Stars on the Run

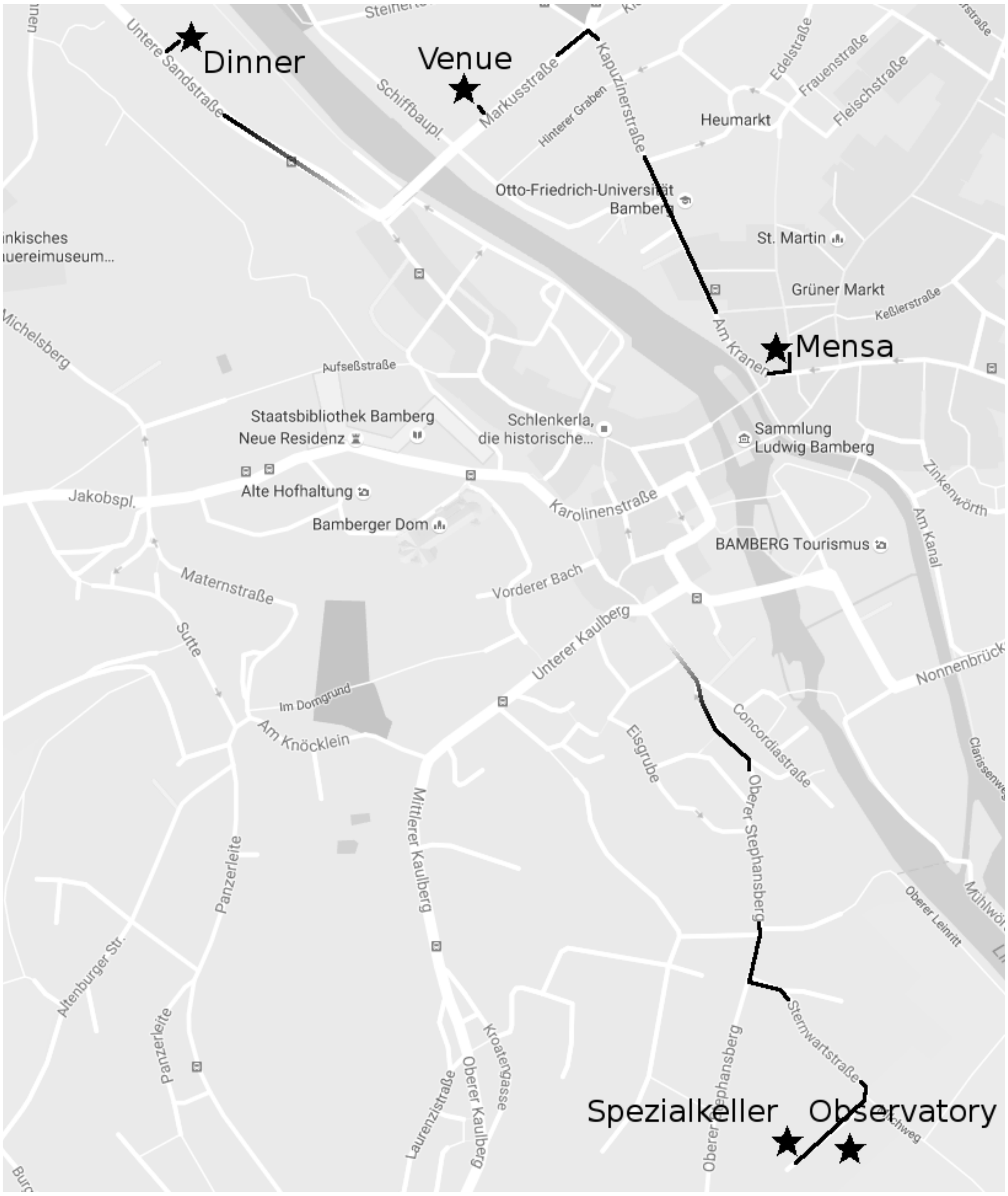
A meeting on run-away and hyper-velocity stars

August 16–19, 2016
Bamberg, Germany

ABSTRACT BOOKLET

http://www.sternwarte.uni-erlangen.de/hvs2016

MAP of LOCATIONS



Closeup of venue and mensa

PROGRAM

Tuesday, August 16, 2016

Session: Overview and Gaia Perspectives

10:15	Brown	Overview of high-velocity stars
11:00	Jordan	High-velocity stars - the Gaia perspective
11:30	Marchetti	Hyper-velocity stars in the GAIA catalogue
12:00	*Lunch / Topical Discussions*	

Session: Binary Supernova Ejection: Models

14:00	Podsiadlowski	Supernova ejection mechanisms
14:30	de Mink	Binary stellar evolution models for run-away stars
15:00	Justham	Binary population synthesis and high-velocity run-aways
15:30	Irrgang	Origin of massive run-away stars
15:50	*Coffee / Posters*	

Session: Binary Supernova Ejection: Candidates

16:20	Schaffenroth	HD 271791: Nucleosynthesis in a core collapse supernova
16:40	Renzo	Massive run-away stars and their constraints on binary interaction and explosion physics
17:00	Yushchenko	HIP 13962 - The possible former member of binary system with supernova
17:20	Dincel	OB run-away stars inside SNRs S147 and IC443
17:40	Paunzen	Tracing run-away stars with the narrow-band Delta a photometric system
18:15	*Guided Tour of the City of Bamberg*	

Wednesday, August 17

09:00	Kerzendorf	Surviving companions of type Ia supernovae
09:30	Pannicke	The search for binary companions of SN progenitors in SNRs (poster)
09:35	Lux	The movement of pulsars in the Galaxy and determination of their kinematic ages
09:55	Neuhaeuser	Kinematic age of neutron stars from run-away stars from binary supernovae
10:15	Bray	Is the link between the observed velocities of neutron stars and their progenitors a simple mass relationship?
10:35	*Coffee / Posters*	

Session: Dynamical Ejection from Star Clusters

10:55	Portegies-Zwart	Run-away stars by dynamical ejection
11:25	Oh	The dynamical ejections of massive stars from young star clusters
11:55	Sana	30 Doradus: a run-away factory caught in the act
12:25	North	The OB-run-aways of R136 - A dynamical fingerprint of massive star formation?
12:45	*Lunch / Topical Discussions*	
14:45	Lennon	Searching for the birthplaces of very massive run-away stars with Hubble

Session: Bow Shocks from Run-away Stars

15:05	Mohamed	Bow shocks from run-away stars
15:35	Bomans	Bow shocks of run-away OB Stars
15:55	Meyer	Bow shocks from Galactic run-away massive stars
16:15	*Coffee / Posters*	
16:45	Bomans	Emission-line bow shock structures of hot run-away stars (poster)
16:50	Peri	Multi-wavelength stellar bow shocks: From the infrared E-BOSS catalogue and radio observations to potential gamma-ray emitters
17:10	Weis	Leaving the bonds of home - the LBV S119
17:30	Pardi	The impact of massive run-away stars on the shaping of the ISM
17:50	Peri	Finding stellar bow shocks by means of citizen science (poster)
19:30	*Reception at Spezialkeller and Tour of the Observatory*	

Thursday, August 18

Session: Hyper-velocity Stars: Ejection Models

09:00	Kobayashi	Hyper-velocity stars and compact binaries
09:30	Gualandris	Ejection of hyper-velocity stars from the Galactic Center
10:00	Haas	Hyper-velocity stars from an eccentric stellar disc in the Galactic Center
10:25	*Coffee / Posters*	

Session: Hyper-velocity Stars: Candidates

10:55	Antonini	Secular evolution of binaries at the Galactic Center
11:15	Hawkins	High-velocity stars from the RAVE project
11:35	Zhong	The nearest high-velocity stars revealed by LAMOST
12:00	Y. Li	The method of searching F/G/K type hyper-velocity star candidates from data release one of LAMOST survey (poster)

12:05	Geier	Searching for hot subdwarfs at high velocity
12:25	*Lunch / Topical Discussions*	
14:25	Ziegerer	Hot subdwarfs at high velocity
14:45	Kawka	Extreme kinematics in the hot subdwarf population
15:05	Németh	The extremely fast halo hot subdwarf binary PB 3877
15:25	Sippel	A dynamical gravitational wave source in a globular cluster
15:45	*Coffee / Posters*	
16:15	Margon	Run-away dwarf carbon stars as supernova ejecta
16:35	Vennes	Extreme kinematics in the white dwarf population
16:55	Heber	What may go wrong in stellar kinematics: Candidate hyper-velocity stars of spectral type G and K revisited
19:00	*Conference Dinner*	

Friday, August 19

Session: Hyper-velocity Stars and the Galactic Center

09:30	Perets	The properties of HVSs in light of their ejection mechanism: rates, velocities, history, mass function and binarity
10:00	Lu	The dynamical origin of hyper-velocity stars and GC S-stars, GC pulsars and hyper-fast pulsars
10:30	Boubert	A dipole on the sky : Predictions for hyper-velocity stars from the Large Magellanic Cloud
10:50	*Coffee / Posters*	

Session: Hyper-velocity Stars and the Galactic Potential

11:20	Gnedin	Constraints on the Galactic potential from hyper-velocity stars
11:50	Zhang	Cool run-aways - Nearby Hills ejecta as a probe of the gravitational potential of the Milky Way
12:10	Rossi	Joint constraints on the Galaxy dark matter halo and Galactic Center from hyper-velocity stars
12:30	*Farewell*	

ABSTRACTS

Overview of High Velocity Stars

Warren Brown

Tuesday, August 16, 2016, 10.15
in session "Overview and Gaia Perspectives"

A brief overview of high velocity stars, linking observations and theory in the context of the conference talks.

High-velocity stars - the Gaia perspective

Stefan Jordan

Tuesday, August 16, 2016, 11.00
in session "Overview and Gaia Perspectives"

The first Gaia data will be released in late summer 2016. It will contain more than one billion star positions, and additionally two million (apparently single) stars with positions, proper motions, and parallaxes. From the latter high-velocity stars can be identified.

One year later, a full five-parameter catalogue for more than one billion stars will be published containing proper motions and parallaxes as well. This and all the later Gaia catalogue will be an incredibly wealthy source of information for kinematic studies in our Milky Way.

Hyper-velocity stars in the GAIA catalogue

Tommaso Marchetti

Tuesday, August 16, 2016, 11.30
in session "Overview and Gaia Perspectives"

A hyper-velocity star (HVS), according to the Hills mechanism, is a star ejected in a three body interaction between a binary system and the massive black hole in the center of our Galaxy. HVSs are a powerful tool to probe both the binary population and the star formation history in the Galactic Center, and they also provide essential information on the shape and mass distribution of the whole Galaxy, all properties on which tight constraints are currently missing. In this talk I will present our on-going work to extract from GAIA data an unprecedented sample of HVSs, that will allow us to derive new and unique constraints on the Galactic Center ecosystem and on the Milky Way dark matter content. In particular, I will show our expectations for the first and second data releases, applying our newly constructed data mining algorithm to the current GAIA mock catalogue, where synthetic HVS populations have been added. We have adopted and tested different hypotheses on the ejection velocity distribution of HVSs and on the stellar population of the Galactic Center, to study the impact of these assumptions on the final estimates of the sample.

Supernova ejection mechanisms

Philipp Podsiadlowski

Tuesday, August 16, 2016, 14.00
in session “Binary Supernova Ejection: Models”

One of the most important mechanisms to produce run-away stars are run-away stars from binaries that were broken up or destroyed due to the explosions of the companion star in a supernova. I will summarize the properties of such run-away stars, including estimates of the maximum run-away velocities achievable and the characteristics of the run-away stars, both for core-collapse supernovae and thermonuclear supernovae, and how these depend on our understanding of supernova kicks (in the case of core-collapse supernovae) and different progenitor models (for thermonuclear supernovae). I will also discuss some available observational constraints and suggest strategies for finding run-away stars in supernova remnants.

Binary stellar evolution models for run-away stars

Selma de Mink

Tuesday, August 16, 2016, 14.30
in session "Binary Supernova Ejection: Models"

One of the main production channel for massive run-away stars is the "Blaauw scenario" in which a massive binary system is disrupted at the explosion of the first star in the system. The kick resulting from mass loss during the explosion and the natal kick combined with the newly born neutron star or black hole can lead to the disruption of close binaries.

I will review the properties of young massive binaries, the evolution and interaction processes that lead up to the disruption of the binary system and the further evolution of the escaping star which is often expected to be a rapid rotator. I will place the current insight in the physics in the context of the observations and briefly discuss the wider implications for massive star feedback as well as predictions for gravitational wave sources.

Binary population synthesis and high-velocity run-aways

Stephen Justham

Tuesday, August 16, 2016, 15.00
in session “Binary Supernova Ejection: Models”

In principle, binary population synthesis modelling helps to connect observables with physical parameters in a way which is not normally possible for individual systems. We can only rarely claim to reliably infer the precise prior history of an individual system, and population-scale modelling should help to extract additional information about evolutionary processes from what we can see in the sky. This will be even more applicable as data sets expand, e.g., in the age of GAIA. However, it is clear that population synthesis predictions are not always infallible. This is perhaps most clearly highlighted by differing predictions regarding type Ia supernova progenitors. I will briefly introduce the variety of binary population synthesis techniques in use, and then describe predictions from different groups which are relevant to run-away stars, concentrating mainly on predictions for escaping companions from systems which produce a supernova.

Origin of massive run-away stars

Andreas Irrgang

Tuesday, August 16, 2016, 15.30
in session "Binary Supernova Ejection: Models"

Two of the most likely ejection scenarios for massive run-away stars are dynamical interactions in star clusters, e.g., close binary-binary encounters, and a core-collapse supernova explosion disrupting a binary system. In general, the kinematic properties of the released run-away star are not sufficient to argue for one of the two competing mechanisms. However, in the case of the binary supernova scenario, the pollution of the secondary component's atmosphere with freshly synthesized supernova ejecta can lead to α-element enhancement and, thus, provide a distinctive feature. Since this effect is expected to be very subtle, it is indispensable to determine elemental abundances with very high precision and to take Galactic abundance gradients into account when checking the derived abundance pattern for supernova signatures. Here, we present the results of a combined spectroscopic and kinematic investigation of a few run-away stars that turned out to be good candidates for the supernova channel.

HD 271791: Nucleosynthesis in a core collapse supernova

Veronika Schaffenroth

Tuesday, August 16, 2016, 16.20
in session "Binary Supernova Ejection: Candidates"

Some young, massive stars can be found in the Galactic halo. As star formation does not occur in the halo, they must have been formed in the disk and been ejected shortly afterwards. There are several scenarios for the origin of such objects. One explanation is a supernova in a binary system. The companion is ejected and becomes a run-away star. HD 271791 is the kinematically most extreme run-away star known (Galacic restframe velocity 725 +- 195 km/s). Because its Galactic restframe velocity exceeds the Galactic escape velocity it is called a hyper-run-away star. Moreover, an analysis of the optical spectrum showed an enhancement of the alpha elements. This indicates an origin in a supernova. As such high velocities are not reached in classical binary supernova scenarii, a very massive but compact primary, probably of Wolf-Rayet type is required. The star is a perfect candidate for studying nucleosynthesis in a core collapse supernova because of the contamination of its surface layers with supernova ejecta of its former very massive primary. The goal of this project is to determine the abundances of a large number of elements from the alpha process, the iron group, and heavier elements by a quantitative spectral analysis of the optical and the UV with detailed stellar atmosphere models taking into account deviations from the local thermal equilibrium (NLTE). We intent to verify whether core collapse supernova are a site of the r-process element production. The first step was to include all atomic data available for these elements in the UV spectrum synthesis. Now we are able to determine abundances of iron group and heavier elements from the UV, at the moment in LTE, but in the next step also in NLTE. The abundance analysis is done differentially with bright B type comparison stars. Here we want to state the current status of the project.

Massive run-away stars and their constraints on binary interaction and explosion physics

Mathieu Renzo

Tuesday, August 16, 2016, 16.40
in session “Binary Supernova Ejection: Candidates”

The run-away phenomenon has been proposed to play a key role in altering the radiative, mechanical, and chemical feedback by massive stars, allowing supernovae to occur up to several hundreds of parsecs away from their birth location. Run-away stars produced through the Blaauw binary supernova mechanism also provide unique constraints on elusive physical processes governing the evolution of massive binaries as well as supernova explosion physics.

Through numerical experiments of massive star populations, we investigate the formation of fast and slow run-aways stars (a.k.a. ”walk-away stars”), and compare our results with the newly discovered sample of run-away stars in the VLT-FLAMES Tarantula survey. This sample is the best-controlled, large, and homogeneous dataset of early-type stars presently available. We investigate the distribution of spatial velocities and the trends with other stellar properties, such as remaining lifetime, mass, and rotation rate.

We discuss the new constraints the data provides on the pre-explosion binary evolution and supernova explosion physics. In particular, we investigate constraints on the natal kicks of black holes, which is one of the crucial uncertainties for predictions of gravitational wave sources.

HIP 13962 - the possible former member of binary system with supernova

Volodymyr Yushchenko

Tuesday, August 16, 2016, 17.00
in session "Binary Supernova Ejection: Candidates"

Previous investigations of this star showed that it was a member of stellar binary system with Supernova. Another component of the system is observed as a pulsar in different constellation now. We investigate the atmosphere parameters of HIP 13962 and the possible spectral variability. The new observations of this star were obtained at 1.8 meter telescope of Bohyunsan astronomical observatory (Korea) and 2.4 meter telescope of NARIT observatory (Thailand). We make detailed chemical abundance of the stellar atmosphere, including the elements with atomic number after 64.

OB run-away stars inside SNRs S147 and IC443

Baha Dincel

Tuesday, August 16, 2016, 17.20
in session "Binary Supernova Ejection: Candidates"

We present first results of a long-term study: Searching for OB–type run-away stars inside supernova remnants (SNRs). We identified spectral types and measured radial velocities (RV) by optical spectroscopic observations and we found OB run-away stars inside SNR S147 and IC443. HD 37424 is a B0.5V type star with a peculiar velocity of 74.0±8 km s^{-1}. Tracing back the past trajectories via Monte Carlo simulations, we found that HD 37424 was located at the same position as the central source PSR J0538+2817 30±4 kyr ago. This position is only ∼4 arcmin away from the geometrical center of the SNR. So, we suggest that HD 37424 was the pre-supernova binary companion to the progenitor of the pulsar and the SNR. We found a distance of 1333^{+103}_{-112} pc to the SNR. The age is 30±4 kyr and the total visual extinction towards the center is 1.28±0.06 mag. The zero age main sequence progenitor mass should be greater than 13 $M_{\odot}$. We calculated the pre-supernova binary parameters for different progenitor masses. The values found for the Roche Lobe radii suggest that it was an interacting binary in the late stages of the progenitor. This is the first OB run-away star ever found which is directly linked to a neutron star (NS) and a SNR. Another OB run-away star we found is the B0II/III type star HD 254577 inside SNR IC443. The proper motion of the star is significantly larger than the average proper motion of the other members of GEM OB1 association. The peculiar velocity of the star is 35 ± 7 km s^{-1} at 1.5 kpc. The bow shock direction of the pulsar wind nebula shows that the NS and HD 254577 may have a common origin: binary supernova disruption. Unlike S147, the explosion center we found is far away from the geometrical center, close to the eastern edge of the remnant. But the relation to the SNR is still possible.

Tracing run-away stars with the narrow-band Delta a photometric system

Ernst Paunzen

Tuesday, August 16, 2016, 17.40
in session "Binary Supernova Ejection: Candidates"

The capabilities of the narrow band, Delta a photometric system, to trace and detect run-away and hyper-velocity stars are presented. The Delta a system was originally introduced by Maitzen (1976, A&A, 51, 223) to investigate the flux depression at 5200A which is a key characteristic of classical chemically peculiar stars. It comprises of three narrow-band filters with FWHMs of about 100A. The "a index" samples the depth of this flux depression by comparing the flux at the center (5200A, g2) to the adjacent regions (5000A, g1 and 5500A, g3 or y). The final intrinsic peculiarity index Delta a is defined as the difference between the individual a-values and the a-values of non-peculiar stars of the same colour (spectral type). However, it can also trace all hyper-velocity stars when compared to Population I type ones with "normal velocities". A survey in the Magellanic Clouds within the Delta a photometric system was started. Here, the preliminary results of this survey will be presented.

Surviving companions of type Ia supernovae

Wolfgang Kerzendorf

Wednesday, August 17, 09.00
in session "Binary Supernova Ejection: Candidates"

Most supernovae should occur in binaries. Massive stars, the progenitors of core collapse supernovae (SN II/Ib/c), have a very high binarity fraction of 80% (on average, they have 1.5 companions). Binary systems are also required to produce thermonuclear supernovae (SN Ia). Understanding the role that binarity plays in pre-supernova evolution is one of the great mysteries in supernova research. Finding and studying surviving companions of supernovae has the power to shed light on some of these mysteries. Searching Galactic and nearby supernova remnants for surviving companions is a particularly powerful technique. This might allow to study the surviving companion in great detail possibly enabling a relatively detailed reconstruction of the pre-supernova evolution. In this talk, I will summarize the multitude of theoretical studies that have simulated the impact of the shockwave on the companion star and the subsequent evolution of the survivor. I will then give an overview of the searches that used these theoretical findings to identify surviving companions in nearby supernova remnants (particularly for type Ia supernovae) as well as their results. Finally, I will give an outlook of new opportunities in the relatively young field.

The search for binary companions of SN progenitors in SNRs

Anna Pannicke

Wednesday, August 17, 09.30
in session "Binary Supernova Ejection: Candidates"

The movement of pulsars in the Galaxy and determination of their kinematic ages

Oliver Lux

Wednesday, August 17, 09.35
in session "Binary Supernova Ejection: Candidates"

Knowing pulsar ages is important to better understand the formation and evolution of the Galactic pulsar population. Since the characteristic age is only a rough estimate, based on assumptions that may not be justified for most pulsars, we use kinematic simulations for 162 non-recycled pulsars and are able to determine kinematic ages for 146 of them, where 92 are considered as reliable. The applied method requires knowledge of the pulsar's current position, proper motion and distance to calculate the trajectory and find its intersections with the Galactic plane, which is assumed as the birth place. The distribution of logarithmic kinematic ages is found to roughly follow a Gaussian, with a peak around 10^6 years. We obtain large individual differences between kinematic and characteristic ages and a smaller median for the kinematic ages. We adjust the distance by up to a factor of two to consider distance uncertainties. For increased distances we note fewer intersections with the Galactic plane, leading to fewer possible age determinations. We note that the method is mainly applicable for middle-aged pulsars, while for old pulsars we obtain too many intersections (and therefore ambiguous age determinations), and for young pulsars it is better to search for individual birth associations, like supernova remnants, OB associations or run-away stars.

Kinematic age of neutron stars from run-away stars from binary SNe

Ralph Neuhaeuser

Wednesday, August 17, 09.55
in session "Binary Supernova Ejection: Candidates"

We use the known parallaxes and proper motions of neutron stars to trace their motion back in time, until their flight path crosses an OB association. If the flight time to such an OB association is not larger than the characteristic spin down age of the pulsar, then the neutron star may have formed in that association in a SN. Since the radial velocities of neutron stars is almost never known, we vary this parameter in a Monte Carlo simulation. We also trace back run-away stars, which can be the former companion of the SN progenitor: if a neutron star and a run-away star could have been at the same time at the same place (for a certain neutron star radial velocity), it is evidence for a SN in a binary. We then search for SN debris on the run-away star. We are now ready to use a new faster software for GAIA data to come soon.

Is the link between the observed velocities of neutron stars and their progenitors a simple mass relationship?

John Christopher Bray

Wednesday, August 17, 10.15
in session "Binary Supernova Ejection: Candidates"

Neutron stars (NSs) are observed with much higher spacial velocities than their accepted OB star progenitors, some with measured velocities in excess of 1,500 $\mathrm{km\,s^{-1}}$. While it is widely accepted that these extreme velocities are a result of the supernovae that create them, the exact mechanism responsible is still not fully understood. We propose the primary source of these extreme velocities is the asymmetric ejection of the outer envelope during the supernovae, with the resulting conservation of momentum imparting a velocity "kick" of the newly created neutron stars. Using the binary stellar evolution models from BPASS and our proposed mass ratio relationship, we are able to show that the observed neutron star velocity is primarily determined by the range of ejecta masses that arise in the supernova progenitors due to binary evolution.

Run-away stars by dynamical ejection

Simon Portegies-Zwart

Wednesday, August 17, 10.55
in session "Dynamical Ejection from Star Clusters"

The dynamical ejections of massive stars from young star clusters

Seungkyung Oh

Wednesday, August 17, 11.25
in session “Dynamical Ejection from Star Clusters”

Massive stars likely form in binary systems with two massive components in dense star clusters. Based on that, they can be effectively ejected from their birth cluster through a close few-body interaction. We performed a large set of direct N-body calculations with diverse initial conditions to study the dynamical ejections of massive stars from young star clusters. We will present how the ejection efficiency varies with cluster mass and with initial configuration of massive stars and their birth cluster. We will discuss properties of the ejected massive stars, for example, their velocity distribution, mass function, and multiple fraction.

30 Doradus: A run-away factory caught in the act

Hugues Sana

Wednesday, August 17, 11.55
in session "Dynamical Ejection from Star Clusters"

As one of the most massive, young, active star forming regions in the local universe, 30 Doradus contains a rich massive star population where stars can still be resolved individually. Hence 30 Doradus is the ideal place to investigate a number of important questions regarding massive star evolution and cluster dynamics. Recent observational programs have increased our knowledge of the 30 Doradus region manyfold. In particular they have led to the identification of a significant run-away population. I will summarize the results of these observational campaigns and the new observational constraints that they bring. I will review the 30 Doradus properties that are critical to interpret the run-away data and I investigate ways to confront predictions of different ejection mechanism and their relative efficiency.

The OB run-aways of R136 - A dynamical fingerprint of massive star formation?

Matt North

Wednesday, August 17, 12.25
in session "Dynamical Ejection from Star Clusters"

Recent observations of the Young Massive Star Cluster (YMSC) R136 in 30 Doradus has revealed a significant number of OB run-aways and it is not yet clear how they formed.

Indeed, the natal environments of massive (OB) stars are still poorly understood. Do all massive stars form in the cores of dense YMSC's, such as R136? Are all massive stars distant from such clusters the result of high velocity ejections from these cores?

By utilising the n-body code NBODY6 and accounting for stellar evolution, I explore the possible conditions that have given rise to the R136 observations and seek to understand the role of the different ejection mechanisms in the evolution of this spectacular cluster.

Through studying the production of OB run-aways from the cores of dense YMSC's generally, I will attempt to constrain initial conditions and unpick the interplay between density, primordial binarity and the OB run-away ejection mechanisms.

Searching for the birthplaces of very massive run-away stars with Hubble

Danny Lennon

Wednesday, August 17, 14.45
in session “Dynamical Ejection from Star Clusters”

I will discuss the status of two Hubble programs whose aims are to constrain the birthplaces of very massive isolated stars in the Tarantula Nebula of the Large Magellanic Cloud, and in the environment around our Galactic Center and the Arches cluster. Preliminary results will be presented for stars in the vicinity of the Tarantula Nebula.

Bow shocks from run-away stars

Shazrene Mohamed

Wednesday, August 17, 15.05
in session “Bow shocks from Run-away Stars”

The supersonic interaction of a stellar wind ejected by a run-away star with the surrounding medium results in the formation of a bow shock, a cometary-shaped structure pointing in the direction of motion. These structures have been observed at radio, optical, infrared, UV and X-ray wavelengths and are often used to trace run-away stars back to their parent clusters. In this talk I will review both analytic and multi-dimensional numerical simulations that have demonstrated how the formation, stability and evolution of bow shocks are affected by the velocity of the star, the properties of its wind and circumstellar environment. I will also highlight how bow shocks can be used to constrain stellar evolution models and their implications for run-aways that are progenitors of supernovae and gamma-ray bursts.

Bow shocks of run-away OB stars

Dominik Bomans

Wednesday, August 17, 15.35
in session "Bow shocks from Run-away Stars"

& K. Scherer, K. Weis, H. Fichtner, J. Kleimann:

All astrospheres, which are in relative supersonic motion with respect to the ambient interstellar medium, build a bow shock. We present an MHD model of the O Star λ Cephei and discuss the MHD shock structure with and without cooling. Furthermore, we use different projections of the MHD model onto the sky, to show that other hot stars can be described by similar model parameters. For this test we generated a sample of large bow shock nebulae and compared the MIR/FIR and optical emission line morphology to the predictions of the projected MHD model representations. The large scale fit and small scale differences are discussed.

Bow shocks from Galactic run-away massive stars

Dominique Meyer

Wednesday, August 17, 15.55
in session "Bow shocks from Run-away Stars"

Massive stars that have been ejected from their parent cluster and supersonically sailing, away through the interstellar medium (ISM) are classified as exiled. While evolving through their different stellar evolutionary phases, they generate circumstellar bow shock nebulae that can be observed (Gull et al. 1979, van Buren et al. 1988). We present a large grid of 2D axisymmetric (magneto-)hydrodynamic numerical simulations of bow shocks generated by a representative sample of Galactic, evolving massive stars in an ambient medium of densities ranging from 0.01 up to 10.0 cm-3 (Meyer et al. 2014a,b) and discuss their optical, X-ray and infrared observability (Meyer et al. 2016). Particularly, we investigate the effects of (i) the so-called thin-shell instability that can affect such bow shocks and (ii) the magnetization of the ISM on their optical Hα and 24 micron infrared emission signatures. We also discuss the consequences of the presence of a bow shock on the supernova remnants that grow after the death of run-away massive stars as type II explosion (Meyer et al. 2015).

Emission-line bow shock structures of hot run-away stars

Dominik Bomans

Wednesday, August 17, 16.45
in session "Bow shocks from Run-away Stars"

Poster presentation: Since the times of IRAS, mid-, and far-infrared emission is used as a tool to search for bow shock nebulae of run-away stars. Still, recent work seems to imply that the dust emission, which dominates most of the IR images, may not trace exactly the same structures as there would be visible in emission lines from the ionized gas. For the case of hot run-away stars, this additional indicator is available due to the strong Lyman continuum flux of these stars. This allows to analyze the differences between the images, and determine the exact physical identification of the structures detected in the MIR/FIR images and ionized gas emission (like e.g. H_α and Br_γ), before using the bow shock structures to determine ISM properties, and/or parameters of the stellar wind. In this paper we will show several observational examples of bow shocks from hot run-away stars with both MIR/FIR and optical/NIR emission line images and analyze the physical parameters of the systems.

Multi-wavelength stellar bow-shocks: from the infrared E-BOSS catalogue and radio observations to potential gamma-ray emitters

Cintia Peri

Wednesday, August 17, 16.50
in session "Bow shocks from Run-away Stars"

Stellar bow shocks produced by run-away stars have been studied both observationally and theoretically in the last decades. These sources seem to possess their highest luminosity in the infrared band, reason why they are easily detected in this range of the spectrum. I will give a brief summary of the two releases of the Extensive stellar BOw Shock Survey (E-BOSS, Peri et al. 2012, 2015), and expose how through radio observations it can be analyzed if this kind of sources can be considered as high-energy photon emitters. Finally, I will show new results recently obtained with the eVLA interferometer.

Leaving the bonds of home - the LBV S119

Kerstin Weis

Wednesday, August 17, 17.10
in session "Bow shocks from Run-away Stars"

A sizable portion of O and B stars are known to have high radial velocity and are regarded as run-away stars. Some of those exhibit strong stellar winds and do form bow shocks that partially surround the star as nebular emission. LBVs are massive evolved stars that do have high mass loss and can even undergo giant eruption - outbursts in which larger amounts of mass are ejected. Are there any run-away LBVs ? And is the rather short LBV phase long enough to form and maintain a bow shock? S119 is an LBV that appears to be a member of LMC, its radial velocity however is considerably lower as that of other LMC stars. The shape of the LBV nebulae around S119 differs from that of other LBVs having a significantly brighter condensation towards one side. This presentation discusses the data with the chances that S119 could be a LBV run-away star and will be put S119 into context with other possible LBV and WR run-away stars and the origin thereof.

The impact of massive run-away stars on the shaping of the ISM

Anabele-Linda Pardi

Wednesday, August 17, 17.30
in session "Bow shocks from Run-away Stars"

We present 3D magnetohydrodynamical (MHD) simulations of the turbulent multiphase interstellar medium (ISM) focusing on the impact of type II supernova (SN) explosions spatially displaced from the density peak position of theirs mother could have on the formation and lifetime of molecular clouds. We follow molecule formation and destruction with a background radiation field, SN explosions being the main dynamical driver. We implement a self-consistent feedback process that mimics massive run-away stars. We see that this approach produces a more realistic ISM with the molecular hydrogen mass fractions and volume filling fractions consistent with observations.

Finding stellar bow shocks by means of citizen science

Cintia Peri

Wednesday, August 17, 17.50
in session "Bow Shocks from Run-away Stars"

Poster presentation: Citizen Science is the participation of no scientist volunteers in scientific projects by means of collection, analysis and dissemination of scientific data. This practice has been spread into the 21st century by the use of information and communication technologies. Several areas have been explored: from agriculture to urban planning, from public health to oceanography, from social sciences to software and services, and to space engineering. Stellar bow shocks produced by run-away stars seem to posses their highest luminosity in the infrared band, and are easily detected in that range of the spectrum by visual inspection. Both releases of the Extensive stellar BOw Shock Survey catalogue (E-BOSS) were generated by these means, using mainly Wide-field Infrared Survey Explorer images, with its four bands. It is an enormous amount of work, and the inspection can be developed by anyone. We are a multidisciplinary group of researchers from astronomical and computer science fields, developing "Run-away stars", a citizen science project aimed to find stellar bow shocks among infrared images. This project is part of the Cientópolis platform which combines citizen science, a social network and gamification. "Run-away stars" includes gamification elements in order to provide an extra motivation through the classification of the infrared images.

Hyper-velocity stars and compact binaries

Shiho Kobayashi

Thursday, August 18, 09.00
in session “Hyper-velocity Stars: Ejection models”

We discuss the tidal disruption of binaries by a massive point mass (e.g. the massive black hole at the Galactic Center). We show that our restricted three-body approximation provides a simple and clear description of the dynamics. In this framework, results can be simply rescaled in terms of binary masses, their initial separation, and the binary-to-black hole mass ratio. We provide the probability distributions for disruption of circular binaries and for the ejection energy. Interestingly, deep-reaching binaries separate widely after penetrating the tidal radius, but always approach each other again on their way out from the BH. The implications to hyper-velocity stars and the recent gravitational wave event GW150914 are discussed.

Ejection of hyper-velocity stars from the Galactic Center

Alessia Gualandris

Thursday, August 18, 09.30
in session "Hyper-velocity Stars: Ejection models"

Most hyper-velocity stars observed in the halo of the Galaxy have ages large enough to be consistent with an ejection from the Galactic Center, due to an encounter with the supermassive black hole (SMBH). For a few of these stars, however, the travel time from the Galactic Center to their current location is much longer than their expected lifetime. A possible origin for these stars is the ejection from the Galactic Center as hyper-velocity binaries followed by sufficient mass transfer or merger with the companion. As a result, the star becomes a blue straggler and is rejuvenated. A possible mechanism to eject hyper-velocity binaries from the GC is the dynamical encounter between a triple system and the SMBH. Due to the encounter, the outermost star in the triple is unbound and captured by the black hole, while the binary is ejected to the halo. This model has been proposed by Perets 2009, but never tested with simulations. I will present numerical simulations of encounters between stellar triples and the SMBH in the Galactic Center and discuss implications for the hyper-velocity stars in the halo.

Hyper-velocity stars from an eccentric stellar disc in the Galactic Center

Jaroslav Haas

Thursday, August 18, 10.00
in session “Hyper-velocity Stars: Ejection models”

Breakup of binaries in the tidal field of the supermassive black hole in the center of the Milky Way represents one of the suggested production mechanisms of the observed hyper-velocity stars. The origin of such binaries, however, is still rather puzzling. In our direct N-body calculations, we explore the possibility that they were born in an eccentric disc of stars around the supermassive black hole and transported inwards by means of the Kozai-Lidov oscillations induced by the potential of the disc itself.

Secular evolution of binaries at the Galactic Center

Fabio Antonini

Thursday, August 18, 10.55
in session "Hyper-velocity Stars: Candidates"

The environment of the supermassive black hole at the Galactic Center contains a large number of stars and compact objects; a fraction of these are likely to be members of binaries. Binaries with highly inclined orbits with respect to their orbit around the supermassive black hole are strongly affected by secular Kozai processes, which periodically change their eccentricities and inclinations (Kozai cycles). During periapsis approach, at the highest eccentricities during the Kozai cycles, some binaries will merge. The environment of the Galactic Center could therefore serve as a catalyst for the merger of stellar binaries. I will discuss the implications of this process in connection to the origin of G2-like objects, the young stellar population and hyper-velocity stars.

High-velocity stars from the RAVE project

Keith Hawkins

Thursday, August 18, 11.15
in session "Hyper-velocity Stars: Candidates"

The advent of large astronomical surveys has opened up a new field of study: high-velocity stars. These stars, while rare, can provide insights into the regions and mechanisms that produced their extreme velocities. We present here new results on the chemodynamical nature of high-velocity stars in the solar vicinity using the RAdial Velocity Experiment (RAVE). Results indicate that these stars mostly resemble the Galactic halo, but there are a few notable exceptions including a late-type hyper-velocity star candidate and a metal-rich halo star. We will present follow-up analysis of the metal-rich halo star and discuss its implications on the assembly of the Galactic halo. Finally we will discuss how future surveys can aid in finding and characterizing high-velocity stars.

The nearest high-velocity stars revealed by LAMOST

Jing Zhong

Thursday, August 18, 11.35
in session "Hyper-velocity Stars: Candidates"

We report the discovery of 28 candidate high-velocity stars (HVSs) at heliocentric distances of less than 3 kpc, based on the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) Data Release 1. Our sample of HVS candidates covers a much broader colour range than the equivalent ranges discussed in previous studies and comprises the first and largest sample of HVSs in the immediate solar neighborhood, at heliocentric distances less than 1–3 kpc. The observed as well as the derived parameters for all candidates are sufficiently accurate to allow us to ascertain their nature as genuine HVSs, of which a subset of 12 objects represents the most promising candidates. Our results also highlight the great potential of discovering statistically large numbers of HVSs of different spectral types in LAMOST survey data. This will ultimately enable us to achieve a better understanding of the nature of Galactic HVSs and their ejection mechanisms, and to constrain the structure of the Galaxy.

The method of searching F/G/K type hyper-velocity star candidates from data release one of LAMOST survey

Yinbi Li

Thursday, August 18, 12.00
in session "Hyper-velocity Stars: Candidates"

Searching for hot subdwarfs at high velocity

Stephan Geier

Thursday, August 18, 12.05
in session "Hyper-velocity Stars: Candidates"

Several hot subdwarf stars (sdOBs) with extreme velocities have been found. Among them US 708, currently the fastest unbound star known in the Galaxy, and likely ejected by a thermonuclear supernova. However, since hot subdwarf stars are old and evolved objects, they can also belong to the halo population. To find the hot subdwarfs with the most extreme kinematics we compiled a new catalogue of essentially all known sdOB stars from published and unpublished sources. Cross-matching this catalogue with recent ground-based proper motion surveys and other catalogues containing radial velocities and multiband photometry, we selected a sample of candidates. In an ongoing campaign we obtain follow-up spectroscopy to study those candidates in detail. I will report on most recent results of this project.

Hot subdwarfs at high velocity

Eva Ziegerer

Thursday, August 18, 14.25
in session "Hyper-velocity Stars: Candidates"

Hyper-velocity stars (HVS) move so fast that they are unbound to the Galaxy. The spatial and velocity distribution of HVSs provides significant constraints on the shape and density distribution of the Galactic dark matter halo. When they were first discovered in 2005, dynamical ejection from the super massive black hole in the Galactic Center (GC) was suggested as their origin. The two dozen of HVS known today are young massive B stars of 3-10 solar masses. Some high-velocity subdwarfs have attracted interest because of their high RVs, most notably, the sdO star US 708, for which an origin in the GC can be excluded, is the fastest unbound star in our Galaxy. We embarked on a kinematic analysis of further subdwarfs based on proper motion measurements using the full 6D phase space information. Their orbital properties can then be derived by tracing back their trajectories in different mass models of our Galaxy. We discuss their origins and their way of acceleration.

Extreme kinematics in the hot subdwarf population

Adela Kawka

Thursday, August 18, 14.45
in session "Hyper-velocity Stars: Candidates"

Recent surveys have shown that hyper-velocity hot subdwarfs are rare. We have composed a sample of bright hot subdwarfs using GALEX ultraviolet and optical colours combined with proper motion measurements. Using this GALEX sample of hot subdwarf stars we will present our spectroscopic and kinematic analysis with the aim of identifying stars with extreme kinematics.

The extremely fast halo hot subdwarf binary PB 3877

Péter Németh

Thursday, August 18, 15.05
in session "Hyper-velocity Stars: Candidates"

We have found the halo hyper-velocity candidate subdwarf B star PB 3877 (SDSS J1211+1437) to be a binary with a K-type dwarf companion. Our spectral decomposition and SED analysis suggests a likely wide binary system, analogous to many such binaries known in the Galactic disk. The new galactic rest frame velocity of the system is 571 ± 77 km s^{-1}. The error bar encloses the Galactic escape velocity and the system is bound to the Galaxy only in the most massive Milky Way models.

The high velocity and unique kinematics of PB 3877 are challenging when trying to explain the origin of the system, because single star acceleration mechanisms (e.g.: sling-shot, supernova ejection, dynamic interactions) would rip such a wide binary apart. The formation of a wide binary after the acceleration of a massive star or a close binary can be excluded. The situation is more complicated if one considers the high probability of an unbound orbit of PB 3877. In contrast, assuming a bound orbit would require a massive dark matter halo of the Milky Way.

The most plausible scenario is that the binary was accreted from the debris of a disrupted satellite galaxy of the Milky Way. In this case the long term gradual acceleration would not harm the integrity of the binary and allow to reach the observed high velocity. The future Gaia measurements and a long-term spectroscopic follow-up will help better understand PB 3877, which will also help better understand the mass and distribution of dark matter in our Galaxy.

A dynamical gravitational wave source in a globular cluster

Anna Sippel

Thursday, August 18, 15.25
in session "Hyper-velocity Stars: Candidates"

Making use of a new N-body model to describe the evolution of a moderate-size globular cluster we investigate the characteristics of the population of black holes within such a cluster. This model reaches core-collapse and achieves a peak central density typical of the dense globular clusters of the Milky Way. Within this high-density environment we see direct confirmation of the merging of two stellar remnant black-holes in a dynamically-formed binary, a gravitational wave source. We describe how the formation, evolution and ultimate ejection/destruction of binary systems containing black holes impacts the evolution of the cluster core.

Run-away dwarf carbon stars as supernova ejecta

Bruce Margon

Thursday, August 18, 16.15
in session "Hyper-velocity Stars: Candidates"

We present new proper motion and spectroscopic observations of an SDSS dwarf carbon (dC) star with an unusually high radial velocity, 550 km/s. The data imply a remarkable galactocentric velocity, 444 +/- 12 km/s. Unlike most hyper-velocity stars, here significant motion is confidently detected in both radial velocity and also proper motion, not simply in one or the other. Several other SDSS dC stars are also inferred to have very high galactocentric velocities, again each based on both high heliocentric radial velocity and also confidently detected proper motions. These extreme velocities and the presence of C2 molecular bands in the spectra of dwarf stars are both rare, and so stars that simultaneously have both properties are particularly interesting. Most mechanisms that produce extreme stellar acceleration involve passage near the Galactic Center, but the large observed orbital angular momenta of these dC stars preclude this explanation. Ejection of a binary from a supernova may be a possibility, and may be appealing as dC stars are thought to obtain their photospheric C2 via mass transfer from a more highly evolved companion.

Extreme kinematics in the white dwarf population

Stephane Vennes

Thursday, August 18, 16.35
in session "Hyper-velocity Stars: Candidates"

I will present recent results from our study of high-proper motion white dwarfs from the SkyMapper, SDSS, and Luyten surveys with an emphasis on the Galactic halo population and peculiar objects. I will also summarize earlier work on this topic.

What may go wrong in stellar kinematics: Candidate hyper-velocity stars of spectral type G and K revisited

Ulrich Heber

Thursday, August 18, 16.55
in session "Hyper-velocity Stars and the Galactic Center"

About two dozen hyper-velocity stars are known today, which are young massive B stars, mostly of 3-4 solar masses. Recently, 20 HVS candidates of low mass were discovered in the Segue G and K dwarf sample (Palladino et al. 2014, ApJ 780,7), but none of them originates from the GC. We embarked on a kinematic analysis of the Segue HVS candidate sample using the full 6D phase space information based on new proper motion measurements. Their orbital properties can then be derived by tracing back their trajectories in different mass models of our Galaxy. We present the results for 14 candidate HVSs for which proper motion measurements were possible.

The properties of HVSs in light of their ejection mechanism: rates, velocities, history, mass function and binarity

Hagai Perets

Friday, August 19, 09.30
in session “Hyper-velocity Stars and the Galactic Center”

The properties of hyper-velocity stars (HVSs) both in term of kinematics as well as physical characteristics depend strongly on their ejection mechanism. I will briefly overview the predictions arising from the different ejection models and compare them with the observed properties of HVSs. Such comparison provides strong constraints on the origins on HVSs. In particular I will point out the potential successes and the many remaining open questions that might be solved with upcoming surveys.

The dynamical origin of hyper-velocity stars and GC S-stars, GC pulsars and hyper-fast pulsars

Youjun Lu

Friday, August 19, 10.00
in session "Hyper-velocity Stars and the Galactic Center"

I will talk about the dynamical origin of the Galactic Center (GC) S-stars, the hyper-velocity stars (HVSs), and also the GC pulsars and the hyper-fast pulsars. We investigate the link between the S-stars moving in the GC and the HVSs escaping from the Galactic halo, under the hypothesis that both the GC S-stars and the HVSs are the products of tidal breakup of the same population of stellar binaries by the central massive black hole (MBH). We find that many statistical properties of the detected HVSs and GC S-stars can be reproduced by some binary injecting models. We predict the statistical distributions of their companions (ejected companions for GC S-stars and captured companions for HVSs). We also study the properties of those pulsars due to the explosion of the GC S-stars and the HVSs resulting from our models, some of which are closely bound to the MBH and some are ejected to the Galactic halo with hyper-fast velocities. Future surveys would provide a test for the predictions and constrain the models.

A dipole on the sky : Predictions for hyper-velocity stars from the Large Magellanic Cloud

Douglas Boubert

Friday, August 19, 10.30
in session "Hyper-velocity Stars and the Galactic Center"

We predict the distribution of hyper-velocity stars (HVSs) ejected from the Large Magellanic Cloud (LMC), under the assumption that the dwarf galaxy hosts a central massive black hole (MBH). For the majority of stars ejected from the LMC the orbital velocity of the LMC has contributed a significant fraction of their Galactic rest frame velocity, leading to a dipole density distribution on the sky. We quantify the dipole using spherical harmonic analysis and contrast with the monopole expected for HVSs ejected from the Galactic Center (GC). There is a tendril in the density distribution that leads the LMC which is coincident with the well-known and unexplained clustering of HVSs in the constellations of Leo and Sextans. Our model is falsifiable, since it predicts that Gaia will reveal a large density of HVSs in the southern hemisphere.

Constraints on the Galactic potential from hyper-velocity stars

Oleg Gnedin

Friday, August 19, 11.20
in session "Hyper-velocity Stars and the Galactic Potential"

I will describe current constraints on the mass distribution in the Galactic halo and shape of the gravitational potential from the surveys of hyper-velocity stars. I will also discuss expected improvements from Gaia data and future space observatories.

Cool run-aways - Nearby Hills ejecta as a probe of the gravitational potential of the Milky Way

Yanqiong Zhang

Friday, August 19, 11.50
in session “Hyper-velocity Stars and the Galactic Potential”

It is now known that the center of the Milky Way hosts a super-massive black hole. This black hole can disrupt nearby stellar binaries, due to dynamical interactions, resulting in one of the stars being flung from the center of the Galaxy at exceptionally high speeds. These so-called Hills stars, or hyper-velocity stars, have been found in the halo of the Milky Way in the form of young (mainly) B-type stars. However, it has been predicted that there should also be a population of older, cooler Hills stars. We search for such stars in the solar neighbourhood using SDSS and our own spectroscopy, obtaining a number of promising candidates. As well as providing valuable insights into the shrouded populations of the central region of the Galaxy, they are important probes of the mass distribution in the Milky Way. With precise 3D velocities and positions from Gaia, the orbits of these stars can be used to directly measure the gravitational potential. We perform simulations to quantify how well Gaia will be able to constrain the potential for nearby Hills stars, showing that even small samples (tens of stars) can result in meaningful constraints. In the future these stars will be an important tool for illuminating the dark matter distribution in the Galaxy.

Joint constraints on the Galaxy dark matter halo and Galactic Center from hyper-velocity-stars

Elena Maria Rossi

Friday, August 19, 12.10
in session "Hyper-velocity Stars and the Galactic Potential"

The mass and shape of the Milky Way dark matter halo are currently poorly known, and tighter constraints are sought in order to differentiate between different underlying cosmological (and dark matter) models. Moreover, the origin of Galactic Center stars within the inner 5 pc is highly debated. Hyper-velocity stars (HVS) have been suggested as a possible alternative dynamical probe of the Galactic potential and their characteristics and origin can shed light onto the Galactic Center formation history. Their potential however has not until now being realised. In this talk, I will review our work on modelling current HVS data and how we may place joint constraints on the Galactic halo and the Galactic Center binary population. We will also show how more and better quality (Gaia) data will allow us to break parameter degeneracy and put tighter constraints.