Annual Report 2019
Jaan Einasto
and Tartu Observatory cosmology group

1 Research

Einasto et al. (2019b) — Aims: We investigate how properties of the ensemble of superclusters in the cosmic web evolve with time. Methods: We performed numerical simulations of the evolution of the cosmic web using the Λ cold dark matter model in box sizes L0 = 1024, 512, 256 h^{-1} Mpc. We found supercluster ensembles of models for four evolutionary stages, corresponding to the present epoch z = 0, and to redshifts z = 1, z = 3, and z = 10. We calculated fitness diameters of superclusters defined from volumes of superclusters divided by filling factors of over-density regions. Geometrical and fitness diameters of largest superclusters, and the number of superclusters as functions of the threshold density were used as percolation functions to describe geometrical properties of the ensemble of superclusters in the cosmic web. We calculated the distributions of geometrical and fitness diameters and luminosities of superclusters, and followed the time evolution of percolation functions and supercluster distributions. We compared percolation functions and supercluster distributions of models and samples of galaxies of the Sloan Digital Sky Survey (SDSS). Results: Our analysis shows that fitness diameters of superclusters have a minimum at a certain threshold density. Fitness diameters around minima almost do not change with time in co-moving coordinates. Numbers of superclusters have maxima which are approximately constant for all evolutionary epochs. The geometrical diameters of superclusters decrease during the evolution of the cosmic web, and the luminosities of superclusters increase during this evolution. Conclusions: Our study suggests that evolutionary changes occur inside supercluster cells of dynamical influence. The stability of fitness diameters and numbers of superclusters during the evolution is an important property of the cosmic web.

Einasto et al. (2019a) — Context. We study biasing as a physical phenomenon by analysing geometrical and clustering properties of density fields of matter and galaxies. Aims: Our goal is to determine the bias function using a combination of geometrical and power spectrum analyses of simulated and real data. Methods: We apply an algorithm based on the local densities of particles, δ, to form simulated, biased models using particles with $\delta \geq \delta_0$. We calculate the bias function of model samples as functions of the particle-density limit δ_0. We compare the biased models with Sloan Digital Sky Survey (SDSS) luminosity-limited samples of galaxies using the extended percolation method. We find density limits δ_0 of biased models that correspond to luminosity-limited SDSS samples. Results: The power spectra of biased model samples allow estimation of the bias function $b(> L)$ of galaxies of luminosity L. We find the estimated bias parameter of $L*$ galaxies, $b* = 1.85 \pm 0.15$. Conclusions: The absence of galaxy formation in low-density regions of the Universe is the dominant factor of the biasing phenomenon. The second-largest effect is the dependence of the bias function on the luminosity of galaxies. Variations in gravitational and physical processes during the formation and evolution of galaxies have the smallest influence on the bias function.

2 Conferences

In February 20 – 22, 2019 in Tartu the Tartu-Tuorla seminar 2019 was organised on topic: “Einasto profile” with over 50 participants, dedicated to Jaan Einasto 90th jubilee. Among participants were Rien van de Weygaert, Bernard Jones, Alexei Starobinsky, Mauri Valtonen, Rado Stoica, Alexis Finoguenov and many Finnish and Estonian cosmologists. Jaan Einasto had presentations "Evolution of superclusters" and "The biasing problem".

In 17 – 19 June in Edinburgh the conference "The Cosmic Web: from Galaxies to Cosmology". Jaan Einasto had a talk "The biasing phenomenon".

In June 27 – 28 Jaan Einasto participated in the conference "Cosmo Gold" in Paris observatory, and the Gruber 2019 Cosmology Prize ceremony.

In 03 October Jaan Einasto had a talk in topic "Universe and we" in Korvekula school in Tartu district.

3 Scientific organisations, awards

I am member of the International Astronomical Union (1961), Estonian Academy of Sciences (1981), American Astronomical Society (1981), European Astronomical Society (1990), Academia Europaea (1990), Royal Astronomical Society (1994).

I have Estonian Science Prizes (1982, 1998, 2003, 2007), Gauss Professor of the Göttingen University (1993), The Estonian Order of the National Coat of Arms (1998), Marcel Grossmann Award (2009), honorary Doctor of Tartu University (2010), Viktor Ambartsumian International Prize (2012), Doctor Honoris Causa degree of the Turku University (2013), Gruber International Cosmology Award (2014).

In 2019 Jaan Einasto got the "Harald Keres" medal of the Estonian Academy of Sciences, Tartu University award, and Tartu Municipality award.

4 Research – Tartu Observatory cosmology group

In this Section the work is described done in Tartu Observatory cosmology group, in addition to the work described in Section 1. This overview is based on abstracts written by authors of respective papers.

Kooistra et al. (2019) — The intergalactic medium (IGM) plays an important role in the formation and evolution of galaxies. Recent developments in upcoming radio telescopes are starting to open up the possibility of making a first direct detection of the 21 cm signal of neutral hydrogen (H I) from the warm gas of the IGM in large-scale filaments. The cosmological hydrodynamical EAGLE simulation is used to estimate the typical IGM filament signal. Assuming the same average signal for all filaments, a prediction is made for the detectability of such a signal with the upcoming mid-frequency array of the Square Kilometer Array (SKA1-mid) or the future upgrade to SKA2. The signal to noise (S/N) then only depends on the size and orientation of each filament. With filament spines inferred from existing galaxy surveys as a proxy for typical real filaments, we find hundreds of filaments in the region of the sky accessible to the SKA that can be detected. Once the various phases of the SKA telescope become operational, their own surveys will be able to find the galaxies required to infer the position of even more filaments within the survey area. We find that in 120 h, SKA1-mid/SKA2 will detect H I emission from the strongest filaments in the field with an S/N of the order of 10 to 150 for the most pessimistic model considered here. Some of the brighter filaments can be detected with an integration time of a few minutes with SKA1-mid and a few seconds with SKA2. Therefore, SKA2 will be capable of not only detecting but also mapping a large part of the IGM in these filaments.

Nogueira-Cavalcante et al. (2019) — Context. Between the blue cloud and the red sequence peaks on the galaxy colour-magnitude diagram there is a region sparsely populated by galaxies called the green valley. In a framework where galaxies mostly migrate on the colour-magnitude diagram from star forming to quiescent, the green valley is considered a transitional galaxy stage. The details of the processes that drive galaxies from star-forming to passive systems still remain unknown. Aims: We aim to measure the transitional timescales of nearby galaxies across the green valley, through the analysis of Galaxy Evolution Explorer and Javalambre Photometric of Local Universe Survey photometric data. Specifically, we seek to study the impact of bars on the quenching timescales. Methods: We developed a method that estimates empirically the star formation quenching timescales of green valley galaxies, assuming an exponential decay model of the star formation histories and through a combination of narrow and broad bands from the Javalambre Photometric of Local Universe Survey and Galaxy Evolution Explorer. We correlated these quenching timescales with the presence of bars. Results: We find that the Javalambre Photometric of Local Universe Survey colours F0395 -g and F0410 -g are sensitive to different star formation histories, showing, consequently, a clear correlation with the Dn(4000) and Hδ, A spectral indices. We measured quenching timescales based on these colours and we find that quenching timescales obtained with our new approach are in agreement with those determined using spectral indices. We also compared the quenching timescales of green valley disc galaxies as a function of the probability of hosting a bar. We find that galaxies with high bar probability tend to quench their star formation slowly. Conclusions: We conclude that: (1) Javalambre Photometric of Local Universe Survey filters can be used to measure quenching timescales in nearby green valley galaxies; and (2) the resulting star formation quenching timescales are longer for barred green valley galaxies. Considering that the presence of a bar indicates that more violent processes (e.g. major mergers) are absent in host galaxies, we conclude that the presence of a bar can be used as a morphological signature for slow star formation quenching.

Gong et al. (2019) — It is well known that satellite galaxies are not isotropically distributed among their host galaxies as suggested by most interpretations of the Λ cold dark matter (ΛCDM) model. One type of anisotropy recently detected in the Sloan Digital Sky Survey (and seen when examining the distribution of satellites in the Local Group and in the Centaurus group) is a tendency to be so-called lopsided. Namely, in pairs of galaxies (like Andromeda and the Milky Way) the satellites are more likely to inhabit the region in between the pair, rather than on opposing sides. Although recent studies found a similar set-up when comparing pairs of galaxies in ΛCDM simulations indicating that such a set-up is not inconsistent with ΛCDM, the origin has yet to be explained. Here we examine the origin of such lopsided set-ups by first identifying such distributions in pairs of galaxies in numerical cosmological simulations, and then tracking back the orbital trajectories of satellites (which at $z = 0$ display the effect). We report two main results: first, the lopsided distribution was stronger in the past and weakens towards $z = 0$. Secondly, the weakening of the signal is due to the interaction of satellite galaxies with the pair. Finally, we show that the $z = 0$ signal is driven primarily by satellites that are on first approach, who have yet to experience a “flyby”. This suggests that the signal seen in the observations is also dominated by dynamically young accretion events.

Ganeshaiah Veena et al. (2019) — We investigate the alignment of galaxies and haloes relative to cosmic web filaments using the EAGLE hydrodynamical simulation. We identify filaments by applying the NEXUS+ method to the mass distribution and the Bisous formalism to the galaxy distribution. Both return similar filamentary structures that are well aligned and that contain comparable galaxy populations. EAGLE haloes have an identical spin alignment with filaments as their counterparts in dark-matter-only simulations: a complex massdependent trend with low-mass haloes spinning preferentially parallel to and high-mass haloes spinning preferentially perpendicular to filaments. In contrast, galaxy spins do not show such a transition and have a propensity for perpendicular alignments at all masses, with the degree of alignment being largest for massive galaxies. This result is valid for both NEXUS+ and Bisous filaments. When splitting by morphology, we find that elliptical galaxies show a stronger orthogonal spin-filament alignment than spiral galaxies of similar mass. The same is true of their host haloes. Due to the misalignment between galaxy shape and spin, galaxy minor axes are oriented differently with filaments than galaxy spins. We find that the galaxies whose minor axis is perpendicular to a filament are much better aligned with their host haloes. This suggests that many of the same physical processes determine both the galaxy-filament and the galaxy-halo alignments. The volume of the EAGLE simulation is relatively small and many of the alignments we have found are weak; validation of our conclusions will require hydrodynamical simulations of significantly larger volumes.

Kipper et al. (2019a) — We study the effect of dynamical friction on globular clusters (GCs) and on the stars evaporated from the GCs (stellar streams) moving in the Galactic halo. Due to dynamical friction, the position of a GC as a stream progenitor starts to shift with respect to its original position in the reference frame of initial GC orbit. Therefore the stars that have evaporated at different times have different mean position with respect to the GC position. This shifting results in a certain asymmetry in stellar density distribution between the leading and trailing arms of the stream. The degree of the asymmetry depends on the characteristics of the environment in which the GC and the stream stars move. As GCs are located mainly in outer parts of a galaxy, this makes dynamical friction a unique probe to constrain the underlying dark matter spatial density and velocity distributions. For a GC NGC 3201 we compared our theoretical shift estimates with available observations. Due to large uncertainties in current observation data, we can only conclude that the derived estimates have the same order of magnitude.

Kruuse et al. (2019) — Context. Galaxy filaments are the dominant feature in the overall structure of the cosmic web. The study of the filamentary web is an important aspect in understanding galaxy evolution and the evolution of matter in the Universe. A map of the filamentary structure is an adequate probe of the web. Aims: We propose that photometric redshift galaxies are significantly positively associated with the filamentary structure detected from the spatial distribution of spectroscopic redshift galaxies. The long-term aim is to use the photometric galaxies in addition to spectroscopic galaxies to create a more detailed and far-reaching map of the filamentary structure. Methods: The catalogues of spectroscopic and photometric galaxies are seen as point-process realisations in a sphere, and the catalogue of filamentary spines is proposed to be a realisation of a random set in a sphere. The positive association between these sets was studied using a bivariate J-function, which is a summary statistics studying clustering. A quotient D was built to estimate the distance distribution of the filamentary spine to galaxies in comparison to the distance distribution of the filamentary spine to random points in 3-dimensional Euclidean space. This measure also gives a physical distance scale to the distances between filamentary spines and the studied sets of galaxies. In the 3-dimensional case, galaxies and random points are described as line of sights following through their positions on the sphere. Results: The bivariate J-function shows a statistically significant clustering effect in between filamentary spines and photometric redshift galaxies. The quotient D confirms the previous result that smaller distances exist with higher probability between the photometric galaxies and filaments. The trend of smaller distances between the objects grows stronger at higher redshift. Additionally, the quotient D for photometric galaxies gives a rough estimate for the filamentary spine width of about 1 Mpc. Conclusions: Photometric redshift galaxies are positively associated with filamentary spines detected from the spatial distribution of spectroscopic galaxies. In addition to the spatial distribution of spectroscopic galaxies, the information embedded in the photometric galaxies could contribute greatly to the detection of cosmic web structures.

Wang et al. (2019) — It has been shown, both in simulations and observationally, that the tidal field of a large galaxy can torque its satellites such that the major axis of satellite galaxies points towards their hosts. This so-called 'shape alignment' has been observed in isolated Milky Way-like galaxies but not in 'Local Group'-like pairs. In this study, we investigate the shape alignment of satellite galaxies in galaxy pairs similar to the Local Group identified in the Sloan Digital Sky Survey Data Release 13 (SDSS DR13). By stacking tens of thousands of satellite galaxies around primary galaxy pairs, we find two statistically strong alignment signals. (1) The major axes of satellite galaxies located in the (projected) area between two primaries (the facing region) tend to be perpendicular to the line connecting the satellite to its host (tangential alignment), while (2) the major axes of satellite galaxies located in regions away from the other host (the away region) tend to be aligned with the line connecting the satellite to its host (radial alignment). These alignments are confirmed at 5σ levels. The alignment signal increases with increasing primary brightness, decreasing pair separation, and decreasing satellite distance. The alignment signal is also found to be stronger in filamentary environments. These findings will shed light on understanding the mechanisms of how satellite galaxies are affected by the tidal field in galaxy pairs and will be useful for investigating galaxy intrinsic alignment in the analyses of weak gravitational lensing.

Richard et al. (2019) — The 4MOST Cosmology Redshift Survey (CRS) will perform stringent cosmological tests via spectroscopic clustering measurements that will complement the best lensing, cosmic microwave background and other surveys in the southern hemisphere. The combination of carefully selected samples of bright galaxies, luminous red galaxies, emission-line galaxies and quasars, totalling about 8 million objects over the redshift range z = 0.15 to 3.5, will allow definitive tests of gravitational physics. Many key science questions will be addressed by combining CRS spectra of these targets with data from current or future facilities such as the Large Synoptic Survey Telescope, the Square Kilometre Array and the Euclid mission.

Finoguenov et al. (2019) — Groups and clusters of galaxies are a current focus of astronomical research owing to their role in determining the environmental effects on galaxies and the constraints they provide to cosmology. The eROSITA X-ray telescope on board the Spectrum Roentgen Gamma observatory will be launched in 2019 and will have completed eight scans of the full sky when 4MOST starts operating. The experiment will detect groups and clusters of galaxies through X-ray emission from the hot intergalactic medium. The purpose of the 4MOST eROSITA Galaxy Cluster Redshift Survey is to provide spectroscopic redshifts of the optical counterparts to the X-ray emission from 40 000 groups and clusters of galaxies so as to perform dynamical estimates of the total mass and to measure the properties of the member galaxies. The survey aims to obtain precise redshift measurements of the photometrically identified brightest cluster galaxies at redshift $z > 0.7$. At lower redshifts ($z < 0.7$) the programme aims to sample over 15 member galaxies per cluster and enable dynamical mass measurements to calibrate the clusters for cosmological experiments. At $z < 0.2$, eROSITA will also detect X-ray emission from galaxy groups and filaments. 4MOST spectroscopic data from the survey will be used for optical identification of galaxy groups down to eROSITA's mass detection limits of 1013 $M_{\odot}$, as well as the detection of the largest filaments for pioneering studies of their X-ray emission.

Guiglion et al. (2019) — The current status of and motivation for the 4MOST survey strategy, as developed by the Consortium science team, are presented here. Key elements of the strategy are described, such as sky coverage, number of visits and total exposure times in different parts of the sky, and how to deal with different observing conditions. The task of organising the strategy is not simple, with many different surveys that have vastly different target brightnesses and densities, sample completeness levels, and signal-to-noise requirements. We introduce here a number of concepts that we will use to ensure all surveys are optimised. Astronomers who are planning to submit a Participating Survey proposal are strongly encouraged to read this article and any relevant 4MOST Survey articles in this issue of The Messenger such that they can optimally complement and benefit from the planned surveys of the 4MOST Consortium.

Walcher et al. (2019) — The 4MOST instrument is a multi-object spectrograph that will address Galactic and extragalactic science cases simultaneously by observing targets from a large number of different surveys within each science exposure. This parallel mode of operation and the survey nature of 4MOST require some distinct 4MOST- specific operational features within the overall operations model of ESO. The main feature is that the 4MOST Consortium will deliver, not only the instrument, but also contractual services to the user community, which is why 4MOST is also described as a facility. This white paper concentrates on information particularly useful to answering the forthcoming Call for Letters of Intent.

de Jong et al. (2019) — We introduce the 4-metre Multi-Object Spectroscopic Telescope (4MOST), a new high-multiplex, wide-field spectroscopic survey facility under development for the four-metre-class Visible and Infrared Survey Telescope for Astronomy (VISTA) at Paranal. Its key specifications are: a large field of view (FoV) of 4.2 square degrees and a high multiplex capability, with 1624 fibres feeding two low-resolution spectrographs ($R = \lambda/\Delta\lambda = 6500$), and 812 fibres transferring light to the high-resolution spectrograph ($R = 20000$). After a description of the instrument and its expected performance, a short overview is given of its operational scheme and planned 4MOST Consortium science; these aspects are covered in more detail in other articles in this edition of The Messenger. Finally, the processes, schedules, and policies concerning the selection of ESO Community Surveys are presented, commencing with a singular opportunity to submit Letters of Intent for Public Surveys during the first five years of 4MOST operations.

Kipper et al. (2019b) — We present a method to calculate gravitational potential gradients within regions containing few 10s of thousands stars with known phase space coordinates. The central idea of the method is to calculate orbital arcs for each star within a given region for a certain parametrized potential (gravitational acceleration) and to assume that position of each star on its orbital arc is a random variable with a uniform probability density in time. Thereafter, by combining individual probability densities of stars it is possible to calculate the overall probability density distribution and likelihood for a given region as a function of gravitational acceleration parameters. The likelihood has a maximum if the calculated probability distribution and the observed distribution of stars in phase space are consistent. This allows us to constrain gravitational accelerations and potential gradient values. The method assumes that phases of stars are mixed within the regions where stellar orbits are calculated. We tested the method for 12 small rectangular regions within simulated disc galaxy from Gaia Wiki. Tests show that even with a rather simple acceleration form the calculated accelerations in galactic plane coincide with their true values from simulation about 5 per cent, misalignment between the calculated and true acceleration vector directions is less than 1 deg (median values). The model can be used with the Milky Way Gaia complete solution data.

Nevalainen et al. (2019) — The cosmological missing baryons at $z < 1$ most likely hide in the hot ($T \geq 105.5$ K) phase of the warm hot intergalactic medium (WHIM). While the hot WHIM is hard to detect due to its high ionisation level, the warm ($T \leq 105.5$ K) phase of the WHIM has been very robustly detected in the far-ultraviolet (FUV) band. We adopted the assumption that the hot and warm WHIM phases are co-located and therefore used the FUV-detected warm WHIM as a tracer for the cosmologically interesting hot WHIM. We performed an X-ray follow-up in the sight line of the blazar PKS 2155-304 at the redshifts where previous FUV measurements of O VI, Si IV, and broad Lyman-alpha (BLA) absorption have indicated the existence of the warm WHIM. We looked for the O VII Heα and O VIII Lyα absorption lines, the most likely hot WHIM tracers. Despite the very large exposure time (≈1 Ms), the Reflection Grating Spectrometer unit 1 (RGS1) on-board XMM-Newton data yielded no significant detection which corresponds to upper limits of log N(O VII(cm-2)) $\leq$ 14.5-15.2 and log N(O VIII(cm-2)) $\leq$ 14.5-15.2. An analysis of the data obtained with the combination of the Low Energy Transmission Grating (LETG) and the High Resolution Camera (HRC) on-board Chandra yielded consistent results. However, the data obtained with the LETG, combined with the Advanced CCD Imaging Spectrometer (ACIS) lead to the detection of an feature resembling an absorption line at $\lambda \approx 20$ Å at simple one-parameter confidence level of 3.7σ, consistent with several earlier LETG/ACIS reports. Given the high statistical quality of the RGS1 data, the possibility of RGS1 accidentally missing the true line at $\lambda \approx 20$ Å is very low: 0.006%. Neglecting this, the LETG/ACIS detection can be interpreted as Lyα transition of O VIII at one of the redshifts ($z \approx 0.054$) of FUV-detected warm WHIM. Given the very convincing X-ray spectral evidence for and against the existence of the $\lambda \approx 20$ Å feature, we cannot conclude whether or not it is a true astrophysical absorption line. Considering cosmological simulations, the probability of the LETG/ACIS $\lambda \approx 20$ Å feature being due to the astrophysical O VIII absorber co-located with the FUV-detected O VI absorber is at the very low level of $\leq 0.1\%$. We cannot completely rule out the very unlikely possibility that the LETG/ACIS 20 Å feature is due to a transient event located close to the blazar.

Hütsi et al. (2019) — Primordial black hole (PBH) dark matter (DM) nonlinear small-scale structure formation begins before the epoch of recombination, due to large Poisson density fluctuations. Those small-scale effects still survive today, distinguishing physics of PBH DM structure formation from the one involving weakly interacting massive particle DM. We construct an analytic model for the small-scale PBH velocities that reproduces the velocity floor seen in numerical simulations and investigate how these motions impact PBH accretion bounds at different redshifts. We find that the effect is small at the time of recombination, leaving the cosmic microwave background bounds on PBH abundance unchanged. However, already at z =20 the PBH internal motion significantly reduces their accretion due to the additional suppression, affecting the 21 cm bounds. Today the accretion bounds arising from dwarf galaxies or smaller PBH substructures are all reduced by the PBH velocity floor. We also investigate the feasibility for the PBH clusters to coherently accrete gas leading to a possible enhancement proportional to the cluster's occupation number, but find this effect to be insignificant for PBH around 10 $M_{\odot}$ or lighter. Those results should be reconsidered if the initial PBH distribution is not Poisson, for example, in the case of large initial PBH clustering.

Kashlinsky et al. (2019) — Next decade, new space- and ground-borne electromagnetic instruments, combined with concurrent theoretical efforts, should shed critical light on the link between primordial Black Holes and Dark Matter. We summarize the prospects to resolve this important issue with electromagnetic observations using instruments and tools expected in the 2020's.

Kalberla & Haud (2019) — Context. The interstellar medium (ISM) on all scales is full of structures that can be used as tracers of processes that feed turbulence. Aims: We used H I survey data to derive global properties of the angular power distribution of the local ISM. Methods: HI4PI observations on an nside = 1024 HEALPix grid and Gaussian components representing three phases, the cold, warm, and unstable lukewarm neutral medium (CNM, WNM, and LNM), were used for velocities $|vLSR| \leq 25$ km/s. For high latitudes $|b| > 20°$ we generated apodized maps. After beam deconvolution we fitted angular power spectra. Results: Power spectra for observed column densities are exceptionally well defined and straight in log-log presentation with 3D power law indices $\gamma \geq -3$ for the local gas. For intermediate velocity clouds (IVCs) we derive $\gamma = -2.6$ and for high velocity clouds (HVCs) $\gamma = -2.0$. Single-phase power distributions for the CNM, LNM, and WNM are highly correlated and shallow with $\gamma = -2.5$ for multipoles $l \leq 100$. Excess power from cold filamentary structures is observed at larger multipoles. The steepest single-channel power spectra for the CNM are found at velocities with large CNM and low WNM phase fractions. Conclusions: The phase space distribution in the local ISM is configured by phase transitions and needs to be described with three distinct different phases, being highly correlated but having distributions with different properties. Phase transitions cause locally hierarchical structures in phase space. The CNM is structured on small scales and is restricted in position-velocity space. The LNM as an interface to the WNM envelops the CNM. It extends to larger scales than the CNM and covers a wider range of velocities. Correlations between the phases are self-similar in velocity.

Adak et al. (2019) — The primary source of systematic uncertainty in the quest for the B-mode polarization of the Cosmic Microwave Background introduced by primordial gravitational waves is polarized thermal emission from Galactic dust. Therefore, accurate characterization and separation of the polarized thermal dust emission is an essential step in distinguishing such a faint CMB B-mode signal. We provide a modeling framework to simulate polarized thermal dust emission based on the model described in Ghosh et al. (2017), making use of both the Planck dust and Effelsberg-Bonn Hi surveys over the northern Galactic cap. Our seven-parameter dust model, incorporating three layers of Hi gas in different phases as a proxy of variable dust intensity and a phenomenological model of Galactic magnetic field, is able to reproduce both 1- and 2-point statistics of observed dust polarization maps seen by Planck at 353 GHz over a selected low-column density sky region in the northern Galactic cap. This work has important applications in assessing the accuracy of component separation methods and in quantifying the confidence level of separating polarized Galactic emission and the CMB B-mode signal, as is needed for ongoing and future CMB missions.

Aguado-Barahona et al. (2019) — Context. The second legacy catalog of Planck Sunyaev-Zeldovich (SZ) sources, hereafter PSZ2, provides the largest galaxy cluster sample selected by means of the SZ signature of the clusters in a full sky survey. In order to fully characterize this PSZ2 sample for cosmological studies, all the members should be validated and the physical properties of the clusters, including mass and redshift, should be derived. However, at the time of its publication, roughly 21% of the 1653 PSZ2 members had no known counterpart at other wavelengths. Aims: Here, we present the second and last year of observations of our optical follow-up program 128-MULTIPLE-16/15B (hereafter LP15), which has been developed with the aim of validating all the unidentified PSZ2 sources in the northern sky with declinations higher than $\sim 15°$ that have no correspondence in the first Planck catalog PSZ1. The description of the program and the first year of observations have been presented previously. Methods: The LP15 program was awarded 44 observing nights that were spread over two years with the Isaac Newton Telescope (INT), the Telescopio Nazionale Galileo (TNG), and the Gran Telescopio Canarias (GTC), all at Roque de los Muchachos Observatory (La Palma). Following the same method as described previously, we performed deep optical imaging for more than 200 sources with the INT and spectroscopy for almost 100 sources with the TNG and GTC at the end of the LP15 program. We adopted robust confirmation criteria based on velocity dispersion and richness estimates for the final classification of the new galaxy clusters as the optical counterparts of the PSZ2 detections. Results: Here, we present the observations of the second year of LP15, as well as the final results of the program. The full LP15 sample comprises 190 previously unidentified PSZ2 sources. Of these, 106 objects were studied before, while the remaining sample (except for 6 candidates) has been completed in the second year and is discussed here. In addition to the LP15 sample, we here study 42 additional PSZ2 objects that were originally validated as real clusters because they matched a WISE or PSZ1 counterpart, but they had no measured spectroscopic redshift. In total, we confirm the optical counterparts for 81 PSZ2 sources after the full LP15 program, 55 of them with new spectroscopic information. Forty of these 81 clusters are presented in this paper. After the LP15 observational program the purity of the PSZ2 catalog has increased from 76.7% originally to 86.2%. In addition, we study the possible reasons for false detection, and we report a clear correlation between the number of unconfirmed sources and galactic thermal dust emission.

Streblyanska et al. (2019) — Aims: The second catalogue of Planck Sunyaev-Zeldovich (SZ) sources, hereafter PSZ2, is the largest sample of galaxy clusters selected through their SZ signature in the full sky. At the time of publication, 21% of these objects had no known counterpart at other wavelengths. Using telescopes at the Canary Island observatories, we conducted the long-term observational programme 128-MULTIPLE-16/15B (hereafter LP15), a large and complete optical follow-up campaign of all the unidentified PSZ2 sources in the northern sky, with declinations above $\sim 15^{\circ}$ and no correspondence in the first Planck catalogue PSZ1. The main aim of LP15 is to validate all those SZ cluster candidates, and to contribute to the characterization of the actual purity and completeness of full Planck SZ sample. In this paper, we describe the full programme and present the results of the first year of observations. Methods: The LP15 programme was awarded 44 observing nights, spread over two years in three telescopes at the Roque de los Muchachos Observatory. The full LP15 sample comprises 190 previously unidentified PSZ2 sources. For each target, we performed deep optical imaging and spectroscopy. Our validation procedure combined this optical information with SZ emission as traced by the publicly available Planck Compton y-maps. The final classification of the new galaxy clusters as optical counterparts of the SZ signal is established according to several quantitative criteria based on the redshift, velocity dispersion, and richness of the clusters. Results: This paper presents the detailed study of 106 objects out of the LP15 sample, corresponding to all the observations carried out during the first year of the programme. We confirmed the optical counterpart for 41 new PSZ2 sources, 31 of them being validated using also velocity dispersion based on our spectroscopic information. This is the largest dataset of newly confirmed PSZ2 sources without any previous optical information. All the confirmed counterparts are rich structures (i.e. they show high velocity dispersion), and are well aligned with the nominal Planck coordinates (i.e. 70% of them are located at less than 3' distance). In total, 65 SZ sources are classified as unconfirmed, 57 of them being due to the absence of an optical over-density, and eight of them due to a weak association with the observed SZ decrement. Most of the sources with no optical counterpart are located at low galactic latitudes and present strong galactic cirrus in the optical images, the dust contamination being the most probable explanation for their inclusion in the PSZ2 catalogue.

Tartu Observatory cosmology group participated in preparation of J-PLUS: The Javalambre Photometric Local Universe Survey (Cenarro et al., 2019). The Javalambre Photometric Local Universe Survey (J-PLUS) is an ongoing 12-band photometric optical survey, observing thousands of square degrees of the Northern Hemisphere from the dedicated JAST/T80 telescope at the Observatorio Astrofísico de Javalambre (OAJ). The T80Cam is a camera with a field of view of 2 deg2 mounted on a telescope with a diameter of 83 cm, and is equipped with a unique system of filters spanning the entire optical range (3500-10 000 Å). This filter system is a combination of broad-, medium-, and narrow-band filters, optimally designed to extract the rest-frame spectral features (the 3700-4000 Å Balmer break region, Hδ, Ca H+K, the G band, and the Mg b and Ca triplets) that are key to characterizing stellar types and delivering a low-resolution photospectrum for each pixel of the observed sky. With a typical depth of AB 21.25 mag per band, this filter set thus allows for an unbiased and accurate characterization of the stellar population in our Galaxy, it provides an unprecedented 2D photospectral information for all resolved galaxies in the local Universe, as well as accurate photo-z estimates (at the $\delta z/(1+z) = 0.005 - 0.03$ precision level) for moderately bright (up to r $\sim$ 20 mag) extragalactic sources. While some narrow-band filters are designed for the study of particular emission features ([O II]/λ3727, $H\alpha$/λ6563) up to $z < 0.017$, they also provide well-defined windows for the analysis of other emission lines at higher redshifts. As a result, J-PLUS has the potential to contribute to a wide range of fields in Astrophysics, both in the nearby Universe (Milky Way structure, globular clusters, 2D IFU-like studies, stellar populations of nearby and moderate-redshift galaxies, clusters of galaxies) and at high redshifts (emission-line galaxies at $z \sim 0.77$, 2.2, and 4.4, quasi-stellar objects, etc.). With this paper, we release the first 1000 deg2 of J-PLUS data, containing about 4.3 million stars and 3.0 million galaxies at $r < 21$ mag. With a goal of 8500 deg2 for the total J-PLUS footprint, these numbers are expected to rise to about 35 million stars and 24 million galaxies by the end of the survey.

Nesci et al. (2019), (Wiedemair et al., 2019) — The photometric variability of ASASSN-18aan has been studied on 93 pairs of B and I plates of the Asiago Observatory archive. The plates were taken with the Schmidt 65/90 telescopes from 1967 to 1975. The star was found generally around B=17.5 mag, near the plate limit, but on four plates was definitely brighter. The I plates showed a light curve consistent with the B ones. We therefore confirm the cataclysmic-variable nature of this star, but the sampling is too sparse to firmly establish a recurrence time scale: a value of about 11 months is compatible with the present data. An X-ray counterpart was found in the Swift XRT archive, supporting the classification of the star. An optical spectrum taken in quiescence shows a clear emission at Halpha, as expected for a cataclysmic binary.

5 List of collaborators

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