Massive Stars and the Gaia-ESO Survey

Brussels, Belgium, 5-7 May 2015

GREAT Workshop

Massive Stars and the Gaia-ESO Survey

Brussels, 5 – 7 May 2015

Abstracts

EUROPEAN SCIENCE FOUNDATION

FREEDOM TO RESEARCH

Session 1: Gaia and GES

Status of the Gaia-ESO Survey

Sofia Randich INAF-Osservatorio Astrofisico di Arcetri, Firenze, Italy

The Gaia-ESO Survey has now completed 35 observing runs for a total of almost 200 nights. Several thousand spectra of open cluster targets, MW field stars, and calibrators have been collected, processed, and analyzed. The talk will provide a progress update, including all the different survey aspects, as well as a few scientific highlights.

GES-WG13: OBA star spectrum analyses

Ronny Blomme Royal Observatory of Belgium

Within the Gaia-ESO Survey, Workgroup 13 is responsible for the analysis of the O-, B- and A-type spectra. I will explain the organization of this workgroup, and what it is expected to deliver. Data are analyzed in subsequent data releases. Various groups analyze the data independently, and a homogenization process is then applied to derive a set of recommended parameters for each star. I will also discuss some of the problems and challenges encountered in this work.

Observational planning and spectral classification

Jesús Maíz Apellániz Centro de Astrobiología (CSIC-INTA), Madrid, Spain

The Carina Nebula is the OB association within 3 kpc with the largest number of O stars and, for that reason, it was selected to be observed within the Gaia-ESO survey. In this talk I will describe the planning of the observations and the issues related to the subtraction of the nebular component in the data. I will also present the spectral classification of the stars already observed and discuss future plans.

Automated spectra analysis for a large sample of stars

Joachim Bestenlehner Max Planck Institute for Astronomy, Heidelberg, Germany

Gaia-ESO provides a large sample of stars with medium and high resolution spectra. The challenge is to develop a spectroscopic analysis method, that can keep up with the cycle of the data releases. The presentation will be about techniques, that can help to achieve such an ambitious goal.

Grid Search in Stellar Parameters GSSP code: a state-of-the-art software for the analysis of high-resolution stellar spectra

Andrew Tkachenko KULeuven, Belgium

Nowadays, detailed analysis of stellar spectra becomes the main source of accurate fundamental atmospheric parameters and chemical compositions of stars accross the entire HR-diagram. The observed spectrum of a star comes from its atmosphere, the behaviour of which is controlled by the density of the gases in it and the energy escaping through it. These in turn depend on the mass and age of the star, thus stellar atmospheres are the connecting links between the observations and the rest of stellar astrophysics.

We present the Grid Search in Stellar Parameters (GSSP) Fortran 90 code, which makes use of an open source Message Passing Interface (Open MPI) implementation to provide effecient determination of accurate atmospheric parameters and individual abundances from stellar spectra. The method is based on a grid search and finds the optimum values of the effective temperature, surface gravity, microturbulent velocity, metallicity, and projected rotational velocity from the minimum in chi2 obtained from a comparison of the observed spectrum with the synthetic ones computed from all possible combinations of the above mentioned parameters. The errors of measurement (1-sigma confidence level) are calculated from the chi2 statistics using the projections of the hypersurface of the chi2 from all grid points of all parameters onto the parameter in question. In this way, the estimated error bars include any possible model-inherent correlations between the parameters. The code has several modules and is applicable to spectra of both single and multiple star systems.

Session 2: Spectral analysis of massive stars

Spectral analysis of A-type stars in the GES

Alex Lobel Royal Observatory of Belgium

We present a brief overview of ongoing research work with spectra of A-type stars observed for the Gaia-ESO Survey. The spectra are being observed for Working Group 13 (OBA Star Spectrum Analyses) primarily in a number of selected galactic (massive) young open clusters. A number of nodes of WG13 have so far provided astrophysical parameters (APs) of A stars from Giraffe and UVES spectra. We present first results of an analysis of 200 A- and late B-type iDR3 Giraffe spectra observed in NGC 3293 & NGC 6705, and 70 iDR4 UVES spectra in NGC 2516, NGC 2547, NGC 6530, NGC 6633, & NGC 6705. We highlight the importance of astrophysical microturbulence (Vmic) in stellar atmosphere models for determining reliable APs. We observe maximum Vmic-values (4-5 km/s) around the mid-A type stars. We discuss the correlation between the maximum convective energy flux at the top of the convection zone in the 1-D ATLAS models and the maximum Vmic-values in our sample.

The A stars abundance patterns in open clusters and constraints on current evolutionary models

Richard Monier Université de Nice and LESIA Observatoire de Meudon, France

I shall briefly review the current state of abundance determinations of A and F dwarfs in a few open clusters of various ages. Within a given cluster and for most chemical elements, the abundances of the A stars usually display much larger star-to-star differences than the F stars do. This is surprising as these stars were all born from the same initial material and indicates that various transport processes are probably at work in the envelopes of the A stars. Radiative diffusion alone does not seem to account for the large scatter found. I will also discuss the available evolutionary models including transport processes and the comparison of the predicted abundances to the ones derived from high resolution spectroscopy.

Fundamental parameters and chemical abundances of B and A stars in open clusters

Marwan Gebran Notre Dame University - Louaize, Lebanon

In this work we investigate the use of the Principal Component Analysis (PCA) technique as a tool to derive fundamental parameters such as the effective temperature, surface gravity, equatorial rotational velocity and metallicity of B and A stars. Databases were constructed using Kurucz LTE model atmospheres for stars having temperatures between 6000 and 15000 K and surface gravities between 3.0 and 5.0 dex. Rotational velocities are varied between 0 and 150 km.s^{-1}. The spectrum synthesis code SYNSPEC48 was used in order to compute a large grid of synthetic Balmer and metallic lines. The procedure was applied to a large number of spectra member of NGC3293, NGC6705, and Trumpler 14. The PCA technique appears to be very efficient when dealing with large data such as GES. New routines are being implemented to test the effect of the metallicity.

Spectral analysis of B-type stars in the GES

Thierry Morel Université de Liège, Belgium

We review the results of the spectroscopic analysis of the B stars observed in the framework of the Gaia-ESO survey, with an emphasis on the homogeneous determination of the stellar parameters and chemical abundances in the two young open clusters NGC 3293 and Tr 14.

The evolution of chemically peculiar stars

Martin Netopil Masaryk University, Brno, Czech Republic

Chemically peculiar (CP) stars are characterised by a wide variety of element abundance patterns. They display abundance peculiarities of various chemical elements from helium to mercury in their photosphere. These are explained by diffusion processes driven by the competition between radiative levitation and gravitational settling. Current estimates suggest that about 15 per cent of all stars in the corresponding spectral range (B to F-type) belong to the various CP groups. The Delta-a photometric system allows to detect a large percentage of the magnetic CP stars and we will present their evolutionary properties based on our photometric survey of about 90 open clusters. Furthermore, we will present the detection of the first pre main-sequence Am star, and we will discuss the limitations of the Delta-a survey and the contribution of the Gaia-ESO Survey to the research field of CP stars.

Stellar Parameters of red giants: a new flavour of the StePar code

Hugo Tabernero Universidad de Alicante, Spain

During this talk, I will introduce a new version of the code StePar (Tabernero et al. 2012) for determining stellar atmospheric parameters (Teff, logg, and [Fe/H]) in an automated fashion. This new flavour of StePar employs the last version of the SPECTRUM code (Gray and Corbally 1994, version v276f) and the ATLAS-APOGEE grid of Kurucz ATLAS9 plane-parallel model atmospheres (Kurucz 1993, Meszaros et al. 2012). The atmospheric parameters are obtained by fitting of 97 Fe I-II lines (compiled from Santos et al. 2004, Hekker and Melendez 2007, Bergemann et al. 2012, and Tsantaki et al. 2013). The code evaluates the chi squared of each synthetic spectra to find the best solution within the paramater-space. The original version of StePar used EWs to derive the stellar atmospheric parameters, however it was limited to slow rotating stars (namely vsini < 15 km/s), to certain spectral types (F6-K4), and to S/N $>$ 20-30. This new version is able to overcome the constraints of the older one. In particular I will explain how stellar atmospheric parameters for the red giant stars in NGC 6067 were derived. In addition I will show some stress-tests against the benchmark stars of the GAIA-ESO survey (Jofre et al. 2014, Blanco-Cuaresma et al. 2014).

Spectroscopic study of NGC 6067

Javier Alonso Universidad de Alicante, Spain

NGC 6067 is a rich, (moderately) young open cluster. With an age about 100 Ma, it is representative of an age range not covered by the GES survey. It hosts a very rich population of evolved stars, including two classical Cepheids and a large number of very massive red giants. These properties make this cluster one of the best laboratories in the Galaxy to study the evolution of intermediate-mass stars. In addition, it may provide us an excellent testbed to gauge the relative calibration of metallicity scales used for modelling of early and late-type stars.

Spectrum analysis for early B-type stars: stellar parameters and abundances

Maria Fernanda Nieva Dr. Remeis Sternwarte Bamberg, Germany

Reducing statistical and systematic uncertainties in stellar parameter and chemical abundance determinations of early B-type stars has been possible thanks to both the construction of robust model atoms for non-LTE line-formation calculations and a novel self-consistent spectral analysis methodology. The method was extensively tested and applied to high-quality spectra of stars from OB associations and the field in the solar neighborhood, covering a broad parameter range. The results, of unprecedented precision and accuracy, allowed us to contrast at high detail quantities derived from observed spectra and model predictions of a variety of fields, and consequently learn about the nature of stars and our Galaxy in much more detail than in previous published work. However, our analysis methodology is quiet time consuming and partially requires interactive work. We made efforts to automatize the technique in order to analyze larger star samples. I will discuss some ideas about how to contribute to the spectral analysis of large samples, like that of the ESO-GAIA survey based on what we have learned from previous work.

Companions and Clusters: X-ray Certified

Nancy Evans SAO, Cambridge, USA

B stars evolve into Cepheids (typically 6 Msun), which provide several approaches to determining their binary/multiple properties. We will discuss results from radial velocities and high resolution imaging. X-ray flux provides a decisive diagnostic to separate old low-mass field stars from young low mass stars which were formed at the same time as massive stars. This lets us investigate two questions, resolved companions and larger stellar groups ranging from clusters to association remnants. Specifically we have observed a number of possible resolved companions identified from an HST survey with XMM. X-ray detected young low mass stars are all found within 4000 AU of the Cepheid, establishing an outer limit for gravitationally bound companions. We have also observed a small sample of Cepheids both with and without known cluster membership. Among the results is the identification of low mass members of the recently identified cluster containing S Mus, as well as possible sparse cluster remnants around several other Cepheids.

Evolved massive stars in W33 and in GMC 23.3-0.3

Maria Messineo Max-Planck-Institut für Radioastronomie, Bonn, Germany

We have conducted an infrared spectroscopic survey for massive evolved stars and/or clusters in the Galactic giant molecular cloud G23.3-0.3 and W33. A large number of extraordinary sub-clumps/clusters of massive stars were detected. The spatial and temporal distribution of these massive stars yields information on the star formation history of the clouds.

In G23.3-0.3, we discovered a dozen massive O-type stars, one candidate luminous blue variable, and several red supergiants. The O-type stars have masses from 25 to 50 Msun and ages of 5-8 Myr, while the RSGs belong to a burst that occurred 20-30 Myr ago. Therefore, GMC G23.3-0.3 has had one of the longest known histories of star formation (20-30 Myr). GMC G23.3-0.3 is rich in HII regions and supernova remnants; we detected massive stars in the cores of SNR W41 and of SNR G22.7-0.2.

In W33, we detected a few evolved O-type stars and one Wolf-Rayet star, but no late-types meet the luminosity of a red supergiant. While our detections of massive evolved stars in W33 are found on the west side of the cloud, Immer et al. (2014) detected several dense molecular cores (prestellar cores) only on the east side of the cloud. W33 is characterized by discrete sources and has had at least 3-5 Myr of star formation history, which is now propagating from west to east.

Rotation & rotational mixing in massive stars

Alex de Koter Anton Pannekoek Institute for Astronomy, The Netherlands

Modern theories of massive star evolution consider effects of rotation. Stellar spin impacts the rate of loose mass and angular momentum, prolongs the main sequence lifetime, modifies the surface chemical profile, and in extreme cases causes chemically homogeneous evolution. I discuss observational constraints on the spin distribution of presumed single O and early B stars, as well as that of O star primaries in binary systems observed in the context of the VLT-FLAMES Tarantula Survey (VFTS; Evans et al. 2011).

The surface nitrogen abundance versus projected spin rate diagram (or Hunter diagram; Hunter et al. 2008) as a calibrator of the mixing efficiency and at the same time tests our ideas about rotational mixing. Interestingly, the Hunter diagram for B dwarfs has revealed groups of massive stars that are not in accord with our ideas about rotational mixing. The nature of these anomalous groups is currently being debated. I present the Hunter diagram for the O type stars analyzed in the VFTS, adding the most massive stars to this test of the physics of rotation in stellar evolution.

Spectral analysis of O-type stars in the GES

Artemio Herrero Instituto de Astrofísica de Canarias, Spain

We present the results of our analyses of O-stars within GES. Analyses were carried out following different approaches to try to determine the main uncertainties. With the final adopted parameters we construct the HRD of Tr14 and compare it other regions in the Milky Way.

O and early B stars in the GES analysed by CMFGEN

Laurent Mahy Université de Liège, Belgium

Several O-type and early B-type stars located in Trumpler 14 have been observed by Giraffe and UVES in the framework of the Gaia-ESO survey. We have investigated them with the CMFGEN atmosphere code to determine their fundamental parameters and their abundances. We will discuss the results and compare them to other previous studies on massive stars obtained from CMFGEN.

The IACOB project: a new era in the study of Galactic massive stars

Sergio Simón-Díaz Instituto de Astrofísica de Canarias, Spain

The IACOB project is an ambitious long-term project which is contributing to the new era of investigation of massive stars by concentrating on Galactic OB stars. In particular, the project aims at building a large database of high-resolution, multi-epoch, spectra of Galactic OB stars, and the scientific exploitation of the database using state-of-the-art models and techniques. The main drivers of the project are:

(1) to increase the statistics of Galactic OB stars with accurate physical parameters and abundances,

(2) to investigate in detail some of the still open questions in our knowledge of the physical properties and evolution of massive stars (e.g., the actual masses of these stars, the nature of the O Vz stars, the driving mechanism of stellar winds in the weak wind regime, the uncertain stage of B supergiants in an evolutionary context, the actual rotational velocities of massive stars, the physical origin of the macroturbulent broadening, and the impact of rotation/binarity/pulsations on the evolution of massive stars), and

(3) to provide an unique ground-based spectroscopic database supporting/complementing the future Gaia database.

In this talk I will briefly introduce the IACOB project, the associated IACOB spectroscopic database and I will highlight the main scientific results obtained up to date. I will end my talk remarking the synergies between the IACOB project, the Gaia-ESO survey, and future studies of massive stars using data from Gaia mission.

Tarantula Surveys with VLT-Flames, Hubble and Gaia

Danny Lennon ESAC, Madrid, Spain

Modeling the spectra of Wolf-Rayet and other hot massive stars

Andreas Sander Institute for Physics and Astronomy, Potsdam, Germany

The spectra of Wolf-Rayet (WR) stars are dominated by strong emission lines originating in their strong stellar wind. The proper modeling of such expanding stellar atmospheres is a formidable problem. The radiative transfer must account for the supersonic expansion, and for strong deviations from local thermodynamical equilibrium (LTE). This non-LTE problem implies the need for solving the equations of statistical equilibrium for the population numbers. Simplifying assumptions, such as spherical symmetry and stationarity, are inevitable.

Despite of these approximations, the few sophisticated stellar atmosphere codes which exist are capable of reproducing the observed spectra of Wolf-Rayet stars quite well. Some insights into the physics of radiation-driven mass loss has been gained, but important questions have still to be settled. The quantitative analysis of the WR spectra forms the empirical basis to put these stars and their different subclasses into the context of massive-star evolution.

The Potsdam group has developed the "Potsdam Wolf-Rayet" (PoWR) model atmospheres for hot stars with winds (specytral types WR, O and B) and provides extensive grids of models via the web. This talk will give an overview about the Wolf-Rayet spectra, their modeling, and their quantitative analysis. The comprehensive studies of the Galactic WR population will be briefly reviewed. A major uncertainty in these studies is inferred by the distance which is often poorly constrained.

Studies of WR stars in nearby galaxies have prompted questions to whether we really know "our" Galactic WR stars as good as we thought. Gaia is expected to improve, or possible revolutionize, our yet incomplete understanding of these important building blocks of the galactic evolution.

Mass-loss rates of massive stars with GES

Jorick Vink Armagh Observatory, Northern Ireland

Stellar winds are of key importance for massive star evolution modelling. However, there are many uncertainties in the mass-loss rates of massive stars, for instance due to the issue of wind clumping. In this talk, I will discuss how one can calibrate wind mass-loss rates using data from spectroscopic surveys, such as VFTS and GES.

Session 3: Massive star evolution

Stellar evolution of massive stars

Sylvia Ekström University of Geneva, Switzerland

Modelling the evolution of massive stars is a challenge: such extreme objects react very strongly to the input physics used to model them. Slight changes of prescriptions can make the tracks diverge, especially after the main sequence, when the stellar structure becomes less trivial. I will present the main physical inputs governing the evolution of massive stars and show how the different ways to implement them lead to very different results. Mass loss, rotation, convection are for the moment impossible to implement in 1D codes from first principles. One has to rely on empirical prescriptions or on theoretical development that need to be calibrated at some point. The choice of one or another prescription, the different ways the calibrations are performed explain the large variations between the different models proposed on the market. Only large surveys, as the GES one, will allow a significant statistics that will help modellers constrain their models and choose the correct physics to apply.

Instabilities induced by element accumulation inside A and B stars: their internal structure and evolution revisited

Morgan Deal and Sylvie Vauclair Université de Montpellier, France & IRAP, Toulouse, France

Standard studies of the internal structure and evolution of A and B stars, even when they include atomic diffusion, forget an important hydrodynamical process induced by local element accumulation, namely "fingering convection". This is a double-diffusive instability similar to the "thermohaline convection" which occurs in the ocean. Computing this effect in stars needs precise computations of the radiative accelerations on each element, coupled with the induced hydodynamical instabilities. At the present time, only one stellar evolution code can tackle this process in a consistent way, the TGEC (Toulouse Geneva Stellar Evolution Code). 3D numerical simulations of the coupling between local element accumulation and the induced instabilities have been performed in collaboration with the group of applied mathematics of the university of Santa Cruz (California). A 1D parametrisation of the effect has been deduced from these simulations and introduced in the TGEC. Detailed results will be showed for one case, that of 1.7 Msun models. Studies of the internal structure and evolution of these types of stars, and comparison with the observations should always include these effects in the future.

Effects of mass loss on the evolution and death of massive stars

Jose Groh University of Geneva, Switzerland

Mass loss is well known to have a significant effect on the evolution of massive stars and their observational appearance. Our understanding of different classes of massive stars is often built by comparing evolutionary models and observations. However, this comparison is far from trivial, in particular when the effects of mass loss are significant. To tackle this problem, we recently combined stellar evolution calculations using the Geneva code with atmospheric/wind CMFGEN models. For the first time, we determined the interior and spectroscopic evolution of a massive star from the zero-age main sequence (ZAMS) to the pre-supernova (SN) stage. In this talk, I will show our latest results on the spectroscopic evolution of massive stars, the lifetimes of the different spectroscopic phases (O-type, LBV, WR), and how they are related to evolutionary phases (H-core burning, H-shell burning, He-core burning). I will also discuss how mass loss on the last stages of massive star evolution can be quantitatively determined by modeling SN spectrum taken within a day of explosion, when the pre-explosion wind of a massive star has not yet been overrun by the SN shock front.

On the evolution and remnants of massive single and binary stars

Ilka Petermann Université de Liège, Belgium

The final fate of massive stars, the type of explosion and the remnant they leave behind, is mostly governed by the masses of their helium cores and hydrogen envelopes in the latest stages of evolution. While for single stars wind mass loss is the only channel to reduce their mass, stars that are a member of a binary system are also assumed to loose their hydrogen envelope due to Roche lobe overflow or a common envelope phase after core hydrogen burning. We aim at assigning the ZAMS masses of stars in the range 15-45 solar masses to their remnant masses and in quantifying their compactness predict their most likely remnants, neutron stars or black holes.

New PARSEC evolutionary tracks of massive stars at low metallicity: testing canonical stellar evolution in nearby star-forming dwarf galaxies

Jing Tang SISSA, Italy

We extend the PARSEC library of stellar evolutionary tracks by computing new models of massive stars, from 14 to 350 M. The input physics is the same used in the PARSEC V1.1 version, but for the mass-loss rate which is included by considering the most recent updates in the literature. We focus on low metallicity, Z=0.001 and Z=0.004, for which the metal-poor dwarf irregular star-forming galaxies, Sextans A, WLM and NGC 6822, provide simple but powerful workbenches. The models reproduce fairly well the observed colour-magnitude diagrams (CMDs) but the stellar colour distributions indicate that the predicted blue loop is not hot enough in models with a canonical extent of overshooting. In the framework of a mild extended mixing during central hydrogen burning, the only way to reconcile the discrepancy is to enhance the overshooting at the base of the convective envelope (EO) during the first dredge-up. The mixing scales required to reproduce the observed loops, EO=2Hp or EO=4Hp, are definitely larger than those derived from, e.g. the observed location of the red-giant-branch (RGB) bump in low mass stars. This effect, if confirmed, would imply a strong dependence of the mixing scale below the formal Schwarzschild border, on the stellar mass or luminosity. Reproducing the features of the observed CMDs with standard values of envelope overshooting would require a metallicity significantly lower than the values measured in these galaxies. Other quantities, such as the star formation rate and the initial mass function, are only slightly sensitive to this effect. Future investigations will consider other metallicities and different mixing schemes.

Session 4: Massive stars in the cluster and galactic context

Massive stars in the cluster context

Nate Bastian Liverpool John Moores University, Liverpool, UK

I will discuss the role of massive stars in the early evolution of stellar clusters, including feedback and their effect on the surrounding ISM. Young clusters appear to be gas free within the first 1-2 Myr of their lives, well before the first SNe goes off, independent of mass and metallicity. These YMCs blow bubbles into the surrounding ISM that can truncate further star-formation within the host galaxy, in the case of dwarfs, for Myr. The spatial distribution of the high mass stars, along with their relative motions derived with GAIA, will provide the best constraints to date on the initial conditions of cluster and association formation.

The Sco-Cen OB association

Guo Difeng et al. Anton Pannekoek Institute for Astronomy, The Netherlands

The Gould Belt is a ring-like molecular gas structure hosting newly formed stars, with the Sun located approximately at the center of the ring. All massive OB-type stars visible by naked eye are located in the Gould Belt. The plane of the ring has an inclination angle of about 20 degrees relative to the Galactic plane; the physical origin of the Gould Belt is not known. The Sco-Cen region is one of the embedded OB associations, still actively forming stars in the associated rho Oph molecular cloud complex; membership, stellar kinematics, mass function, age (gradient) and star-formation history are addressed by analyzing parallax, proper motion, radial velocity and extinction of the individual stars. We are re-evaluating the stellar population of the Sco-Cen region based on new and archival data, in preparation for the release of Gaia observations. Our ultimate goal is to reconstruct the star-formation history of the Gould Belt, and to determine its physical origin.

Modelling massive stars populations

Cyril Georgy Keele University, UK

During the recent years, the Geneva stellar evolution group has released various sets of stellar model grids. On top of these grids, in order to produce data that are the most directly comparable with the observations, we also developed a toolbox called "Syclist", able to produce interpolated models, isochrones, and to build synthetic clusters of massive stars. In this talk, I will introduce the new grids of stellar models, and discuss how Syclist generates synthetic clusters (IMF, initial distribution of rotation rate, binarity, gravity and limb darkening, binarity, and so on). I will discuss how these effects impact the look of the HRD (or colour-magnitude diagrams), and show some recent results obtained with Syclist in the modelling of populations of Be stars in stellar clusters.

The dynamical ejections of O stars from young star clusters: the origin of field O stars

Seungkyung Oh University of Bonn, Germany

The core of massive young star clusters composed of massive stars can efficiently shoot out some of its members through energetic three- or four-body interactions. We study how the ejection of O-stars varies with cluster mass by means of direct N-body calculations under diverse initial conditions. The results show robustly that the ejection fraction of O star systems exhibits a maximum at a cluster mass of 3000 $M_{\odot}$, even though the number of the ejected systems increases with cluster mass. Synthesising a young star cluster mass function it follows, given the stellar-dynamical results of this study, that the observed fractions of field and runaway O stars can be well understood theoretically if all O stars form in embedded clusters.

Galactic abundance gradient

Simone Daflon Observatorio Nacional, Rio de Janeiro, Brazil

In this talk, I will present a review on radial abundance gradients on the Galactic Disk, considering some difficulties such as radial sampling, stellar rotation and stellar multiplicity. I will also present some preliminary results of a current analysis of radial gradient of oxygen based on self-consistent, Non-LTE analysis of oxygen in massive stars. Possible synergy with other Surveys such as APOGEE and J-PLUS will be addressed.

Using massive stars as probes of star formation

Richard Parker Liverpool John Moores University, Liverpool, UK

From a dynamical point of view, massive stars often dominate the formation and evolution of star clusters and associations. Some star clusters are observed to be mass segregated, whereby the most massive stars have moved to the centre of the cluster on dynamical timescales. I will show that the spatial distribution of massive stars can be a powerful tracer of the past, and future evolution of a star cluster or association. With the upcoming Gaia and GES observations we will be able to use massive stars to understand the formation and evolution of star-forming regions in general.

How the cluster environment influences the formation of massive stars

Susanne Pfalzner Max-Planck-Institut für Radioastronomie, Bonn, Germany

It is well known that massive stars have profound influence on the young clusters surrounding them. For example do they provide a huge energy input in the form of radiation leading to the photo-evaporation of the discs of stars in their neighbourhood. But they influence also the dynamics of these clusters functioning as gravitational foci. Here we concentrate on the reverse process, demonstrating how the cluster influences the massive stars in their development. We show that the duster environment is responsible for their lower disc fraction and higher binarity. Even the formation and growth of massive stars is influenced by the type of cluster they reside in. We show that not only the cluster mass, but also its density determines the upper mass limit of the stars they contain.

Modeling the magnetic field distribution of massive stars

Aleksei Medvedev Saint Petersburg State University, Russia

The population synthesis code allowing to follow the evolution of the magnetic stars from the pre-main sequence (PMS) stage to the end of the evolution of the star at the MS is developed. We study changes of stellar radii, masses, temperatures, effective magnetic fields and magnetic fluxes with age. We also develop the simple dynamo-action model at PMS stage to reproduce the initial magnetic fields and fluxes distribution at the ZAMS. The distribution of the magnetic fields at ZAMS appeared to be the lognormal. We supposed that with increasing the age of a star its magnetic flux can be dissipated. As a result of our simulations the distribution of stars by magnetic fields from ZAMS to TAMS is obtained. The shape of the distribution is highly dependent on the rate of the magnetic field dissipation. It is shown that the model distribution of the magnetic field of OBA stars is in agreement with that obtained from the analysis of the measured magnetic fields of these stars.

New OB star candidates in the Carina Arm around Westerlund 2 from VPHAS+

Michael Mohr-Smith University of Hertfordshire, UK

O and early B stars are at the apex of galactic ecology, but in the Milky Way, only a minority of them may yet have been identified. We present the results of a pilot study to select and parametrise OB star candidates in the Southern Galactic plane, down to a limiting magnitude of g=20. A 2 square-degree field capturing the Carina Arm around the young massive star cluster, Westerlund 2, is examined. The confirmed OB stars in this cluster are used to validate our identification method, based on selection from the (u-g, g-r) diagram for the region. Our Markov Chain Monte Carlo fitting method combines VPHAS+ u, g, r, i with published J, H, K photometry in order to derive posterior probability distributions of the stellar parameters log(Teff) and distance modulus, together with the reddening parameters Ao and Rv. The stellar parameters are sufficient to confirm OB status while the reddening parameters are determined to a precision of (Ao)$\sim$0.09 and (Rv)$\sim$0.08. There are 489 objects that fit well as new OB candidates, earlier than $\sim$B2. This total includes 74 probable massive O stars, 5 likely blue supergiants and 32 reddened subdwarfs. This approaches a factor of 10 increase in the number of previously known and candidate OB stars in the region. Most of the new objects are likely to be at distances between 3 and 6 kpc. We have confirmed the results of previous studies that, at these longer distances, these sight lines require non-standard reddening laws with $3.5<Rv<4$.

Binarity in clusters

Hugues Sana Space Telescope Science Institute, Baltimore, USA

The evolution of massive close binaries: the effect on overall massive star population synthesis

Dany Vanbeveren Vrije Universiteit Brussel, Belgium

Since the late nineties the Brussels research group has defended the thesis that massive star population synthesis without the inclusion of the effect of binaries may have an academic value but may be far from reality. We reconsider this thesis accounting for recent developments in massive binary research. We then apply our massive star population model including binaries in order to discuss the predicted population of double compact star binaries and we link our results to the forthcoming Advanced LIGO experiment.

Quantitative spectroscopy of stars in close binary systems

Kresimir Pavlovski University of Zagreb, Croatia

The complexity of composite spectra of close binary systems makes study of the spectra of their component stars extremely difficult. For this reason there exists very little information on the photospheric chemical composition of stars in close binaries, despite its importance for improving our understanding of the evolutionary processes of stars. In a long-term observational project we aim to fill this gap with systematic abundance studies for the variety of binary systems. The core of our analysis is the spectral disentangling technique, which allows isolation of the individual component star spectra from the time series of observed spectra. Some of our recent results of the quantitative spectroscopy for different sorts of the early-type stars in binary and multiple systems would be presented.

Index