Stars on the Run II

25.8.–30.8.2019

University of Potsdam, Germany

Scientific contributions

Talk

Kinematics of sdB and sdOB stars from GAIA and SDSS data

A. Bastian[1], S. Geier[1], I. Pelisoli[1]

[1]*Institut für Physik und Astronomie, Universität Potsdam, Germany*

We present the kinematic analysis of 279 sdB and sdOB stars from the GAIA Data Release 2 and compare that with a previous analysis using data from ground based proper motion surveys and the Sloan Digital Sky Survey DR 7. We use the GalPy python package to do an analysis of the stars kinematic properties in order to separate them into thin disk, thick disk, and halo populations. We found that, using the significantly more precise proper motion measurements of GAIA DR2, the number of halo stars decreased from 78 in the previous analysis to 30, while the thin disk stars grew in number from four to 155.

Talk

Remnants of Donor Stars Ejected from Close Binaries with Thermonuclear Supernovae

Evan B. Bauer[1], Christopher J. White[1], Lars Bildsten[1]

[1]*Kavli Institute for Theoretical Physics, University of California, Santa Barbara*

Some binary systems composed of a white dwarf (WD) and a hot sub-dwarf (sdB) helium star will make contact within the helium burning lifetime of the sdB star at orbital periods of 20-30 minutes. Helium accretion onto the WD will then lead to a detonation resulting in a thermonuclear supernova. The short orbital period at this moment implies donor orbital velocities of 700-900 km/s. Motivated by the recent discovery of objects moving at these velocities and occupying unusual locations on the HR diagram, we explore the impact of the thermonuclear supernovae on the donors in this specific double detonation scenario. We discuss models employing MESA to model the binary up to the moment of detonation, then 3D Athena++ to model the hydrodynamic interaction of the supernova ejecta with the donor star, calculating the amount of mass that is stripped and the entropy deposited in the deep stellar interior by the strong shock that traverses it. We model the long-term thermal evolution of remnants by introducing the shock entropy into MESA models. In response to this entropy change, donor remnants expand and brighten for timescales ranging from 10^6-10^8 years, giving ample time for these runaway stars to be observed in their inflated state before they leave the galaxy. Even after surface layers are stripped, some donors retain enough mass to resume core helium burning and further delay fading for more than 10^8 years. Finally, we discuss the relationship of this work to related work on double WD systems where a WD donor can be ejected from the system at even higher velocities. In the double WD case, the entropy imparted by the shock traversing the donor star has limited power to explain the significant expansion and brightening needed for observed hypervelocity objects.

Talk

The origin of massive runaway stars from nearby open clusters

Aakash Bhat[1], Andreas Irrgang[1], Ulrich Heber[1]

[1]*Dr. Karl Remeis-Observatory & ECAP, Astronomical Institute, Friedrich-Alexander University Erlangen-Nuremberg (FAU), Sternwartstr. 7, 96049 Bamberg, Germany*

Using proper motions and parallaxes from *Gaia's* second data release, we re-analyze the trajectories of nearby, massive runaway stars to check whether their kinematics are still consistent with an origin in the parent clusters that were identified by pre-*Gaia* studies. Moreover, we present a new method for finding stars that might have once been part of a cluster and report on the potential runaway candidates from nearby open clusters resulting from it.

Talk

Multi-wavelength observations of astrospheres/bow shocks of run-away stars

D.J. Bomans[1,2,3]

[1] *Ruhr University Bochum, Faculty of Physics and Astronomy, Astronomical Institute, Germany*
[2] *RUB Research Department "Plasmas with Complex Interactions"*
[3] *Ruhr Astroparticle and Plasma Physics (RAPP) Center*

During the last 20 years, observation of the circumstellar material around stars, and specially bow-shocks (and bow-waves) allowed the investigation of the mass loss properties and mass loss histories of very different stellar types. It also opened new avenues to determine the interaction mechanisms and properties of the surrounding circumstellar and interstellar medium, and their magnetic fields. In this talk I will review the current state of multi-wavelength observations of astrospheres/bow shock nebulae. While most observations of bow-shock nebulae concentrated on the MIR and FIR emission up to now, I will especially discuss the power of UV, optical, and NIR line emission to characterize circumstellar environments/astrospheres. Further, I will discuss the observational properties for different temperature, mass-loss properties, and evolutionary state of the stars, as well as the effects of different interstellar environments and the relative motion of the run-away stars.

Talk

Hypervelocity discoveries with GAIA DR2

D. Boubert[1]

[1] *Magdalen College, University of Oxford, High Street, Oxford OX1 4AU, UK*

The Gaia mission is an unprecedented opportunity to discover and characterise hypervelocity and runaway stars. Already with the preliminary second data release, we have seen the discovery of white dwarfs moving at 1000s of km/s and proof of a massive star having been ejected from the Large Magellanic Cloud at 900 km/s. However, we must be careful to distinguish rare fast-moving stars from statistical and systematic outliers. I will illustrate this point by presenting investigations into fast stars that have uncovered issues with the Gaia radial velocities of more than a hundred thousand stars. I will end by demonstrating the power of Gaia to characterize faint, blue sources as white dwarfs, blue horizontal branch stars and quasars, and thus show an efficient way to find massive hypervelocity stars in the halo.

Talk

Gaia and the Galactic Center Origin of HVS

W. R. Brown[1]

[1] *Center for Astrophysics | Harvard & Smithsonian*

We use *Gaia* to examine the origin of high velocity B-type stars in the HVS Survey. The stars are selected by magnitude and color. We then measured their radial velocity. We observe three classes of stars with distinct but overlapping distributions: Galactic center HVSs, Galactic disk runaways, and normal halo stars. Halo stars dominate the sample at speeds 100 km/s below Galactic escape velocity. Disk runaways dominate the sample at speeds within ±100 km/s of Galactic escape velocity. Galactic center HVS ejections dominate the sample at speeds >100 km/s above Galactic escape velocity.

Talk

SMC Field OB Stars: Dynamical vs Supernova Ejections

N. Castro[1], M. S. Oey[2], J. Dorigo Jones[2], I. Vargas-Salazar[2], K. Paggeot[2], M. Moe[3], S. Simon-Diaz[4], D. J. Lennon[4], M. K Szymanski[5]

[1] *Leibniz-Institut fr Astrophysik An der Sternwarte 16 14482 Potsdam, Germany*
[2] *Department of Astronomy University of Michigan 1085 South University Ave. Ann Arbor, MI 48109-1107, USA*
[3] *Steward Observatory University of Arizona 933 North Cherry Avenue, Tucson, AZ 85721, USA*
[4] *Instituto de Astrofsica de Canarias E-38205 La Laguna, Tenerife, Spain*
[5] *Warsaw University Observatory, Al. Ujazdowskie 4, 00-478 Warszawa, Poland*

Field OB stars comprise a significant fraction of the massive star population in star-forming galaxies. We evaluate the relative contribution of runaway stars vs in-situ formation of massive field stars in the Small Magellanic Cloud, using the Runaways and Isolated O-Type Star Spectroscopic Survey of the SMC (RIOTS4). We present GAIA DR2 kinematics of the sample, identifying subsets of eclipsing binaries, double-lined spectroscopic binaries, and high-mass X-ray binaries (HMXBs) from the literature. The non-compact binaries are tracers of dynamical ejections of runaways from clusters, while the HMXBs are tracers of the supernova ejection mechanism. We also present projected rotational velocities for most of our targets, measured from our RIOTS4 spectra. Using OGLE-III data, we carry out stellar density analyses around the target stars to evaluate the presence of sparse clusters indicative of in-situ formation. Overall, we infer that the vast majority of field OB stars in our sample are runaways, dominated by dynamical ejections from clusters.

Talk

A Systematic Search for OB Runaway Stars in Several Supernova Remnants

B. Dinçel[1], R. Neuhäuser[2] S. K. Yerli[3] A. Ankay[4]

[1] *Dr. Karl Remeis-Sternwarte, Erlangen Centre for Astroparticle Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, Sternwartstrasse 7, D-96049 Bamberg, Germany*
[2] *Astrophysikalisches Institut und Universitäts-Sternwarte Jena, 07745 Jena, Germany*
[3] *Orta Doğu Teknik Üniversitesi, Department of Physics, 06531 Ankara, Turkey*
[4] *Boğaziçi University, Department of Physics, 34342 İstanbul, Turkey*

We performed a systematic search for OB–type runaway stars inside 30 supernova remnants (SNRs) to find the pre–supernova binary companion. Using BVJHK band photometry we created a OB–type star candidate list of targets which are located close to the geometrical center of the SNRs. We then carried out low resolution spectroscopic observations of 170 stars and identified their spectral types. Based on Gaia parallax and proper motion values, we had a clear view of the kinematics of the candidates. However, except for five candidates in different SNRs with poor astrometric data, the massive runaway star HD 37424 inside the SNR S 147 is the only OB runaway star which can be linked to an SNR. HD 37424 is a B0V–type runaway star with a peculiar velocity of 100±4 km s^{-1}. The effective temperature of the star is 30000±1000 K and the logarithm of surface gravity is 4.0±0.25 in cgs. The star has a moderate projected rotational velocity, 140±20 km s^{-1}. Tracing back the past trajectories via Monte Carlo simulations, we found that HD 37424 had been located close to the SNR's geometrical center and at the same position as the pulsar PSR J0538+2817, 29200±400 yr ago. Another massive runaway star HD 254577 inside SNR IC 443 shows a kinematic relation to a neutron star but its position is a chance projection with the SNR.

We also discuss the reasons why OB runaway stars are missing inside SNRs with regard to the nature of the progenitors and the observational limitations.

Talk

Hypervelocity stars and the LMC

D. Erkal[1]

[1]*Department of Physics, University of Surrey*

I will discuss the past orbits of 26 hypervelocity stars with proper motions from Gaia DR2. One of these, HVS3, has a past orbit consistent with being ejected from the center of the LMC with a large velocity of $\sim 900\,\mathrm{km/s}$. Such a large velocity can only arise with a Hills-type encounter with a massive blackhole, suggesting that the LMC harbours a $\sim 4 \times 10^3 - 10^4\,M_\odot$ black hole. I will also discuss the predicted influence of the LMC on the population of hypervelocity stars ejected from the Milky Way center and how this must be accounted for in order to use hypervelocity stars to measure the potential of our Galaxy.

Talk

A modelling pipeline for Gaia constraints on the Galactic dark matter halo

F. Evans, E. M. Rossi, T. Marchetti, O. Contigiani

Leiden Observatory, Leiden University, 2300 RA, Leiden, The Netherlands

The prospect of a population of hypervelocity stars lurking in current and future data releases from the *Gaia* mission has sparked renewed interest in them as a dynamical tracer of the Galactic dark matter halo. In this talk, I will outline how we have developed a sophisticated modelling pipeline to assess the ability of hypervelocity stars to constrain the size, mass and shape of the Milky Way halo given realistic observational errors. In doing so, we will be better prepared to maximally exploit future populations of hypervelocity stars uncovered in *Gaia* data releases. Using a realistic sample of hypervelocity stars ejected and propagated through the Milky Way with mock *Gaia* observations applied, I will show how relevant halo potential parameters can be extracted and how large a sample is required to achieve a given precision. While the hypervelocity star sample size and measurement accuracy provided by *Gaia* DR2 may not be sufficient to meaningfully constrain the Milky Way halo potential parameters, we forecast forward to DR3 and beyond, offering insight on how these constraints should improve and the number of hypervelocity stars required to achieve these constraints.

Talk

The Gravitational Potential of the Milky Way and the Riddle of the Hypervelocity Stars

N. Wyn Evans[1]

[1] *Institute of Astronomy, Madingley Rd, Cambridge*

Before stars can be flagged as hypervelocity, they must be shown to exceed the escape velocity of the Milky Way galaxy. Data from the Gaia satellite have revolutised our ideas of the mass and potential of the Milky Way. Here, we review a number of recent methods to measure these quantities, including: (i) virial mass estimates derived from the three dimensional motions of the globular clusters and of the halo stars, (ii) estimates of the potential from dynamical modelling of the stellar phase space distributions, and (iii) direct measures of the escape velocity from the high-velocity tail of halo stars. Whilst a range of Milky Way masses have been advocated in the literature, from below $10^{12} M_\odot$ to above $2 \times 10^{12} M_\odot$, the Gaia data imply an intermediate mass is most likely. Our increased knowledge of the gravitational potential, as well as the improved Gaia proper motions for the candidates, has two important consequences for the hypervelocity stars; first, few of the hypervelocity stars seem to emanate from the Galactic Centre and second, few of the hypervelocity stars seem to emanate from from the LMC or the satellite galaxies. We conclude that the origin of the hypervelocity stars is a complex riddle without a unique and tidy answer.

Talk

Searching for fast hot subdwarfs before and after Gaia DR2

S. Geier[1], et al.

[1] *Institut für Physik und Astronomie, Universität Potsdam, Germany*

Motivated by the discovery of the hot subdwarf (sdO) US 708 as second HVS, we conducted a survey to search for more stars of this kind. Combining spectroscopic data from SDSS with ground-based proper motions, we compiled a catalogue of fast sdO/B candidates and performed numerous spectroscopic follow-up observations to refine their radial velocities and spectroscopic distances. I will present the results of this survey in combination with Gaia DR2.

Talk

Stellar motions near the Galactic Center black hole

S. Gillessen[1]

[1] *MPE Garching, Germany*

By means of high resolution techniques the stellar population in the Milky Way center is fully resolved, and positions and 3D velocities for a large number of individual stars can measured. Most spectacular are the stellar orbits in the central arcsecond, that have turned into precision tools for measuring mass and distance of SgrA* and which also allow for tests of general relatvity. The novel interferometer GRAVITY on the VLTI delivers spectacular results, owed to its unprecedented resolution and astrometric accuracy in the highly crowded stellar field. I will present the latest results of our team, which includes a very accurate measurement of the distance to the Galactic Center, the detection of the gravitational redshift in the gravitational field of SgrA* and a test of the equivalence principle.

Talk

THERMAL EMISSION FROM BOW SHOCKS I: 2D HYDRODYNAMICAL MODELS OF THE BUBBLE NEBULA

S. Green[1,2], J. Mackey[1], T. J. Haworth[3], V. V. Gvaramadze[4,5],, P. Duffy[2]

[1]*Dublin Institute for Advanced Studies, Astronomy & Astrophysics Section, 31 Fitzwilliam Place, Dublin 2, Ireland*
[2]*School of Physics, University College Dublin, Belfield, Dublin 4, Ireland*
[3]*Astrophysics Group, Blackett Laboratory, Imperial College London, Prince Consort Road, London SW7 2AZ, UK*
[4]*Sternberg Astronomical Institute, Lomonosov Moscow State University, Universitetskij Pr. 13, Moscow 119992, Russia*
[5]*Space Research Institute, Russian Academy of Sciences, Profsoyuznaya 84/32, 117997 Moscow, Russia*

The Bubble Nebula (or NGC 7635) is a parsec-scale seemingly spherical wind-blown bubble around the relatively unevolved O star BD+60°2522. The young dynamical age of the nebula and significant space velocity of the star suggest that the Bubble Nebula might be a bow shock. We ran 2D hydrodynamic simulations to model the interaction of the wind of the central star with the interstellar medium (ISM). The models cover a range of possible ISM number densities of $\mathrm{n} = 50-200\,\mathrm{cm}^{-3}$ and stellar velocities of $\mathrm{v}^{\star} = 20-40\,\mathrm{km\,s}^{-1}$. Synthetic H$\alpha$ and $24\,\mu$m emission maps predict the same apparent spherical bubble shape with quantitative properties similar to observations. The synthetic maps also predict a maximum brightness similar to that from the observations and agree that the maximum brightness is at the apex of the bow shock. The best-matching simulation had $\mathrm{v}^{\star} \approx 20\,\mathrm{km\,s}^{-1}$ into an ISM with n $\sim 100\,\mathrm{cm}^{-3}$, at an angle of 60° with respect to the line of sight. Synthetic maps of soft (0.3−2 keV) and hard (2−10 keV) X-ray emission show that the brightest region is in the wake behind the star and not at the bow shock itself. The unabsorbed soft X-rays have a luminosity of $\sim 10^{32} - 10^{33}\,\mathrm{erg\,s}^{-1}$. The hard X-rays are fainter: $\sim 10^{30} - 10^{31}\,\mathrm{erg\,s}^{-1}$, and may be too faint for current X-ray instruments to successfully observe. Our results imply that the O star creates a bow shock as it moves through the ISM and in turn creates an asymmetric bubble visible at optical and infrared wavelengths and predicted to be visible in X-rays.

Talk

Hypervelocity stars from star clusters hosting Intermediate-Mass Black Holes

Alessia Gualandris[1]

[1] *University of Surrey, UK*

The leading scenario for the ejection of Hypervelocity Stars (HVSs) is an encounter with the supermassive black hole in the Galactic Centre. However, new proper motions from the Gaia mission indicate that only the fastest HVSs can be traced back to the Galactic centre and the remaining stars originate in the disc or halo. I will present results from a study of HVSs generated by encounters of stellar binaries with an intermediate-mass black hole (IMBH) in the core of a star cluster. For the first time, the effect of the cluster orbit in the Galactic potential on the observable properties of the ejected population is included in the model. HVSs generated by this mechanism do not travel on radial orbits consistent with a Galactic centre origin, but rather point back to their parent cluster, thus providing observational evidence for the presence of an IMBH. I will also discuss the ejection of high-velocity stars from the Galactic population of globular clusters, assuming that they all contain an IMBH, including the effects of the clusters orbit and propagation of the star in the Galactic potential up to detection. High-velocity stars ejected by IMBHs have distinctive distributions in velocity, Galactocentric distance and Galactic latitude, which can be used to distinguish them from runaway stars and stars ejected from the Galactic Centre.

Nebulae around runaway stars

V.V. Gvaramadze[1,2]

[1]*Sternberg Astronomical Institute, Lomonosov Moscow State University*
[2]*Space Research Institute, Russian Academy of Sciences*

Infrared sky surveys carried out by the modern space telescopes *Spitzer* and *WISE* led to the discovery of a large variety of circum- and interstellar nebulae around massive and less massive stars. The high angular resolution of these surveys allowed us to see the fine structure of newly discovered and previously known nebulae, which leads to the need for modification or revision of models of their formation. In this presentation, I will discuss the possible role of variable mass loss in interacting binary systems, stellar and interstellar magnetic fields, and circumstellar disks in the formation of the observed morphological diversity of nebulae produced by runaway stars.

Talk

Stars on the run from N-body simulations

J. Haas[1], L. Šubr[1]

[1]*Astronomical Institute of Charles University, Prague, Czech Republic*

One of the most natural ways how to investigate the stellar dynamical processes that lead to production of high/hyper-velocity stars is direct N-body modelling. In my talk, I will describe three examples, mainly focusing on the possible galactocentric origin of the hypervelocity stars observed in the Galactic halo.

Talk

Insights from the massive hyper-runaway subgiant star LAMOST-HVS1

Kohei Hattori[1,2]

[1] *University of Michigan*
[2] *Carnegie Mellon University*

The orbits of massive fast-moving stars provide information on the physical mechanism to eject such stars as well as the environment where massive stars form.

Here I report that LAMOST-HVS1 is a massive hyper-runaway subgiant star with a mass of $\sim 8.3 M_\odot$ and super-solar metallicity, which was ejected from the inner stellar disk of the Milky Way ~ 33 Myr ago with the intrinsic ejection velocity of 568^{+19}_{-17} km/s (corrected for the streaming motion of the disk), based on the proper motion data from Gaia DR2 and high-resolution spectroscopy from Magellan/MIKE. The extremely large ejection velocity indicates that this star was not ejected by the supernova explosion of a binary companion. Rather, it was probably ejected by a three- or four-body dynamical interaction with more massive objects in a high-density environment. Such a high-density environment may be attained at the core region of a young massive cluster (YMC) with mass of $10^4 M_\odot$. The ejection agent that took part in the ejection of LAMOST-HVS1 may be an intermediate mass black hole ($\sim 100 M_\odot$), a very massive star ($\sim 100 M_\odot$), or multiple ordinary massive stars ($\sim 30 M_\odot$). Based on the flight time and the ejection location of LAMOST-HVS1, we argue that its ejection agent or its natal star cluster is currently located near the Norma spiral arm. The natal star cluster of LAMOST-HVS1 may be an undiscovered YMC near the Norma spiral arm.

Currently, LAMOST-HVS1 is the only well-confirmed massive ($> 8 M_\odot$) hyper-runaway star. Based on some theoretical argument, we expect that we will find a few more examples of massive hyper-runaway stars. If more examples of massive hyper-runaway stars are discovered in the future, they will provide some insights into the physical mechanism to eject such stars.

Talk

Hyper-velocity stars in the Gaia era: Old friends revisited

U.Heber[1]

[1] *Dr. Remeis-Sternwarte & ECAP, Universität Erlangen-Nürnberg, D 96049 Bamberg, Germany*

In 2005 three hyper-velocity star were discovered serendipitously. The short life time of the massive B star HVS3 was found to be at variance with an origin in the Galaxy and it was suggested that the star originates from the Large Magellanic cloud (LMC, Edelmann et al. 2005). It remained the only known HVS star likely to come from the LMC. HVS 2 (US 708) is a helium-rich sdO star unbound to the Galaxy (Hirsch et al. 2005). Large efforts have been undertaken to find high-velocity hot subdwarf stars (e.g. Tillich et al. 2011, Nemeth et al. 2016, Ziegerer et al. 2017) but did not reveal any candidates travelling as fast as US 708. The second data release of Gaia provided proper motions of unprecedented precision. We revisit HVS2 and the hot subdwarf candidates using Gaia proper motions.

Edelmann et al. 2005, ApJ 634, L181
Hirsch et al. 2005, A&A 444, L61
Tillich et al. 2011 A&A 527, 137
Nemeth et al. 2016, ApJ 821, L13
Ziegerer et al. 2017, A&A 601, 58

Talk

Spectroscopy of partially burnt runaway stars

M. Hollands[1], R. Raddi[2], D. Koester[3], B. Gänsicke[1], J.J. Hermes [4], et. al.

[1] *The University of Warwick*
[2] *Friedrich-Alexander Universität Erlangen-Nürnberg*
[3] *University of Kiel*
[4] *Boston University*

LP 40-365 is a runaway star that has survived the thermonuclear detonation of its progenitor white dwarf. This is inferred not only from its unusual kinematics, but also from its metal-dominated spectrum. The stellar atmosphere contains a plethora of alpha and Fe-group elements, and is devoid of hydrogen and helium. New examples of this class show up to 19 elements thanks to high-resolution spectroscopy.

In this talk, I will discuss the spectroscopic abundances of the LP 40-365 class and the information they yield about their formation scenario. Furthermore I will detail some of the challenges involved in modelling their complicated spectra, as well future prospects for identifying LP 40-365 stars from large spectroscopic surveys. I will conclude by presenting recent observations of another kinematically and chemically peculiar object, whose abundances are incompatible with other runaway objects (i.e. LP 40-365 and D^6 stars).

Talk

Hypervelocity stars in the *Gaia* era: Runaway B stars beyond the velocity limit of classical ejection mechanisms

Andreas Irrgang[1], Simon Kreuzer[1], Ulrich Heber[1]

[1] *Dr. Karl Remeis-Observatory & ECAP, Astronomical Institute, Friedrich-Alexander University Erlangen-Nuremberg (FAU), Sternwartstr. 7, 96049 Bamberg, Germany*

Young massive stars in the halo are assumed to be runaway stars from the Galactic disk. Two mechanisms are usually discussed in the literature to explain them: binary supernova ejection and dynamical ejection from star clusters. With typical ejection velocities below a few hundred $\mathrm{km\,s^{-1}}$, both of these "classical" disk runaway scenarios are by far less powerful than the Hills mechanism, i.e., the tidal disruption of a binary system by the supermassive black hole at the Galactic center, which can eject stars with thousands of $\mathrm{km\,s^{-1}}$. Thus, until recently, the Hills mechanism was widely assumed to be the only ejection scenario that is capable of accelerating massive stars to hypervelocity, i.e., beyond their local escape velocity from the Galaxy. However, based on proper motions from *Gaia*'s second data release, we demonstrate here that the Galactic center can be most likely ruled out as spatial origin for some of the known hypervelocity candidates. Because the disk-ejection velocities of those dismissed Hills stars exceed the upper limits for the two "classical" scenarios mentioned above, we argue that a powerful but yet neglected or unknown mechanism, e.g., dynamical interactions with massive stars or intermediate-mass black holes, must be at work.

Talk

Heavy Metal Subdwarfs and Hypervelocities

C. Simon Jeffery[1], P. Martin[1], et al.

[1]*Armagh Observatory and Planetarium*

Hot subdwarfs are smaller than hydrogen-burning main-sequence stars and larger than white dwarfs. They include stars in several different advanced stages of evolution. Most have surfaces severely depleted in either hydrogen or helium; some explanation exists for most of these. In between lie the rare "intermediate helium subdwarfs", which pose significant challenges, not least to explain their surface composition in terms of diffusion physics and a coherent formation paradigm. Discovered in 2011, LS IV-14 116 became the first "heavy-metal subdwarf". This subgroup of intermediate helium subdwarfs shows extraordinary surface abundances of the heavy metals zirconium, yttrium, strontium, germanium and lead. Now numbering eleven stars, all heavy-metal subdwarfs appear to be on high-energy galactic orbits. Three pulsate in modes which, until now, were thought impossible and can only be driven if the interior is substantially enriched on carbon and oxygen. The question is – are the high velocities due to a halo origin, or to ejection from a binary following a catastrophic event? Can either hypothesis be reconciled with heavy-metal surface and the interior opacity required to drive pulsations?

Talk

Gaia and hyper-velocity stars

S. Jordan

Astronomisches Rechen-Institut am Zentrum fr Astronomie der Universität Heidelberg, Mönchhofstr. 12-14, D-69120 Heidelberg, Germany

Several dozen papers have been published using the high-precision astrometry from Gaia Data Release 2 for run-away and hyper-velocity stars. The talk will discuss the status of the Gaia mission and will explain how to utilize the Gaia catalogue most efficiently and with care. Finally, an outlook on Gaia DR3 and further releases will be provided.

Talk

The discovery of a nearby 1700 km/s hyper-velocity star ejected by Sgr A*

S. E. Koposov[1], S5 Collaboration

[1] *Carnegie Mellon University*

We present a discovery of a remarkable hyper-velocity star in the Southern Stellar Stream Spectroscopic Survey. It is an 16-th magnitude A-type 2 solar mass main sequence star located at the distance of 7.3±1.3 kpc from the Sun with radial velocity of >1000 km/s. The current velocity of the star in the Galactic frame is 1500 ± 150 km/s. When integrated backwards in time the orbit of the star points with accuracy at the Galactic center (GC), suggesting it as the source. Assuming that the GC is the origin of the HVS, we derive ejection speed from Sgr A* of 1800 km/s and travel time of 5 Myr to the current location. The star provides strong constraints on the geometry and kinematics of the Sun in Galaxy, such as the V velocity component of the Solar motion V_y= 245±5km/s. The ejection direction of the star also coincides with the orbital plane of disk of young stars orbiting the Galactic center, suggesting that S5-HVS1 may have been produced by a binary from young stellar disk around the GC.

Talk

MMT HVS sample revisited

S. Kreuzer[1], A. Irrgang[1], U. Heber[1]

[1]*Dr. Karl Remeis-Observatory & ECAP, Astronomical Institute of the FAU, Sternwartstr. 7, 96049 Bamberg, Germany*

The MMT survey carried out by Brown et al. (2006) was a systematic search for Hypervelocity stars in the Galactic halo. Here, we present a new analysis of the spectra of all HVS stars discovered in the course of the MMT survey. We applied new spectral models calculated in a hybrid LTE/non-LTE approach following the description in Przybilla et al. (2011) in order to determine atmospheric parameters. Gaia proper motions would allow us for the first time to perform a kinematic analysis by making use of the full 6D phase space information. However, Gaia parallaxes are by far too uncertain because of the stars' large distances (tens of kpc). Therefore, we have to determine accurate and precise spectroscopic distances. After obtaining the full 6D phase space information we are able to trace back the HVS stars to their places of origin using different models of the Galactic potential. This allows us to distinguish between different acceleration mechanisms.

Talk

Stellar disc streams as probes of the Galactic potential

C. Laporte[1]

[1] *Department of Physics & Astronomy, University of Victoria, Canada*

Stars aligned in thin stream-like features (feathers), with widths of $\delta \sim 10^\circ$ and lengths as large as $\Delta l \sim 180^\circ$, have been observed towards the Anticenter of our Galaxy. We re-interpret their origin by analysing similar features arising in an N-body simulation of a Galactic disc interacting with a Sagittarius-like dwarf spheroidal galaxy (Sgr). By following the orbits of the particles identified as contributing to feathers backwards in time, we trace their excitation to one of Sgr's previous pericentric passages. The structures are long lived and persist after multiple passages on timescales of $\sim 4\,$Gyrs. On the sky, they exhibit oscillatory motion that can be traced with a single orbit mapped over much of their full length and with amplitudes and gradients similar to those observed. These structures can be exploited to measure the potential, its flattening, as well as infer the strength of recent potential perturbations.

Talk

Hubble astrometry and proper motions of isolated massive stars near the Galactic Center

D. Lennon[1], M. Libralato[2], R. van der Marel[2], A. Bellini[2]

[1]*IAC*
[2]*STScI*

The Galactic Center is one of the most perplexing and unusual regions of the Galaxy. Not only is it home to the central massive black hole but it contains three very massive young star clusters within the central 30 pc; the Arches, Quintuplet and Central clusters. Furthermore, emission-line surveys have revealed the presence of what appears to be a diaspora of ∼50 very massive isolated Wolf-Rayet-like stars scattered throughout the region, outside of these massive clusters. Their origin is currently unkown but the suspected causes include such diverse and exotic mechanisms as ejection by dynamical interaction within the massive clusters, ejection by supernovae events within those clusters old enough to have SN, ejection by interaction with the central black hole, stellar mergers in the field, in situ star formation of isolated massive stars, and tidal distruption of clusters. Here we present a proper motion catalogue of stars around the Galactic Center obtained using the WFC3 IR camera of the Hubble Space Telescope and discuss initial results concerning the dynamics of the isolated massive stars that have been discovered in this region.

Talk

LAMOST and hypervelocity stars

Y. Lu[1]

[1]*National Astronomical Observatory of China, Beijing*

In this talk, I will give a short overview of the formation mechanisms for hypervelocity stars and the possible signatures to identify its origin. Then I will summarize the discovery of some hypervelocity stars and high velocity stars by LAMOST and further discuss the origin of those stars.

Talk

Runaway stars in supernova remnants

Oliver Lux[1], Ralph Neuhäuser[1], Markus Mugrauer[1]

[1] *Astrophysical Institute and University Observatory Jena*

It is suggested that runaway stars can result from core-collapse supernova (SN) explosions in multiple stellar systems, where they get unbound and then travel through space with their former orbital velocity. Previous searches for runaway stars have considered only OB-type stars, because they are always young (the age of the SN remnant (SNR) plus the life-time of the SN progenitor) and easier to find. We search for runaway stars of all spectral types, down to the lowest possible stellar masses, in nearby SNRs. We selected five SNRs up to a distance of 500 pc plus four historical SNRs, namely Cas A, 3C58 (SN 1181), Crab and G347.3-00.5 (SN 393). We use *Gaia* data to trace back the trajectories of candidate stars to the geometric center of the SNR and/or the birth location of an associated neutron star. For our runaway candidates we take spectra to determine the spectral type, radial and rotational velocities. In case of late-type stars we also search for the Lithium 6708 line to check for youth. Within our distance-limit, we expect to detect almost all runaway stars; hence, even non-detections will yield constraints about massive binary evolution and SN kick mechanisms.

Talk

Combining Gaia DR2 and multi-epoch optical spectroscopic surveys to find runaway OB stars

J. Maíz Apellániz[1], M. Pantaleoni González[1,2], R. H. Barbá[3], et al.

[1] *Centro de Astrobiología, ESAC Campus, Madrid, Spain.*
[2] *Universidad Complutense, Madrid, Spain.*
[3] *Universidad de La Serena, La Serena, Chile.*

Last year we published an analysis of Gaia *DR1* proper motions (Maíz Apellániz et al. 2018) in which we detected 76 runaway stars, one quarter of them previously unknown. Here we will describe our efforts finding runaways with Gaia *DR2*, for which we are combining parallaxes and proper motions with additional information from ground-based data. We are using our multi-epoch LiLiMaRlin high-resolution spectroscopy to determine accurate radial velocities for the candidate runaway stars in order to detect and correct for spectroscopic binaries, which are ubiquitous among OB stars. We are also using GOSSS (Galatic O-Star Spectroscopic Survey) spectra to provide accurate spectral classifications.

Talk

Asymmetric supernova remnants from runaway Wolf-Rayet stars

D. M.-A. Meyer[1]

[1] *Institute of Physics and Astronomy, University of Potsdam, D-14476, Potsdam, Germany*

The Luminous Blue Variable/Wolf-Rayet phenomena are amongst the most violent events that can affect the evolution of high-mass ($> 40\,M_{\odot}$) stars. It consists of the release of successive dense shells of outer stellar envelope material, which expand into the stellar surroundings and collide together, leading to the formation of complex wind bubble nebulae. Hence, when these stars die as core-collapse supernovae, the explosion takes place into a pre-shaped medium which strongly carries the imprint of their past stellar evolution. I will present self-consistent high-resolution numerical (magneto)- hydrodynamics simulations and radiative transfer calculations of the evolution of the surroundings of Luminous Blue Variable/Wolf-Rayet-evolving stars moving at different space velocities through the interstellar medium (ISM) of the Galaxy. The calculations are performed from the zero-age-main-sequence to the old ($\sim 100\,$kyr) supernova remnant phase. The nebula of such moving progenitor stars impose important asymmetries in the later expansion phase of their supernova shock wave. Particularly, the strongness of their Luminous Blue Variable/Wolf-Rayet stellar winds, as an additional effect, couple of the bulk stellar motion to generate unstable outflows made of mixed stellar wind, supernova ejecta and ISM gas which naturally explains the formation of old bipolar X-ray-emitting supernova remnants.

Talk

A pulsar-runaway-pair from a nearby supernova about 1.8 Myr ago that ejected 60-Fe found on Earth

R. Neuhäuser[1], F. Gießler[2], V. Hambaryan[2]

[1] *Astrophysics Institute, U Jena, Germany, rne@astro.uni-jena.de*
[2] *Astrophysics Institute, U Jena, Germany*

The detection of 1.5-3.2 Myr old 60-Fe on Earth indicates recent nearby core-collapse supernovae. For supernovae in multiple stars, the primary stars become neutron stars, while former companions can get unbound (runaway stars). By tracing back the space motion of runaway and neutron stars to the nearest young (about 16 Myr) association of massive stars (Scorpius-Centaurus-Lupus), we found kinematic evidence that a certain runaway star and a certain radio pulsar were released by a supernova in a binary about 1.8 Myr ago at about 107 pc distance; association age and flight time determine the progenitor mass (16-18 $M_{\odot}$), which can constrain supernova nucleosynthesis yields and 60-Fe uptake on Earth. Our scenario links 60-Fe found on Earth to an individual supernova in a binary.

Talk

Runaway hot subdwarfs - a key to understanding thermonuclear supernovae?

P. Neunteufel[1]

[1]*Argelander Institut fr Astronomie, Bonn, Germany*

Recent progress in theory as well as observation has strengthened the proposition that hypervelocity runaway hot subdwarfs may be products of thermonuclear supernova explosions. Given the persisting lack of a clear progenitor, aside from its suspected identity as close single or double degenerate binaries, of thermonuclear events such as supernovae of the Type Ia and related types, it would be attractive to use these objects as probes into the pre-explosion state of their ejection event.

This talk will discuss the viability of probing supernova progenitor binary states, and the explosion mechanism, using hypervelocity hot subdwarfs in the single degenerate channel. Building on the results of an extensive numerical study of the evolution of close binary systems, using the MESA framework, this talk will discuss the dependence of the ejection velocity of the prospective hypervelocity runaway on a wide range of initial conditions, including the metallicity of the progenitors host population, mass transfer efficiency and orbital configuration, while remaining as agnostic about the explosion mechanism as possible. It will be shown that the velocity space open to runaways produced in the single degenerate channel is well constrained, which allows strong limits to be placed on the pre-explosion state of the progenitor binary and that the metallicity of the host population does not strongly affect the ejection velocity.

These findings will be correlated with observations such as US 708 and the D6 objects, also commenting on the possibility of super-Chandrasekhar mass explosions.

Talk

Host Associations around Supernova Remnants S 147 and Antlia SNR

A. Pannicke[1,2], K. Schreyer[2], U. Heber[1], M. Sasaki[1], R. Raddi[1], B. Dinçel[1]

[1] *Dr. Karl Remeis-Observatory Bamberg*
[2] *Astrophysical Institute and University Observatory Jena*

Massive stars are mostly formed as a multiple system and end their life as type II supernova. In certain cases the binary gets disrupted and its companion becomes a runaway star. One of such is the supernova remnant (SNR) G180.0-01.7 (S 147), containing a neutron star and its corresponded runaway HD 37424. The already known distance and age information open the way to find their origin association, and to reconstruct the path of the SNR progenitor star. We present first results of the study on S 147 and also show the case of SNR G276.5+19.0 (Antlia SNR), as being a very close SNR with a neutron star and a possible runaway HIP 47155. We use data from Gaia DR2 and construct stellar vicinity maps around the SNRs. Population analysis reveals possible associations around the SNRs. In the case of S 147 a possible association has been found and will be discussed in the presented poster.

Talk

Testing Models for Runaway Stars

P. Podsiadlowski[1]

[1]*Department of Physics, University of Oxford*

Models for runaway stars fall into roughly three groups: runaways from supernova-disrupted binaries, dynamical ejection from clusters and interactions with very massive black holes. In the first part of the talk I will compare the various models and confront them with observed objects, particularly assessing the maximum velocities that can be attained, the actual population characteristics and their origin and the possible implications of observed systems for the underlying physics of the model (e.g. the supernova physics). In the second part I will propose a new model that does not fall into any of the three main classes, but that may be able to explain ultra-high-velocity objects, ranging from very low-mass white dwarfs to hot subdwarfs and possibly more massive compact objects.

Talk

The Gaia DR2 View on Hyper-Runaway Stars

N. Przybilla[1], A. Irrgang[2]

[1]*Institut für Astro- und Teilchenphysik, Universität Innsbruck, Technikerstr. 25/8, 6020 Innsbruck, Austria*
[2]*Dr. Karl Remeis-Observatory & ECAP, Astronomical Institute, Friedrich-Alexander University Erlangen-Nürnberg (FAU), Sternwartstr. 7, 96049 Bamberg, Germany*

Two kinds of massive stars have been found to move so fast that they are unbound to the Galaxy, hypervelocity stars and hyper-runaway stars. The former were accelerated using the Hills mechanism by the supermassive black hole in the Galactic centre, while the latter reached their velocity by other means, originating from locations in the Galactic disk. Ejection mechanisms comprise dynamical interactions in star clusters, supernova explosions of a Wolf-Rayet primary in a binary system and possibly interactions with an intermediate-mass black hole. A definite assignment to one of these object classes requires full knowledge of the six-dimensional phase-space information, and ideally also a quantitative spectroscopic analysis. Based on our initial studies of the stars HD 271791 and HIP 60350 we review the current knowledge of the class of hyper-runaway stars, in particular in the light of improved distances and proper motions from the Gaia DR2.

Talk

Runaway white dwarfs that survive to peculiar thermonuclear supernovae

R. Raddi[1], M. Hollands[2], D. Koester[3] et al.

[1] *Friedrich-Alexander Universität Erlangen-Nürnberg*
[2] *University of Warwick*
[3] *Universität Kiel*

LP 40-365 stars are suggested to be partly burned white dwarfs that survived to peculiar thermonuclear supernovae. These stars are likely thermally bloated and still contracting after being heated by the supernova explosion. Kinematic analysis suggests that LP 40-365 stars are ejected from compact binaries and, in some cases, overcome the Galactic escape velocity becoming unbound to the Milky Way. The focus of this presentation will be on the pre- and post-*Gaia* identification, providing an overview of the physical and kinematic properties of LP 40-365 stars as well as a comparison with theoretical models. The properties of the known class members are used to estimate their numbers in the *Gaia* database at the end of mission, showing that most LP 40-365 stars could stay bound to the Milky Way.

Talk

Hypervelocity Stars from a Supermassive Black Hole – Intermediate Mass Black Hole Binary

A. Rasskazov[1], G. Fragione[2], N. W. C. Leigh[3], 4, 5, H. Tagawa[1], A. Sesana[6], A. Price-Whelan[7], E. M. Rossi[8]

[1]*Institute of Physics, Eötvös University, Pazmany P. s. 1/A, Budapest, 1117, Hungary*

[2]*Racah Institute for Physics, The Hebrew University, Jerusalem 91904, Israel*

[3]*Department of Physics and Astronomy, Stony Brook University, Stony Brook, NY 11794-3800, USA*

[4]*Department of Astrophysics, American Museum of Natural History, New York, NY 10024, USA*

[5]*Departamento de Astronomia, Facultad de Ciencias Fisicas y Matematicas, Universidad de Concepcion, Concepcion, Chile*

[6]*School of Physics and Astronomy and Institute of Gravitational Wave Astronomy, University of Birmingham, Edgbaston B15 2TT, UK*

[7]*Department of Astrophysical Sciences, Princeton University, 4 Ivy Lane, Princeton, NJ 08544, USA*

[8]*Leiden Observatory, Leiden University, PO Box 9513, NL-2300 RA Leiden, the Netherlands*

We consider a scenario where the currently observed hypervelocity stars in our Galaxy have been ejected from the Galactic center as a result of dynamical interactions with an intermediate-mass black hole (IMBH) orbiting the central supermassive black hole (SMBH). By performing 3-body scattering experiments, we calculate the distribution of the ejected stars velocities given various parameters of the IMBH-SMBH binary: IMBH mass, semimajor axis and eccentricity. We also calculate the rates of change of the BH binary orbital elements due to those stellar ejections. One of our new findings is that the ejection rate depends (although mildly) on the rotation of the stellar nucleus (its total angular momentum). We also compare the ejection velocity distribution with that produced by the Hills mechanism (stellar binary disruption) and find that the latter produces faster stars on average. Also, the IMBH mechanism produces an ejection velocity distribution which is flattened towards the BH binary plane while the Hills mechanism produces a spherically

symmetric one. We then use these results to construct the model distributions of hypervelocity star positions and velocities in the galaxy that could be compared with Gaia observations.

Talk

Massive "widowed" stars: probes for explosions physics and binary evolution

M. Renzo[1].

[1]*Astronomical Institute Anton Pannekoek, University of Amsterdam, 1098 XH, Amsterdam, The Netherlands*

The vast majority of massive binary systems are disrupted at the first core-collapse event. The main cause are supernova natal kicks, which unbind the binary by increasing its total energy accelerating the compact object, but do not modify the velocity of the stellar companion. Thus, most disrupted massive binaries produce a slow "walkaway" star and a fast moving isolated compact object. In this talk, I am going to present the most common binary evolution path from population synthesis simulations, focusing on how we could use the mass distribution of runaways from the binary disruption scenario to put constraints on the black hole kicks, without seeing neither the black holes nor their formation. The over-production of walkaways relative to fast runaways also results in a small predicted O-type runaway fraction. This result is hard to reconcile with the observed value of $\sim 10-20\%$ and the common assumption that the majority of runaways come from binaries. This potential "missing runaway problem" might indicate insufficient understanding of the binary orbital evolution before the first core-collapse, problematic selection effects in observed runaway samples, and/or underestimated efficiency of the competing channel to form runaways by cluster ejections. I will illustrate how this potential problem might be addressed using present and future Gaia data releases, which should provide in DR5 a complete picture of the projected kinematics of Galactic massive stars.

Talk

Unbound stars to jointly investigate their explosive origin and the Galaxy mass

E. Rossi[1],

[1] *University of Leiden, The Netherlands*

In this talk, I will review the work done by my group to improve our understanding on how to use hyper/high velocity stars to trace the Galactic mass and its distribution. In addition, our dedicated studies to understand the origin of these stars using theory and observations will be reported.

Talk

Massive and Very Massive Runaway Stars

A.A.C. Sander[1], J. Vink[1]

[1]*Armagh Observatory & Planetarium, College Hill, BT61 9DG, Northern Ireland*

Massive runaway stars are interesting testbeds for various important astrophysical questions. Massive runaway stars might often be the remaining secondary of a binary system that has been disrupted by the core collapse of the primary. The detection of isolated massive and especially very massive stars is also inherently connected to whether or not massive stars can only be born in clusters or also in-situ, which is an ongoing debate in the field of star formation. Identifying, whether isolated massive stars are actually runaways than can be traced back to a cluster is crucial to set constrains for theories and simulations in this field. Confirmed massive runaways also have further implications for cluster dynamics and their potential upper mass limit. Since N-body dynamics suggest that typically the least massive participant is kicked out in an interaction, the finding of very massive runaways with more than $100\,M_\odot$ hints at stars significantly more massive in the originating clusters.

To properly identify massive runways stars and to really understand their nature, we need to combine astrometric and spectroscopic data. While sufficient astrometric data is a necessary basis, a quantitative spectroscopic analysis is crucial to verify the stellar parameters and to check whether e.g. candidates are really as massive as they seem to be. In this talk I will give a short overview about the basics of quantifying stellar spectra including the difficulties of obtaining radial velocities from emission-line stars and the need for a profound understanding of stellar wind structures to lift current degeneracies. I will also discuss a selection of massive star runaways and candidates of different evolutionary stage to illustrate the importance of understanding them with regards to the different astrophysical questions mentioned above.

Talk

Runaways from the Orion Nebula Cluster in simulations and observations

C. Schoettler,[1,2] J. de Bruijne,[2] R. J. Parker,[1] E. Vaher[2]

[1] *Department of Physics and Astronomy, The University of Sheffield, Hicks Building, Hounsfield Road, Sheffield S3 7RH, UK*

[2] *Science Support Office, Directorate of Science, European Space Research and Technology Centre (ESA/ESTEC), Keplerlaan 1, NL-2201 AZ Noordwijk, the Netherlands*

Theory predicts that we should find fast ejected (runaway) stars of all masses around dense, young star-forming regions like the Orion Nebula Cluster. N-body simulations show that the number and distribution of these ejected stars could be used to constrain the initial spatial and kinematic substructure of these regions. Most current observations of these runaway stars are high-mass stars (O or B stars). Until now, observational limitations have made it difficult to find lower-mass runaways, but this has changed with the advent of Gaia.
In this talk, I will present results from N-body simulations that produce a population of ejected stars from a star-forming region with initial conditions similar to the ONC. Using *Gaia* DR2, I have then searched the vicinity ($\sim$ 100 pc) of this cluster and find a number of runaway (and also walkaway star candidates at lower velocities) that could have been ejected from the ONC during its past dynamical evolution. I conclude by commenting on the likely initial conditions of the ONC, as constrained by these runaway and walkaway stars.

Talk

Nearby, halo, and hypervelocity white dwarfs in Gaia DR2

R.-D. Scholz[1]

[1]*Leibniz-Institut für Astrophysik Potsdam*

The first two data releases of Gaia (DR1 and DR2) have already been widely used to improve our knowledge on white dwarfs (WDs). Among the topics, where Gaia provided new insights, are (1) the overall census of these stellar remnants in the immediate Solar neighbourhood, (2) the membership of relatively nearby WDs in different Galactic populations including the Galactic halo, and (3) exotic luminous and more distant WD candidates that may reach even higher velocities than bound halo stars. In this poster the very nearby ($d < 10\,\mathrm{pc}$) newly discovered but also missing WDs in the Gaia data are highlighted. The Gaia 20 pc and 100 pc samples are discussed with respect to the WDs included therein, in particular concerning halo WDs defined kinematically with tangential velocities above 200 km/s. Finally, a critical review is given on local hypervelocity WD candidates with Galactocentric tangential velocities larger than 500 km/s and at distances from the Sun of up to 2.5 kpc. The important role of astrometric and photometric quality criteria in Gaia DR2, which one needs to apply for selecting nearby, halo, and hypervelocity WD candidates, is demonstrated in colour-magnitude diagrams.

Talk

The heavy metal sdB+MS halo binary MCT 0146−2651

J. Vos[1]

[1]*Institut für Physik und Astronomie, Universität Potsdam, Germany*

All currently known heavy metal hot subdwarfs are single stars on strange halo trajectories. MCT 0146−2651 is the first heavy metal sdB in a long period composite binary with an F-type companion. A long term monitoring program has yielded an orbital parameters and allowed for a detailed spectroscopic study of the companion. The existence of a heavy metal sdB in binary systems limits the possible formation channels, and can offer constraints on binary interactions. Furthermore, the analysis of the companion allows us a glimpse into the initial conditions under which these heavy metal stars were formed.

Talk

Luminous Blue Variables - a few among many

K. Weis[1], R. M. Humphreys[2]

[1]*Ruhr University Bochum, Faculty of Physics and Astronomy, Astronomical Institute, Germany*
[2]*Minnesota Institute for Astrophysics, Minneapolis, USA*

Luminous blue variables (LBVs) are massive evolved stars showing photometric as well as spectroscopic variabilities on various timescale and amplitudes. They are situated at very upper, but several also in a the lower regime of the HRD. LBVs have a high mass loss and can be unstable – being temporarily close to the Eddingtion limit – and undergo giant eruptions. Strong winds and eruption lead to the formation of small LBV nebulae.

The kinematics of this class of massive stars is not clear, and there is ongoing discussion on their relative isolation compared to other classes of massive stars. LMC-S119, however, is an LBV which stands out by showing signs of a high velocity motion compared to the ISM as well as a bowshock typ nebula.

In this contribution we discuss the nature of the LBV class and their nebulae in comparison to Wolf-Rayet stars, and revisit the possibility of the LBV LMC-S119 being a run-away star.

Talk

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

Y. Q. Zhang[1], M. C. Smith[2], P. J. McMillan[3]

[1]*Ningbo University of Technology, Zhejiang, 315200, China*
[2]*Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai, 200030, China*
[3]*Lund Observatory, Department of Astronomy and Theoretical Physics, Lund University, Box 43, SE-22100 Lund, Sweden*

We report the results of a new population synthesis model for stars ejected from the Galactic centre via the Hills mechanism (so-called Hills stars). This is done using a new model for the Galactic potential, based on McMillan (2017) but adapted to provide a better match to the inner galaxy. This is crucial for correctly modelling the deceleration as the stars leave the central few hundred parsecs. Our synthetic population is then normalised by comparing to the MMT Hyper-Velocity Star Survey, which is a magnitude-complete survey and thus ideal for this purpose. We have found a number of intriguing discrepancies between the synthetic and observed populations: firstly, it produces too many Hills stars with extremely high velocities (in excess of 700 km/s); secondly it produces too many nearby Hills stars; and thirdly the distribution is practically isotropic on the sky. We propose solutions to each of these discrepancies and discuss the physical implications. We also find interesting results concerning the properties of the resulting S-star population. Finally, our model predicts the distribution of lower-velocity bound Hills stars, most of which are faint and nearby. We show how these can be used to constrain models for the Galactic potential, demonstrating that meaningful constraints can be obtained if we have samples of around 50 nearby Hills stars.