MW-Gaia WG1-WG4 Workshop

The Galactic Centre and the Inner Galaxy

Heidelberg (Germany), 10th-12th February 2021

The workshop The Galactic Centre and the Inner Galaxy took place online organised by the Center for Astronomy of Heidelberg University, from 10th to 12th February 2021.

This was the fifth workshop of the CA18104 COST Action MW-Gaia and the first, which was held completely online due to the COVID-19 restrictions. It was the second workshop of the Working Groups 1 and 4. The format of the workshop was based on invited key presentations and contributed talks, e-posters, a practical hands-on session for EDR3, and dedicated discussions.

A main channel in Zoom was defined for plenary sessions and breakout channels for additional focussed discussions and meetings. Slack Channels were set up for dedicated chats.

Scientific motivation of the workshop

The inner regions of our Milky Way are dominated by the Galactic bar and a classical bulge. The barred potential causes gas to flow inwards and form stars in the central few 100 parsecs. Over time this process may have built up the nuclear stellar disk, also found at these radii. At the very centre, the nuclear star cluster surrounds the Galactic supermassive black hole, Sgr A*. The larger inner bulge region also contains the highest-density parts of the Milky Way's stellar halo, and perhaps a classical bulge component.

After this workshop, the Gaia data release EDR3 was released on Dec. 3, 2020, based on 34 months of observations. Compared to DR2 improvements in completeness and astrometry (20% in parallaxes, factor of two in proper motion) were expected. Additionally, more information on the parallax zero point was going to be included and the basis of the Celestial Reference Frame (CRF) extended to 1.5 million objects, a factor of three more.

This three-day workshop in (virtual) Heidelberg, was focused on the impact of the ultra-precise Gaia astrometry on our understanding of the structure and dynamics of the Galactic bar and bulge region including the interrelation with the inner halo, the nuclear stellar disc and the central star cluster. Chemical enrichment, ages and the assembly history were also covered. The celestial reference frame, zero points of parallaxes and proper motions, as well as questions of fundamental physics were discussed. Also first results based on EDR3 were presented.

Topics Covered

- ✓ Gaia EDR3: overview, completeness
- ✓ Gaia Ref Frame: zero points in parallax and proper motion, fundamental physics and relativistic effects using Gaia and VLBI, Sgr A* and testing GR
- ✓ Bulge, Bar and Inner Halo: kinematics, dynamics, mass distribution
- ✓ Bulge, Bar, Inner Halo: metallicity-orbit distribution and stellar ages
- ✓ Bulge, Bar, Inner Halo: critical discussion on stellar ages in Bulge, assembly history from (hydro-)dynamical and cosmological simulations
- ✓ Nuclear Disk, Gas Inflow and Star Formation

In each session there were invited review and contributed talks followed by a general discussion. Additionally, we offered short presentations of e-Posters and a hands-on session to learn how to use the Gaia EDR3 data.

Online Mode of Workshop

Since the workshop was fully online, we accepted more than 200 participants. This workshop was run online via Zoom with a number of parallel channels:

- One main channel for plenary sessions
- One channel for EDR3 hand-on sessions
- Three breakout channels for presentations (oral and e-Posters) for additional focused discussions and meetings.
- One additional free channel for spontaneous meetings (appointments via Slack or email).

Additional Slack Channels were set up for dedicated chats and a repository of questions and answers concerning the presentations.

A dedicated workshop website was setup to accompany the workshop. This website

- Summarized the mission statement of this workshop
- Provided the current workshop program which linked talks to abstracts and video recordings
- Presented workshop representatives in the SOC/LOC to the participants
- Gave instructions to participants regarding presentations, ZOOM issues, e-Poster presentations
- Linked Talks and Abstracts
- Provided access to video recordings of presentations more or less immediately after each session
- Informed about workshop news and current changes

Overview and summary of workshop sessions

Day One

Session 1: Gaia and EDR3

The first session started with an overview over the COST action MW-Gaia by Nicolas Walton, followed by an introduction by Carine Babusiaux (Paris) on the “Gaia satellite & EDR3: Status, Overview, Completeness.“. The great interest and importance of the new Gaia data release EDR3 was demonstrated by three contributed talks, which show first results already a few weeks after the data release: Céline Reyle discussed “The solar neighborhood kinematics from Gaia EDR3” based on the Gaia Catalogue of Nearby Stars (GCNS); Vikrant Jadhav identified about 2000 blue (and yellow) stragglers in 300 open cluster by “A search for Blue Stragglers in Galactic Open Clusters”; Eugene Vasiliev used the “Gaia EDR3 view on Galactic globular clusters”, especially the kinematic structure, in order to demonstrate that the formal uncertainties of Proper motions in EDR3 are underestimated by 10-20%.

Anthony Brown (Leiden) led a question-and-answer session on Gaia EDR3, where a lot of interesting aspects were discussed. Session 1 was completed by the Hands-on to EDR3 hold by Hendrik Heinl and Stefan Jordan (Heidelberg), which was also planned as part of the plenary sessions, because about 2/3 of all participants had registered for this course (about 90 people joined the course). An introduction to the usage of the EDR3 data and Topcat (a convenient tool for quick and also complex investigations) was given. A homework was posed for the next day, which was discussed in the lunch break of day 2.

Session 2: Reference Frame and fundamental Physics

In session 2, Mario G. Lattanzi (Torino) gave an excellent overview over fundamentals, i.e. “Reference frame, zero points, and relativistic effects; The impact of full GR solutions at the Milky Way scale: from the inner Galaxy outward”; Complementary to standard physics Sankha Chakrabarty discussed in a contributed talk alternative gravity by “Probing MOND with hypervelocity stars.“. The result is still inconclusive, but more precise observations in the future can exclude the QUMOND theory, if the predicted limit of tangential velocities is exceeded.

The series of 11 e-Poster presentations (in machine gun style: 1 slide, 2 minutes each) proves in an impressive manner the variety of potential applications of Gaia data:

- Aaron Bryan “Far - Infrared view of the Galactic Centre Circumnuclear Disk”
- Frances Cashmen “3D Structure of the ISM around the Galactic Center”
- Chirag Chawla “Gaia may detect hundreds of black holes”
- Paola Re Fiorentin “Icarus: a Flat and Fast Prograde Stellar Stream in the Milky Way disk” (also as contributed talk: Paola was able to jump in and replace a canceled talk over night)
- Francesco Conte “Gamma-gamma absorption in the Galactic Center2”
- Kosmas Gazeas “CoBiToM Project Contact Binaries Towards Merging”
- Priya Hasan “New Insights in Mass Segregation using Gaia”
- Mercedes Mollá “The rapid time evolution of the abundance gradient: the flattening due to gas mixing”
- Sara Ortega-Martinez “Inner discs? An insight on the inner region of simulated disc galaxies”
- Mohammad J. Shahhoseini “A detailed study of Radio-IR correlation in Dwarf irregular galaxies (Magellanic clouds)”

- Lukasz Wyrzykowski “Invisible population of remnants in the Galactic Centre revealed with microlensing”

After coffee break two invited talks on the additional value of other instruments were highlighted: Mark J. Reid (Cambridge MA) showed based on absolute “Parallaxes and Proper Motions from VLBI” that SgrA* is at rest and must be supermassive and Frank Eisenhauer (Garching) presented “Relativistic effects in the orbit of star S2 from GRAVITY”. Then Paola Re Fiorentin jumped in for a cancelled talk presenting the discovery of “Icarus: a Flat and Fast Prograde Stellar Stream in the Milky Way disk”. Session 2 was finalized by a general discussion led by Anthony Brown (Leiden).

Day Two

Session 3: Bulge, Bar and Inner Halo I

The morning started with a review talk of Juntai Shen (Shanghai) on “Bulge, Bar and Inner Halo: Kinematics, dynamics, and mass distribution” to provide a comprehensive basis for the following sessions. Angeles Perez-Villegas (Sao Paulo) was invited to speak on the usage of “Globular clusters and their orbits in the bulge” to derive properties of the inner halo. Jonathan Clarke gave a contributed talk on “Global Parameters of the Milky Way - Sun System; Insights from VIRAC and Gaia”, which was focused on the determination of the bar pattern speed combining VIRAC proper motions of red clump stars with the Gaia reference system. After lunch Andrea Kunder (US) talked about the “RR Lyrae distribution and kinematics: what do these stars represent?” She showed that 25% of the sample are halo interloopers and the rest is a combination of bulge/bar stars and a centrally concentrated population. More properties of the bar structure and kinematics were discussed in contributed talks by Dongwook Lim on “A new view on the double red clump in the Milky Way bulge through luminosity and color distribution”, Mercè Romero-Gomez (Barcelona) by “Dissecting the kinematics of the Galactic bar”, and Rain Kipper with “Measuring torque of bar from Solar Neighbourhood“. Ortwin Gerhard (Munich) chaired the final discussion of this section.

The tutorial of the hands-on session by Henrik Heinl and Stefan Jordan (Heidelberg) in the lunch break was visited by about 1/3 of those, who joined the hand-on course.

Session 4: Bulge, Bar and Inner Halo II

This session, which was focusing on ages and metallicities, was the largest session of the workshop. In four invited talks different aspects of age distributions, correlations to kinematics and abundances were discussed: Anna Barbara Queiroz (Postdam) on the “Metallicity-orbit distribution in the inner Galaxy“; Thomas Bensby (Lund) on “Ages from microlensed stars”; Elena Valenti (Garching) on “Ages of bulge stars from colour-magnitude diagrams and globular clusters”; and Diane Feuillet (Lund) on the “Distribution of stellar ages in the bulge”. This was complemented by contributed talks of Carme Gallart (Tenerife) on “Unbiased age distributions for the Milky Way inner halo and disk through colour-magnitude diagram fitting”, Anke Arentsen on “Finding the most metal-poor stars in the inner Galaxy with PIGS”, Andreas Koch-Hansen on “Chemodynamics of stellar oddballs in the bulge”, and Shola Wylie on “Abundance maps of the Milky Way's b/p bulge and long bar using the combined A2A and APOGEE surveys”.

This session was not finished on Thursday and continued on day 3.

Day Three

Session 4 was finalized by a contributed talk of Henrique Reggiani on “A Thermonuclear Explosion in the inner Bulge Slides” to explain the odd abundance pattern of a metal poor bulge star, and the general discussion led by Andreas Burkert.

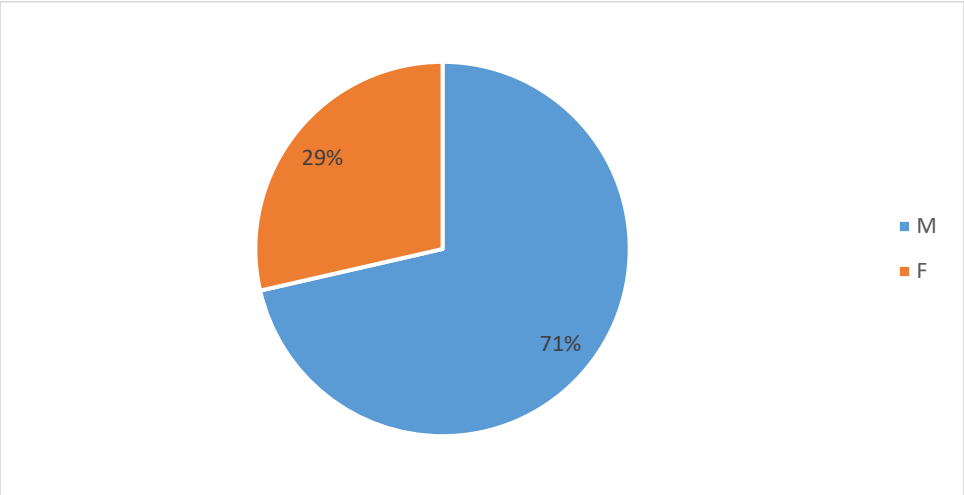
Session 5: Bulge, Bar and Inner Halo

Session 5 was also on ages but illuminating the assembly history of the inner Galaxy. Andrea Miglio (Birmingham) started with an invited talk on a “Critical Discussion of Stellar Ages in the Bulge” critically comparing different methods of age determination. Li Zhi introduced the kinematics of the ISM in a contributed on “Gas Dynamics in the Galaxy: Mass distribution and Bar Pattern Speed”. Then Françoise Combes (Paris) was invited to present the “Assembly history from (hydro)dynamical and cosmological simulations”, which was supplemented by a contributed talk of Francesca Fragkoudi (Garching) on “The formation and properties of the Milky Way's bar and bulge according to cosmological simulations”. Two more contributed talks by Horta Danny on “The galaxy within the Galaxy: Evidence from APOGEE for the presence of a major building block of the Milky Way halo buried in the inner Galaxy” and by Diederik Kruijssen on “A sleeping giant in the inner Galaxy - the merger history of the Milky Way reconstructed with cosmological simulations of the globular cluster population” together with the general discussion chaired by Lia Athanassoula finalized this session.

Session 6: Nuclear Disc and Star Cluster

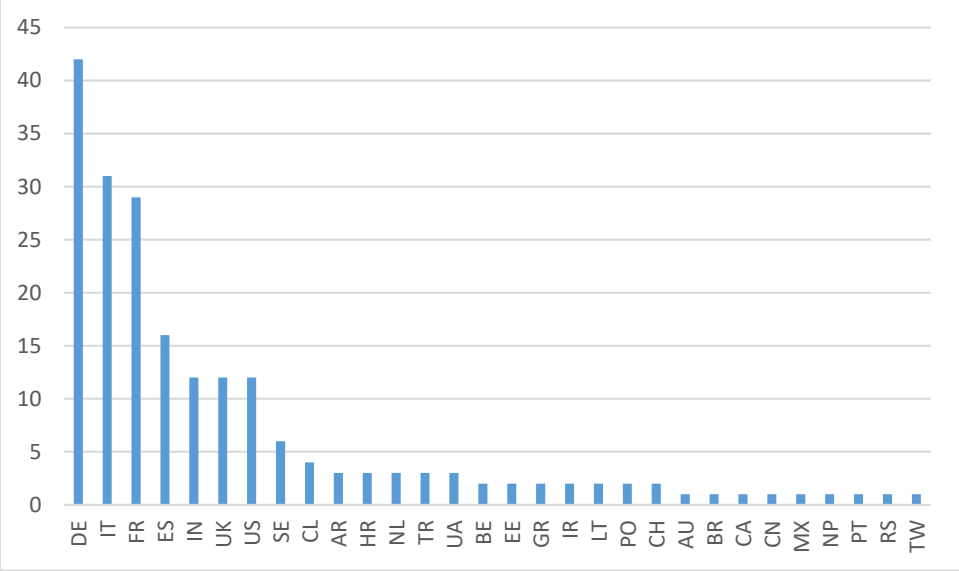
The last session focused on the very centre of the Milky Way. Francisco Nogueras-Lara (Heidelberg) was invited to talk on “The Nuclear Disc” and Anja Feldmeier-Krause (Chicago) on “The Nuclear Star Cluster”. In two contributed talks Brian Thorsbro on “Clues to galaxy evolution from chemical abundances of stars in the Galactic centre” and Sergey Khoperskov on “Bar-spirals coupling in the Milky Way: fuelling galactic nuclei and multiple populations in the chemical abundance space” discussed the formation of the Galactic nucleus. Mattia Sormani (Heidelberg) was invited to discuss the “Galactic Centre: Gas Inflow and Star Formation“. Then, two contributed talks by Jason Sanders on “Kinematics of long period variables in the central nuclear disc” and Alessandra Mastrobuono on “Star formation at the Galactic Centre: coevolution of multiple young stellar discs” completed the presentations of the workshop. Rainer Schödel led the final Discussion on session 6.

The workshop in numbers



The workshop was attended by 203 researchers (online), 29% of them female.

The SOC and LOC had a 44 and a 40% of female researchers respectively.



There were researchers from 30 different countries in Europe (mostly Germany), US, Chile, Argentina, Mexico, Canada, Brazil, China, India, Nepal, Taiwan e Iran.

There were 51 presentations. 38% of female participants presented while 20% of male participants did. There were 18 Invited talks (44% female), 22 Contributed talks (41% female) and 11 eposters (45% female).

Report prepared by Andreas Just, Guido Thimm and Lola Balaguer-Núñez.