Ramses User Meeting 2019

Report of Contributions

Contribution ID: **3** Type: **not specified**

What happens to the galaxy during the epoch of disc settling?

Monday 30 September 2019 09:20 (20 minutes)

Last year, I presented how the galaxies in New Horizon settle their galactic scale disc. More massive galaxies seem to have a settled disc earlier in the simulation, but it was not clear what is the main driver. This year I present a few pieces of information on the properties of galaxies, such as merger history, star formation rate, stellar feedback, black hole accretion and feedback, during and around the epoch of disc settling in the hope of pinning down the main driver.

Presenter: Prof. YI, Sukyoung (Yonsei University)

Session Classification: Galaxy Formation and Evolution

Contribution ID: **4** Type: **not specified**

The evolution of disk structure and star formation activity of the Galactica galaxies

Monday 30 September 2019 09:40 (20 minutes)

Using the unprecedented high-resolution cosmological simulation, New Horizon, we have studied the origin of galactic structures: disk and spheroid. However, since New Horizon has only reached z=0.7, covering the first half of the cosmic time, it is not yet clear about the formation of the structures of local galaxies, including the Milky Way. Zooming in two individual galaxies in the field environment in the Horizon-AGN volume, the Galactica runs, we investigate the evolution of one disk galaxy and one S0 galaxy down to z=0. Especially, in this talk, we present some preliminary results on how star formation history affects the disk structure: the thickness, age/metallicity, and kinematics. We show (i) the formation of a thin disk from recent star formation triggered by interaction with a neighboring galaxy and (ii) the evolution of the disk structure in a quenched S0 galaxy.

Presenter: Ms PARK, Min-Jung (Yonsei University)

Session Classification: Galaxy Formation and Evolution

Contribution ID: **5** Type: **not specified**

Radiation-coupled Chemistry in Cosmological Simulations of Galaxy Formation

Monday 30 September 2019 10:00 (20 minutes)

In cosmological, radiation-hydrodynamics simulations of galaxy formation, chemical abundances and ionisation fractions are often determined by post-processing, which fails to capture the effect the chemical state has on the radiation field (by absorption and emission processes) and ultimately on the dynamics of the gas (by radiative cooling, and indirectly by other interactions with radiation). We have modified the RAMSES-RT radiation-hydrodynamics code to include a rich chemical network, coupled to the radiative transfer solver, so that the chemical state can be calculated self-consistently, rather than via post-processing.

Presenter: Mr BARRETT, Sean (University of Oxford)

Session Classification: Galaxy Formation and Evolution

Contribution ID: **6** Type: **not specified**

Unveiling the hidden universe: studying low-surface-brightness galaxies using the New Horizon cosmological simulation

Monday 30 September 2019 11:10 (20 minutes)

Galaxy evolution studies have been dominated by objects that lie above the surface brightness (SB) limit of current wide surveys like the SDSS (23 mag/arcsec^2). However, hints of a much larger population of low-surface-brightness galaxies (LSBGs) have recently been discovered. State-of-the-art cosmological simulations, and new deep wide surveys, have begun to show that these galaxies might dominate the local number density, indicating that our current understanding of galaxy evolution is incomplete. We use New Horizon, a cosmological hydro-dynamical simulation, to quantify the origin of LSBGs. We show that the majority of galaxies occupy a fairly tight LSB locus in the SB vs stellar mass plane, which is invisible in past surveys. However, some galaxies scatter off this locus, and these are the ones that are visible in past datasets and on which our theoretical paradigm is predicated. Key to understanding galaxy evolution, therefore, is to understand both the formation of the LSB locus and the objects that lie off it. We show that on-locus LSB galaxies form more of their stellar mass at higher redshift. More intense supernova feedback and mergers at early epochs flatten their gas profiles. This gas then produces diffuse LSB galaxies. The off-locus population exhibits milder supernova feedback at high redshift, which enables them to progressively deepen their potential wells, continue to form stars more vigorously to later epochs, thus attaining high SBs that make them visible in past surveys. We make testable predictions for the next generation of deep-wide surveys, such as LSST.

Presenter: Mr JACKSON, Ryan (University of Hertfordshire)

Session Classification: Galaxy Formation and Evolution

Contribution ID: **7** Type: **not specified**

Probing low surface-brightness populations with cosmological simulations

Monday 30 September 2019 10:50 (20 minutes)

Cosmological simulations provide an alternative way of probing populations of low-surface-brightness (LSB) objects, which make up the majority of galaxies in the Universe, but which remain poorly studied observationally. Making predictions for this sub-set of the galaxy population is important, since our current understanding of galaxy evolution is underpinned by the parts of the galaxy population that we can observe (most galaxies with surface brightnesses below 23 mag/square arcsec are not seen in SDSS for example). This population appears particularly important since our predictions indicate that a significant majority (>85 per cent) of galaxies may reside in the LSB regime and that significant extreme populations of LSB galaxies (e.g. UDGs) exist even outside of clusters in line with recent observational results (Sedgwick+19). Using the Horizon-AGN and New Horizon simulations, we have probed the formation of LSB galaxies, showing that LSB and UDG galaxies may be descended from populations with almost identical properties to their high-surface-brightness analogues. UDGs are produced principally as a consequence of interactions, regardless of environment. In part, the shallower matter density slopes of LSB galaxies, which are a consequence of their early formation (assembly bias), contribute to allowing tidal processes / interactions to work more efficiently.

Presenter: Dr MARTIN, Garreth (University of Arizona)

Session Classification: Galaxy Formation and Evolution

Contribution ID: **8** Type: **not specified**

Merger-driven outflows and inefficient star formation

Monday 30 September 2019 11:30 (20 minutes)

Regulating the available gas mass inside galaxies proceeds through a delicate balance between inflows and outflows, but also through the internal depletion of gas due to star formation. At the same time, stellar feedback is the internal engine that powers the strong outflows. Since star formation and stellar feedback are both small scale phenomena, we need a realistic and predictive subgrid model for both. We describe the implementation of supernova momentum feedback and star formation based on the turbulence of the gas in the RAMSES code. For star formation, we adopt the so called multi-freefall model. The resulting star formation efficiencies can be significantly smaller or bigger than the traditionally chosen value of 1%. We apply this new numerical models to cosmological simulations of Milky Way-like halos and discuss our findings.

Presenter: Mr KRETSCHMER, Michael (ICS Zurich)

Session Classification: Galaxy Formation and Evolution

Contribution ID: **9** Type: **not specified**

AGN in dwarf galaxies: frequency, triggering processes and the plausibility of AGN feedback

Monday 30 September 2019 11:50 (20 minutes)

While AGN are considered to be key drivers of the evolution of massive galaxies, their potentially significant role in the dwarf-galaxy regime (M < 10^9 MSun) remains largely unexplored. We combine optical and infrared data, from the Hyper Suprime-Cam (HSC) and the Wide-field Infrared Explorer (WISE) respectively, to explore the properties of ~800 AGN in dwarfs at low redshift (z<0.3). Infrared-selected AGN fractions are ~10-30 per cent in dwarfs, which, for reasonable duty cycles, indicates a high BH-occupation fraction. Visual inspection of the deep HSC images indicates that the merger fraction in dwarf AGN ~6 per cent) shows no excess compared to a control sample of non-AGN, suggesting that the AGN-triggering processes are secular in nature. Energetic arguments indicate that, in both dwarfs and massive galaxies, bolometric AGN luminosities (L_AGN) are significantly greater than supernova luminosities (L_SN). Together with the potentially high BH-occupation fraction, this suggests that, if AGN feedback is an important driver of massive-galaxy evolution, the same is likely to be true in the dwarf regime, contrary to our classical thinking. We then compare these empirical results to predictions from the New Horizon simulation in order to gain an understanding of how well state-of-the-art simulations currently reproduce the black-hole properties of dwarf galaxies.

Presenter: Dr KAVIRAJ, Sugata (University of Hertfordshire)

Session Classification: Galaxy Formation and Evolution

Contribution ID: **10** Type: **not specified**

A hydrodynamical simulation of the Virgo cluster of galaxies

Monday 30 September 2019 13:40 (20 minutes)

At about 15 Mpc from us, the Virgo cluster of galaxies is a formidable source of information to study cluster formation and galaxy evolution in this rich environment. Several observationally-based scenarios for the cluster formation arose within the past decade regarding the number and properties of the galaxies that entered the cluster recently and the nature of the last major merger that the cluster underwent. Confirming these scenarios requires extremely faithful numerical counterparts of the cluster. I will present the first zoom-in cosmological hydrodynamical simulation, with feedback from supernovae and active galactic nuclei, within a 10 Mpc/h radius sphere, with a dark matter mass resolution of 2x1e+7 Msun/h and a spatial resolution down to 0.24 kpc/h, that reproduces the Virgo cluster within its large scale environment.

Presenter: SORCE, Jenny (CRAL)

Session Classification: Galaxy Clusters

Contribution ID: **11** Type: **not specified**

Hierarchical fragmentation in high redshift galaxies revealed by hydrodynamical simulations

Monday 30 September 2019 14:00 (20 minutes)

High redshift galaxies have a very different morphology than nearby ones. Indeed, the high gas fraction in such galaxies drives strong gravitational instabilities which lead to fragmentation and formation of giant star forming structures of masses up to 10^8 and 10^9 \msun often dubbed «giant clumps». Recent observations with high resolution questioned the existence of the giant clumps by showing only lighter structures or no structures at all. We use Adaptative Mesh Refinement (AMR) hydrodynamical simulations of galaxies with parsec-scale resolution to study the formation of structures inside high redshift galaxies. We show that the star formation occurs in small gas clusters with mass between 10^6 and 10^7 \msun that are themself located inside giant complex with mass up to 10^8 and 10^9 \msun. Those massive structures are the giant clumps observed with HST. They are found to be gravitationally bound and present a relation between their Jeans'masses and their substructures masses coherent with a scenario of hierarchical fragmentation. We also compare the top-down fragmentation of an initially warm disk and the bottom-up fragmentation of an initially cold disk. By realizing mock observation of the simulated galaxies we show that at very high resolution with instrument like ALMA or with the help of gravitational lensing only the lighter structures are detected. This leads to non detection of the giant clumps and therefore introduces a bias in the detection of the structures.

Presenter: Mr FAURE, Baptiste (CEA)

Session Classification: Galaxy Clusters

Contribution ID: **12** Type: **not specified**

Cold gas formation in galaxy clusters

Monday 30 September 2019 14:20 (20 minutes)

Extended filamentary nebulae of cold, dense gas are a striking feature or nearby galaxy clusters, but their formation mechanism and the processes which shape their morphology remain poorly understood. In this talk, I will present work investigating the condensation and evolution of this cold gas under the influence of a spin-driven AGN jet in a Perseus-like clusters.

Presenter: Dr RICARDA, Beckmann (Institut d'Astrophysique de Paris)

Session Classification: Galaxy Clusters

Contribution ID: **13** Type: **not specified**

The star-gas misalignment from Horizon-AGN

Monday 30 September 2019 15:50 (20 minutes)

We have explored star-gas misalignment using Horizon-AGN simulation and compared the result with Sydney-AAO Multi-object Integral field spectrograph (SAMI) Galaxy Survey. While stars and gas are expected to have aligned rotational axes in a galaxy, IFU observations found that about 11% of the observed galaxies are misaligned. Horizon-AGN showed the distribution of misalignment angles found by the observation surprisingly closely. Moreover, Horizon-AGN reproduced the observed/expected misalignment features in terms of morphology, gas fraction, and galaxy mass. However, the simulation failed to reproduce the misalignment properties of galaxies in cluster environments. We also have investigated formation channels (origins) and a lifetime of star-gas misalignment using the simulation, which provides clues about how gas flows into galaxies and how gas accretion affects the galaxy evolution.

Presenter: Mr KHIM, Donghyeon (Yonsei University)

Session Classification: Galaxy Clusters

Contribution ID: **14** Type: **not specified**

Measuring the dark matter velocity anisotropy to the cluster edge

Monday 30 September 2019 15:10 (20 minutes)

Dark matter dominates the properties of large cosmological structures such as galaxy clusters, and the mass profiles of the dark matter have been measured for these equilibrated structures for years using X-rays, lensing or galaxy velocities. A new method has been proposed, which should allow us to measure a dynamical property of the dark matter, namely the velocity anisotropy. For the gas a similar velocity anisotropy is zero due to frequent collisions, however, the collisionless nature of dark matter allows it to be non-trivial. Numerical simulations have for years found non-zero and radially varying dark matter velocity anisotropies. Here we employ the method proposed by Hansen and Pifaretti (2007), and developed by H{\o}st et al. (2009) to measure the dark matter velocity anisotropy in the bright galaxy cluster Perseus, to near 5 times the radii previously obtained. We find the dark matter velocity anisotropy to be in good agreement with the results of numerical simulations, however, still with large error-bars. At half the virial radius we find the velocity anisotropy to be non-zero at 1.7σ , thus confirming the collisionless nature of dark matter.

Presenter: Mr SVENSMARK, Jacob

Session Classification: Galaxy Clusters

Contribution ID: **15** Type: **not specified**

The Properties and Evolution of High Redshift Filaments

Monday 30 September 2019 15:30 (20 minutes)

Cold mode accretion filaments are extremely important in determining the morphology of galaxies at high redshifts, being responsible for transporting around 90% of a galaxy's mass and angular momentum. Unfortunately these structures are nearly invisible to current instruments despite numerous pieces of indirect evidence. With simulations however we can bypass these limitations to study their properties and evolution. In this talk I will present a simple analytic model to describe the profile of cold mode accretion filaments which connect to a Milky Way-like galaxy. Filaments to have an inner and outer scale, growing with the size of the galaxy and halo respectively.

Presenter: Mr RAMSOY, Marius (University of Oxford)

Session Classification: Galaxy Clusters

Contribution ID: **16** Type: **not specified**

Registration and coffee

Monday 30 September 2019 08:30 (40 minutes)

Session Classification: Registration and coffee

Contribution ID: **17** Type: **not specified**

Welcome

Monday 30 September 2019 09:10 (10 minutes)

Session Classification: Registration and coffee

Contribution ID: **18** Type: **not specified**

The SPHINX simulations of reionisation

Tuesday 1 October 2019 09:00 (20 minutes)

The epoch of reionisation marks a major shift from a cold neutral Universe to a warm ionised one, a transition which was thought to be powered by UV radiation emitted from young massive stars in the first galaxies. Our understanding of this epoch is still limited: observationally we glimpse a handful of the most luminous galaxies existing at the end of the epoch, but with the advent of the James Webb Telescope and other upcoming instruments we will soon start getting better information about the sources powering reionisation. Theoretically, the best way to gain an understanding is with cosmological simulations. I will present our suite of SPHINX simulations, where we have developed new methods that allow us to perform radiation-hydrodynamical simulations of cosmic reionisation, resolving the emission and escape of radiation in the inter-stellar medium of tens of thousands of galaxies all evolving together in the same simulation, hence capturing the interplay of multiple star-formation and feedback processes from ISM to IGM scales. I will show how the escape of ionising radiation from the SPHINX galaxies is regulated by stellar feedback and how this translates into an escape fraction of ionising photons that is sensitive to the evolution of the stellar population luminosity with age. I will also discuss the strategies we were forced to deploy to allow the very large and memory-heavy SPHINX simulations to run on the memory-light supercomputer that was allocated to us via PRACE.

Presenter: Dr ROSDAHL, Joakim (Centre de Recherche Astrophysique de Lyon)

Session Classification: Reionisation

Contribution ID: **19** Type: **not specified**

Characterizing the sources of reionization in the SPHINX simulation

Tuesday 1 October 2019 09:20 (20 minutes)

The epoch of reionization is the period during which the hydrogen present in the universe is entirely reionized, between z = 15 and z = 6. The nature of the sources of reionization is still a matter of debate. In this talk I will use the SPHINX simulation to characterize the properties of the galaxies that drive reionization. The SPHINX simulation focuses on the epoch of reionization and describes a cosmological volume of 10 cMpc on a side. It reaches a resolution better than 10 pc in the ISM of all galaxies. This way the escape fraction of ionizing photons from haloes is accurately predicted by the simulation. In this talk I will present preliminary results of my analysis of the SPHINX simulation. In particular I will discuss the relation between the duty cycle of Lyman continuum photon leakage and the dark matter (DM) halo Virial mass. I will also discuss the link between the star formation rate and the number of ionizing photons escaping from DM haloes, and the directionality of these escaping photons. Finally I will discuss the evolution of these results with redshift.

Presenter: Mr CHUNIAUD, Mathieu (CRAL)

Session Classification: Reionisation

Contribution ID: **20** Type: **not specified**

Cosmic Dawn II (CoDa II): a new radiation-hydrodynamics simulation of the self-consistent coupling of galaxy formation and reionization

Tuesday 1 October 2019 09:40 (20 minutes)

Cosmic Dawn II (CoDa II) is a new, fully-coupled radiation-hydrodynamics simulation of cosmic reionization and galaxy formation and their mutual impact, to redshift z < 6. With 4096^3 particles and cells in a (94 Mpc)^3 box, it is large enough to model global reionization and its feedback on galaxy formation while resolving all haloes above 10^8 Msun. To accomplish this massive numerical enterprise, CoDa II uses the hybrid CPU-GPU code RAMSES-CUDATON (Ocvirk et al. 2016), deployed on 16384 GPUs and 65536 CPUS. CoDa II modified and re-calibrated the subgrid star-formation algorithm with respect to our previous simulation CoDa I, making reionization end earlier, at z ~ 6, thereby better matching the observations of intergalactic Lyman-alpha opacity from quasar spectra and electronscattering optical depth from cosmic microwave background fluctuations. The post-reionization UV background intensity is somewhat high, however, making the H I fraction after overlap lower than observed, a possible sign of missing bound-free opacity from unresolved substructure. I will use the unique CoDa II dataset to build predictions on the behaviour of the observable galaxy population at high redshift, in particular the luminosity function, and the observable fraction of the star formation rate density with current and future telescopes. Pushing deeper into the (currently) unobservable territory, I will present results on the environmental dependence of radiative star formation suppression in low mass galaxies. I will also show the first implementation of the CoDa II galaxy catalog public database.

Presenter: Mr OCVIRK, Pierre (Observatoire astronomique de Strasbourg)

Session Classification: Reionisation

Contribution ID: **21** Type: **not specified**

Galactic ionising photon budget during the Epoch of Reionization in the radiation-hydrodynamics Cosmic Dawn II cosmological simulation

Tuesday 1 October 2019 10:00 (20 minutes)

A growing consensus seems to point towards the ionising UV light of galaxies having been the main driving force behind the reionisation process. I analysed the ionising photon contribution of galaxies to the intergalactic medium and its relation to galactic properties such as mass and star formation in the Cosmic Dawn II simulation, a new, massive, fully-coupled radiation-hydrodynamics simulation of galaxy formation during the Epoch of Reionization, performed with RAMSES-CUDATON, as an update of Cosmic Dawn I (Ocvirk et al. 2016). To this end, I computed the amount of escaping ionising photons from the dark matter haloes during and before the EoR. I found that dark matter halos between 1e9 and 5e10 solar masses produce more than 80% of the ionising photons reaching the IGM between z=8 and z=6. Less massive haloes are too dim, whereas brighter haloes are too few, and dense and opaque in their cores to provide a more significant contribution. As redshift increases past z=8, this dominant mass interval moves to lower mass haloes.

Presenter: Mr LEWIS, Joseph (Observatoire Astronomique de Strasbourg)

Session Classification: Reionisation

Contribution ID: **22** Type: **not specified**

Radiation Hydrodynamics of Turbulent HII Regions: LyC-LyA connection

Tuesday 1 October 2019 10:50 (20 minutes)

The question of whether early star-forming galaxies generated sufficient Lyman continuum (LyC) photons to drive cosmic reionisation is one of the major challenge in modern cosmology. Recent deep HST UV imaging and spectroscopy have revealed a signature of LyC leakage along the lines-of-sight of Lyman-alpha emitting galaxies. The observed correlations between LyC escape fraction, Lyman alpha line, and other nebular lines provide a valuable insight into the ISM of reionisation-era galaxies. In order to understand these new observational results, in this talk, we present a result from the RAMSES-RT simulation of turbulent HII regions in giant molecular clouds, examining the physical origins of the correlations between LyC leakage, HI covering fraction, kinematics, and the emergent Lyman alpha spectra. We discuss the role of turbulence and radiative feedback and show that radiative transfer through turbulent HII regions in molecular clouds is key for understanding the observed LyC leakage and the Lyman alpha spectral properties. We also discuss the extension to radiation magnetohydrodynamics and the effect of shocks, winds, and jets in UV nebular emission lines.

Presenter: Mr KAKIICHI, Koki (University College London)

Session Classification: Lyman A+C

Contribution ID: **23** Type: **not specified**

The origin of low escape fractions of ionizing radiation from Lyman-break galaxies at high-redshift

Tuesday 1 October 2019 11:10 (20 minutes)

The physical origin of low escape fractions of ionizing radiation derived from Lyman-break galaxies (LBGs) at $z \sim 3$–4 is a puzzle in the theory of reionization. We perform idealized disk galaxy simulations to investigate how galactic properties, such as metallicity and gas mass, affect the escape of Lyman continuum (LyC) photons using radiation-hydrodynamic code, \texttt{RAMSES-RT}, with strong stellar feedback. We find that the luminosity-weighted escape fraction from a metal-poor ($Z = 0.1\,Z_{\odot}$) galaxy embedded in a halo of mass $M_h \simeq 10^{11}\,M_{\odot}$ is $\langle fesctd \rangle \simeq 8\%$. However, when the gas metallicity is increased to $Z = 1Z_{\odot}$, the escape fraction is significantly reduced to $\left\langle f_{esc}^{3D} \right\rangle \simeq 1\%$, as young stars are enshrouded by their birth clouds for a longer period of time. On the other hand, increasing the gas mass by a factor of 5 leads to $\left\langle f_{esc}^{3D} \right\rangle \simeq 4\%$, as LyC photons are only moderately absorbed by the thicker disk. Our experiments seem to suggest that high metallicity is primarily responsible for the low escape fractions observed from LBGs, supporting the scenario in which the escape fraction has a negative correlation with halo mass. Indeed, our simulated galaxy with the typical metallicity ($Z = 0.3\,Z_{\odot}$) shows the relative escape fraction of
$f_{esc,rel}^{3D} = 8\%$, consistent with recent observations of LBGs with $M_{1500} \sim -20$ at $z \sim 4$.

Presenter: Mr YOO, Taehwa (Yonsei University)

Session Classification: Lyman A+C

Contribution ID: **24** Type: **not specified**

Tracing the origin of circum-galactic Lyman alpha emission

Tuesday 1 October 2019 11:30 (20 minutes)

I will present scientific results from a Ramses-RT zoom-in simulation of a z=3 galaxy, run including the implementation of Monte Carlo tracer particles recently developed by Corentin Cadiou. I will show how tracer particles can be used to identify the Lagrangian origin of the gas emitting and scattering Lyman-alpha photons, and discuss how this informs the interpretation of recent observations made by the MUSE guaranteed time observing team.

Presenter: Dr MITCHELL, Peter (Leiden Observatory)

Session Classification: Lyman A+C

Contribution ID: **25** Type: **not specified**

Mock UV absorption lines in Ramses-RT simulations and link with escape fractions

Tuesday 1 October 2019 11:50 (20 minutes)

To understand the role of galaxies during the epoch of reionization, it is essential to know more about the values of the escape fractions of ionizing photons from those galaxies. Since the intergalactic medium was opaque to lyman continuum radiation during reionization, it will never be possible to observe directly the escape fraction, so we have to rely on indirect measurements. One potential method for an indirect measurement uses the absorption lines from low-ionization states of metal, like SiII 1260A, OI 1302A etc. Those ions are good tracers of neutral hydrogen, and so the covering fraction measured from these absorption lines are thought to correlate well with the HI covering fraction. And, in turn, if the covering fraction of HI is less than unity, there are some low density channels in the ISM in which the ionizing photons can espace. Our aim is to compute mock spectra of these absorption lines from simulated galaxies and correlate their spectral characteristics with 1/ the covering fraction of HI along the same direction of observations and 2/ the escape fraction of LyC radiation along that line of sight. In this work, I selected a sample of galaxies from the "sphinx"RHD simulation (Rosdahl et al, 2018). For each galaxy, I compute the density of several absorbers in all the cells with KROME(Grassi et al, 2014), and I use RASCAS (Michel-Dansac et al, 2019) to scatter the stellar light through the interstellar medium of these galaxies (since all the LIS lines considered are resonant lines with or without fluorescent reemission). Finally, I build mock spectra in chosen directions of observation using the peeling-off technics, and measure several observables such as equivalent widths —in absorption and in emission through fluorescent channels—, or velocities (Vmin at the maximum of absorption, Vmax the maximum velocity at which there is absorption). I will present first results on the link between these observables and the distribution of column density and velocity field along several lines of sights, discuss the notion of covering fraction, and the relation between velocity measurements on the spectrum and velocity distribution in the gas. Finally, I will show preliminary results on the correlations between these mock observables and the escape fraction of ionising radiation.

Presenter: Mr MAUERHOFER, Valentin (University of Geneva)

Session Classification: Lyman A+C

Contribution ID: **26** Type: **not specified**

Impact of AGN feedbacks on the 1D power spectra from the Lya forests

Tuesday 1 October 2019 13:40 (20 minutes)

Neutral hydrogen in the IGM scatters light at 1216A producing an absorption spectrum that is observed on any background sources known as the Lyman-alpha forest. The fluctuations in the Lyman-alpha forest absorption can be used as a tracer of the varying density of intergalactic gas expected from the growth of structures from primordial fluctuations in the Universe. They can be accurately described by the flux auto-correlation along a line of sight, which has been shown to be a powerful tool in astrophysics and cosmology. We use the complete Baryon Oscillation Spectroscopic Survey (BOSS) and first extended-BOSS (eBOSS) spectra datasets which cover thirteen redshift bins, from z = 2.1 to z = 4.7 to compute the 1D flux power spectrum in the Lyman-alpha forest. We performed an extensive investigation of the systematic uncertainties affecting the measurement, and cosmological impacts as well. The current constraints are at the percent level, and will even shrink further in the DESI era. The P1D measurement becomes sensitive to the complex mechanical effects of quasar outflows, known as AGN feedback. We use Adaptative Mesh Refinement (AMR) hydrodynamical simulations performing AGN feedback as a sub-grid model, the Horizon-AGN and Horizon-noAGN simulations, to evaluate its effect on the P1D of the Lyman-alpha forest. We observe two antagonist effects; the strong outflows regulate baryonic content at small scales by redistributing it at larger scales and suppress power on the largest scales of the Lyman-alpha P1D. We study the hypothesis of an ionization of the reinjected gas at large scales, heated by the AGN, to understand the decrease of power. We run extended Horizon-AGN simulations by varying principal parameters of the AGN feedback model to estimate uncertainties in our P1D correction. As the P1D probes the neutral hydrogen in the diffuse IGM, we increase the minimal resolution from 100 kpc/h to 50 kpc/h. This last simulations presents differences with the Horizon-AGN simulation, so in addition to the P1D correction analysis, we present tentative results about the virial shocks position.

Presenter: Ms CHABANIER, Solène (CEA Saclay)

Session Classification: Lyman A+C

Contribution ID: **27** Type: **not specified**

Recent progress on cosmological initial conditions

Tuesday 1 October 2019 14:00 (20 minutes)

Presenter: Prof. HAHN, Oliver (Lagrange/UCA/OCA)

Session Classification: Evolving RAMSES

Contribution ID: **28** Type: **not specified**

A French initiative to support the RAMSES community⋯perhaps.

Tuesday 1 October 2019 14:30 (20 minutes)

Community codes such as RAMSES face similar challenges regarding maintenance, upgrades, documentation, and user support, as classical observing instruments. They further face the issue of rapidly evolving platforms (e.g. computer centres buying GPUs), and have to manage a posteriori community developments. The French RAMSES community has been lobbying for RAMSES (and simulation codes in general) to be recognised as a numerical instrument which deserves the same attention and support as classical observing instruments. This recognition would give easier access to engineer support, and would allow some form of recognition for researchers who spend a fraction of their time working for the community. There are finally signs suggesting that things may change rapidly and that France may soon (within a year?) support officially RAMSES. I would like to present the project that we have been pushing, and to exchange on how it can be improved and extended to the international RAMSES community.

Presenter: Dr BLAIZOT, Jeremy (CRAL)

Session Classification: Evolving RAMSES

Contribution ID: **29** Type: **not specified**

Experiences from full-time software development and how they can benefit scientific computing

Tuesday 1 October 2019 15:20 (20 minutes)

I left the field of astrophysics a year ago and started working as a full-time software developer for the European Spallation Source, a large neutron physics facility current under construction in Lund (Sweden). I am involved in a sizeable project counting about 30 core developers, over 50 more casual developers, and ~2000 users. I will share my experiences on the methods we use to coordinate such a development between Scandinavia, France, the UK and the US, and how some could really benefit development practises for Ramses. These involve code reviews, continuous integration, build servers, and performance monitoring. Setting all this up often seems too time-consuming for scientists who also have to analyse their results, publish articles and write funding applications. I will try to convince you that they do really save time in the long run, and attempt to start a discussion on how computational astrophysics software development could evolve in the future.

Presenter: Dr VAYTET, Neil (European Spallation Source, Copenhagen, Denmark)

Session Classification: Evolving RAMSES

Contribution ID: **30** Type: **not specified**

OpenMP implementation to Ramses

Tuesday 1 October 2019 15:40 (20 minutes)

Classic RAMSES code is purely written with MPI and not optimized for large simulations that use more than thousands of cores. We try to overcome this issue by adding OpenMP feature to RAMSES, implementing hybrid parallelism that takes advantage of both distributed and shared memory models. With the latest developed OpenMP version, we ran a small cosmological test simulation and it showed a satisfactory level of additional scalability. Although we focused on preserving the RAMSES calculation routines as it is, the exact reproduction of the classical version is not possible for the following reasons. (i): Random number generator that is embedded in RAMSES, (ii): propagation of roundoff error in the Fortran arithmetic operations. We plan to run our new cluster simulation in Korean supercomputer Nurion next year, with subgrid physics that is equivalent, but different in some aspect to New Horizon.

Presenter: Mr HAN, San (Yonsei University)

Session Classification: Evolving RAMSES

Contribution ID: **31** Type: **not specified**

Next Generation RAMSES

Tuesday 1 October 2019 16:00 (20 minutes)

Presenter: Prof. TEYSSIER, Romain (University of Zurich)

Session Classification: Evolving RAMSES

Contribution ID: **32** Type: **not specified**

Star by star simulations in RAMSES

Wednesday 2 October 2019 09:20 (20 minutes)

I am currently testing a model I have implemented in RAMSES which treats individual stars, both in isolated galaxies and cosmological context. In this talk, I will present a new star formation model that samples the IMF fast and accurately, hence allowing for a more sophisticated star-by-star treatment of stellar feedback processes. The model can currently trace stars down to 8 solar masses and an extension down to one solar mass stars is currently under development. In addition, this model allows for a treatment of previously unexplored collisional effects such as runaway stars in a fully cosmological context. I demonstrate the importance of this mechanism on scales covering ultra-faint dwarves up to Milky Way-mass galaxies. We find that massive runaway stars can explode 100s of parsecs away from their natal birth environments, hence injecting energy and metals in low-density gas. This leads to a change in outflows properties on galactic scales which impact the evolution of the aforementioned galaxies. Runaway stars is an ignored effect in modern simulations of galaxy formation, and quantifying this is important for our understanding of galaxy evolution.

Presenter: Mr ANDERSSON, Eric (Lund Observatory)

Session Classification: Star Formation

Contribution ID: **33** Type: **not specified**

Rambody: Coupling RAMSES and Nbody6 to simulate collisional systems in galactic environments

Wednesday 2 October 2019 09:40 (20 minutes)

Modelling the formation and evolution of globular clusters in cosmological simulations is a notoriously difficult problem. Due to the extreme differences in scales in space and time required to resolve the star-by-star dynamics of the globular clusters, most simulations presently use subgrid and semi-analytical models as prescriptions for the globular clusters. Moreover, even if this extreme scaling is resolved in high-resolution simulations, cosmological codes such as RAMSES compute collisionless dynamics which is not suited for the evolution of dense stellar systems. We present Rambody: a coupling between RAMSES and the collisional dynamics code Nbody6 to follow the dynamical evolution of dense clusters in cosmological context. This innovative approach allows us to capture the coupling between stellar and galactic (hydro-)dynamics through live intercode communications of the galactic potential and stellar evolution. We present the method and the results of preliminary validation runs.

Presenter: Dr DELORME, Maxime (University of Surrey)

Session Classification: Star Formation

Contribution ID: **34** Type: **not specified**

The loss of the intra-cluster medium in old stellar clusters

Wednesday 2 October 2019 10:00 (20 minutes)

Stars in old stellar clusters lose a non negligible amount of mass during their evolution. This material is then expected to build up a substantial intra-cluster medium. However, the observed gas content in these old stellar clusters is a couple of orders of magnitude below these expectations. We follow the evolution of the stellar wind material thanks to hydrodynamical simulations taking into account the ram-pressure stripping by the motion of the stellar cluster in the galactic halo medium and the inclusion of ionising sources to reconcile theoretical predictions with observations.

Presenter: Dr CHANTEREAU, William (ARI (LJMU))

Session Classification: Star Formation

Contribution ID: **35** Type: **not specified**

Ramses with cosmic rays : anisotropic diffusion, streaming instability and shock-acceleration

Wednesday 2 October 2019 10:50 (20 minutes)

I will detail the implementation of cosmic rays (CR) in Ramses. This numerical method of CRs is based on a fluid description of CRs. The anisotropic diffusion of CRs along magnetic field lines is modeled with an implicit solver. CR streaming instability (CRs streaming down their own gradient at the Alfven velocity) can be solved within the implicit diffusion solver. The so-called diffuse shock acceleration mechanism is captured with a shock finder algorithm performed on-the-fly that injects CR pressure at shocks with acceleration efficiencies depending on the Mach number, the pre-shock fraction of CRs, and the magnetic obliquity. A few applications of the diverse elements of the CRMHD description will be touched: structure of the interstellar medium, supernova remnants and the formation of large-scale galactic winds.

Presenter: Dr DUBOIS, Yohan (Institut d'Astrophysique de Paris)

Session Classification: Star Formation

Contribution ID: **36** Type: **not specified**

Impact of radiation-modulated cooling on stellar feedback

Wednesday 2 October 2019 11:10 (20 minutes)

Strong radiation fields can change the ionization state of metals and hence cooling rates. In order to understand their effects on the momentum transfer from radiation and supernova feedback, we perform a suite of radiation-hydrodynamic simulations with radiation-modulated metal cooling. For this purpose, we pre-tabulate the metal cooling rates for a variety of spectral shapes and flux levels with the spectral synthesis code, Cloudy, and accurately determine the rates based on the local radiation field strength. We find that the inclusion of the radiation-modulated metal cooling decreases the total radial momentum produced by photo-ionization heating by a factor of up to 3 due to enhanced cooling at temperature T~1e3-1e4K. The amount of momentum transferred from the subsequent SN explosions, however, turns out to be little affected by radiation, as the main cooling agents at T~1e5−1e6 K are only destroyed by soft X-ray radiation which is generally weak. We further discuss the total momentum budget in various conditions.

Presenter: Prof. KIMM, Taysun (Yonsei University)

Session Classification: Star Formation

Contribution ID: **37** Type: **not specified**

Regulation of star formation by stellar feedback from individual massive stars

Wednesday 2 October 2019 11:30 (20 minutes)

The interstellar medium (ISM) is notoriously difficult to reproduce in simulations. The standard approach models star formation following a Schmidt law and performs feedback with the same single instantaneous injections of the SN energy per stellar population particle. I will present an alternative method using sink particles to represent individual star clusters. This allows for each stellar cluster to have its own stellar population with individual delay time distributions. Stellar feedback from massive stars, in the form of radiation, winds, and SNe, is coupled to the sink particles following stellar evolution tracks. I will discuss applications to molecular cloud and galactic disc simulations.

Presenter: Dr BIERI, Rebekka (MPA)

Session Classification: Star Formation

Contribution ID: **38** Type: **not specified**

Formation of star clusters by cloud-cloud collision

Wednesday 2 October 2019 11:50 (10 minutes)

Presenter: Mr HAN, Daniel (Yonsei University)

Session Classification: Star Formation

Contribution ID: **39** Type: **not specified**

Explaining the luminosity spread in young clusters: proto and pre-main sequence stellar evolution in a molecular cloud environment

Wednesday 2 October 2019 13:40 (20 minutes)

Presenter: Mr JENSEN, Sigurd (Niels Bohr Institute)

Session Classification: Star Formation

Contribution ID: **40** Type: **not specified**

The peak of the IMF explained by tidal forces

Wednesday 2 October 2019 14:00 (20 minutes)

Understanding the stellar initial mass function has been a long standing problem in star formation. Recently, a new theory has been proposed that puts forward the idea that tidal forces caused by young stars prevent the formation of other stars within a certain radius. To study this, I ran a set of turbulent box simulations with ramses and analyzed the tidal field around new born stars. This gave us insight in how tidal forces can determine the mass of a star. In this talk I will present the simulations and discuss the results.

Presenter: Ms COLMAN, Tine (ICS, University of Zurich)

Session Classification: Star Formation

Contribution ID: **41** Type: **not specified**

Simulating the formation of binary stars

Wednesday 2 October 2019 14:20 (20 minutes)

I present theoretical work done using the AMR MHD code FLASH on the formation of binary stars and the evolution of their discs in these systems. I simulated the collapse of molecular cores until the formation of protostars and followed the early evolution of these systems. I investigated the influence that binarity has on the global evolution of a young stellar system, including looking at mechanisms such as accretion of material, jets and outflows, and dynamical interactions. I find that while in some scenarios binary stars may produce hostile environments for planet formation via the destruction of circumstellar discs, the formation of large circumbinary discs is possible. This can lead to the formation of planets around binary stars to be just as likely as the their formation around single stars. I also present preliminary results on the influence of eccentricity on episodic accretion, independent of separation.

Presenter: Dr KURUWITA, Rajika (Niels Bohr Institute)

Session Classification: Protostellar Systems

Contribution ID: **42** Type: **not specified**

Zooming-in on protostellar multiple formation

Wednesday 2 October 2019 15:10 (20 minutes)

Stars form as a consequence of gravitational collapse in Giant Molecular Clouds. Contrary to models of individual stars forming due to the collapse of an isolated core, we account for the molecular cloud environment during the epoch of star and protoplanetary disk formation. Using zoom-in simulations with the magnetohydrodynamical codes RAMSES, we investigate the accretion process of young stars that are embedded in different environments during their first ~100 kyr after formation. Starting initially from a turbulent (40 pc)^3 Giant Molecular Cloud, efficient use of adaptive mesh refinement allows us to resolve the formation process of stars and their protoplanetary disks with a resolution down to 0.06 AU. We find that the accretion process of stars is heterogeneous in space, time and among different protostars with a tendency of more violent accretion for deeply embedded objects. We show that large-scale infall can trigger accretion bursts leading to enhanced protostellar luminosities. Apart from that, we investigate the formation of wide companions at distances of ~1000 au due to turbulent fragmentation for one of the objects. A comparison with observations shows that filamentary structures connecting two protostellar sources, such as kinematically quiescent 'bridges' as observed for e.g. IRAS16293-2422, appear to be transient phenomena of multiple star formation. Such structures occur as a consequence of compression induced by the underlying turbulence. Finally, we suggest that protostellar companions initially form with wider separation of ~1000 au, and migrate to smaller separations of ~100 au on time scales of a few 10 kyr.

Presenter: KÜFFMEIER, Michael (Zentrum für Astronomie Heidelberg (ZAH))

Session Classification: Protostellar Systems

Contribution ID: **43** Type: **not specified**

Simulations of auto-gravitating disks with Ramses

Wednesday 2 October 2019 15:30 (20 minutes)

We run hydrodynamical simulations of protoplanetary disk to investigate the effects of a classical very simplified cooling model on disk fragmentation. The goals are to estimate the fragmentation boundary when using a Godunov scheme, probe convergence and build a simple analytical model.

Presenter: Mr BRUCY, Noe (CEA)

Session Classification: Protostellar Systems

Contribution ID: **44** Type: **not specified**

Dust dynamics in RAMSES : Protostellar collapse and disk formation

Wednesday 2 October 2019 15:50 (20 minutes)

Dust grains are the building blocks of protoplanetary disks and planets. Dust regulates the thermal evolution of the disk through its opacity. In addition, it plays a major role in the coupling between the gas and the magnetic field, hence in the disk and jet formation. In observations, the polarized light emitted by the grains can be used to measure the magnetic fields orientation or to estimate the maximum grain size. Nevertheless the dust evolution remains poorly constrained during the early phases of star formation. The dependence of the drag force on the grain and gas properties can lead to a dynamical sorting, in particular for the large dust grains. Assumed to be uniform at low densities, the dust-to-gas can increase up to large values during the protostellar collapse that leads to the protostar and disk formation (Bate and Loren Aguilar 2017, Lebreuilly et al. 2019). I will present our dust dynamics algorithm (Lebreuilly et al, 2019) in the adaptive-mesh-refinement code RAMSES (Teyssier 2002) and first collapse simulations of gas and dust mixtures with a simultaneous treatment of multiple grains species of different sizes (Lebreuilly et al, in prep). I will show how the dynamics of the dust phase during the first protostellar collapse can lead to an important increase of the dust-to-gas ratio and how this sorting depends on the initial properties of the core.

Presenter: Mr LEBREUILLY, Ugo (CRAL)

Session Classification: Protostellar Systems

Contribution ID: **45** Type: **not specified**

On-going RAMSES developments from I/O to GPU and performance portability

Tuesday 1 October 2019 14:20 (10 minutes)

Presenter: Mr FREDERIC, Bournaud (CEA Saclay)

Session Classification: Evolving RAMSES