied to Nbody simulations of stellar clusters – taking the Orion Nebula Cluster (ONC) as a model. As observations find clusters with various densities, we additionaly simulated density-scaled versions of the ONC. The influence of these distinct environments onto protoplanetary discs will be discussed. Furthermore, we show that disc-size changing encounters are common events in stellar clusters, irrespective of their density, as most stars undergo at least one such encounter within the first 5Myr of cluster evolution.

Name: Thomas Wijnen
Institution: Radboud University Nijmegen

Title:

How efficient is accretion onto a protoplanetary disc?

Authors:

T.P.G. Wijnen, O. Pols ,S. Portegies Zwart, E. Glebbeek

Abstract:

The recent observations that Globular Clusters (GCs) harbour multiple stellar populations are hard to reconcile with the classic picture of GCs, which approximates them as a single generation of stars. However, Bastian et al. recently suggested an evolutionary scenario in which a second population is formed by the accretion of enriched material onto the low-mass stars in the initial GC population. The idea is that the low-mass, pre-main sequence stars sweep up gas expelled by the more massive stars of the same generation into their protoplanetary disc as they move through the cluster centre. Using hydrodynamic models and assumptions that represent the conditions in a typical GC, we investigate whether a low-mass star surrounded by a protoplanetary disc can accrete sufficient enriched material to account for the observed abundances in ‘second generation' stars. In particular, we focus on the lifetime and stability of the disc and on the accretion rate onto both the star and the disc.

Name: Brunetto Marco Ziosi
Institution: University of Padova

Title:

Influence of dynamics and metallicity on the formation and evolution of black-hole binaries in star clusters

Authors:

Brunetto Ziosi, Michela Mapelli, Marica Branchesi

Abstract:

We study the formation and dynamical evolution of black hole-black hole binaries in young intermediate-mass star clusters, by means of N-body simulations. The simulations include metallicity-dependent recipes for stellar evolution and stellar winds. Following recent theoretical models of wind mass-loss and core-collapse supernovae, we assume that the mass of the stellar remnants depends on the metallicity of the progenitor stars. We find that gravitational three-body encounters dominate the formation and evolution of BH-BH binaries. In particular, the vast majority of BH-BH binaries form through dynamical exchanges. The rate of formation of BH-BH binaries (~0.04 Myr^-1 per star cluster) is ~2 orders of magnitude higher than the formation rate of NS-NS binaries, because dynamical exchanges enhance the formation of massive BH-BH binaries, while they suppress the formation of lighter binaries.