Annual Report 2017

Jaan Einasto and Tartu Observatory cosmology group

1 Research

Galaxy populations and possible merging substructures were searched in the core of the rich galaxy supercluster A2142 by Einasto et al. (2017a). Normal mixture modelling revealed in A2142 several infalling galaxy groups and subclusters. The projected phase space diagram was used to analyse the dynamics of the cluster and study the distribution of various galaxy populations in the cluster and subclusters. The cluster, supercluster, BCGs, and one infalling subcluster are aligned. The cluster A2142 may have formed as a result of past and present mergers and infallen groups, predominantly along the supercluster axis. Mergers cause complex radio and X-ray structure of the cluster and affect the properties of galaxies in the cluster, especially in the infall region. Explaining the differences between galaxy populations, mass, and richness of A2142, and other groups and clusters may lead to better insight about the formation and evolution of rich galaxy clusters.

Einasto et al. (2018) developed a percolation method to allow the comparison of geometrical properties of models and observations for a whole ensemble of over- and under-density systems. We scan density fields of dark matter (DM) model and SDSS observational samples, and find connected over- and underdensity regions in a range of threshold densities. Lengths, filling factors and numbers of largest clusters and voids as functions of the threshold density are used as percolation functions. We find that percolation functions of DM models of different box sizes are very similar to each other. This stability suggests that properties of the cosmic web, as found in the present paper, can be applied to the cosmic web as a whole. Percolation functions depend strongly on the smoothing length. At optimal smoothing length 1 h^{-1} Mpc the percolation density threshold in mean density units is for clusters is 4.9 ± 0.2 and for voids 0.142 ± 0.016, very different from respective percolation density thresholds for random samples, 1.04 ± 0.02 and 0.96 ± 0.02, respectively. Percolation functions are very sensitive to the faint filamentary web, present in DM samples, but absent in SDSS samples. Percolation analysis allows to characterise geometrical properties of the cosmic web over a large range of densities, to find the difference between model, observational and random samples, and to calculate percolation density threshold densities. The paper is almost finished.

An International Symposium, dedicated to the 70th anniversary of the Byurakan Astrophysical Observatory (BAO), was held at National Academy of Sciences of the Republic of Armenia: “Non-Stable Universe: Energetic Resources, Activity Phenomena, and Evolutionary Processes.” Proceedings of the Symposium were published. In my talk I discussed the evolution of the cosmic web (Einasto, 2017). In the evolution of the cosmic web dark energy plays an important role. To understand the role of dark energy we investigated the evolution of superclusters in four cosmological models: standard model SCDM, conventional model LCDM, open model OCDM, and a hyper-dark-energy model HCDM. Numerical simulations of the evolution were performed in a box of size 1024 Mpc/h. Model superclusters were compared with superclusters found for Sloan Digital Sky Survey (SDSS). Superclusters were searched using density fields. LCDM superclusters have properties, very close to properties of observed SDSS superclusters. Standard model SCDM has about 2 times more superclusters than other models, but SCDM superclusters are smaller and have lower luminosities. Superclusters as principal structural elements of the cosmic web are present at all cosmological epochs.

Annual Review of Astronomy and Astrophysics suggested to write a prefatory chapter for the Journal. In this paper I describe my background and main steps in the study. Each following step was a basis for the next one without a certain plan. I started my path with the study of kinematical properties of galactic populations, which smoothly transformed to calculation of population models of galaxies. I had difficulties to model satisfactory galaxies using population data; this led me to the dark matter problem. Discussing dark matter started a collaboration with Yakov Zeldovich, which initiated the search for regularities in the distribution of galaxies. As is characteristic in paradigm shifts, there is no single discovery. New concepts were developed step-by-step by many scientists. I shall describe our efforts to understand the structure of galaxies, the amount and nature of dark matter, and detection of the filamentary structure of the universe, called presently as the cosmic web. The paper is sent to publisher (Einasto, 2018). In October I participated in the conference "What We Have Learned in Galaxy Formation" in Yale University. This gave me the possibility to discuss the paper with the editor Prof. Sandy Faber.

2 Lectures

• September 26, lecture in Tartu-Tuorla workshop: "The biasing problem".

3 Visits

• October 11–16, Yale University, New Haven, USA; Conference "What We Have Learned in Galaxy Formation".

4 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).

5 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.

The cosmic web is one of the most striking features of the distribution of galaxies and dark matter on the largest scales in the Universe. It is composed of dense regions packed full of galaxies, long filamentary bridges, flattened sheets and vast low density voids. The study of the cosmic web has focused primarily on the identification of such features, and on understanding the environmental effects on galaxy formation and halo assembly. As such, a variety of different methods have been devised to classify the cosmic web – depending on the data at hand, be it numerical simulations, large sky surveys or other. In this paper we bring twelve of these methods together and apply them to the same data set in order to understand how they compare (Libeskind et al., 2018).

Poudel et al. (2017) investigated properties of groups and their central galaxies in different large-scale environments defined by the luminosity density field and the cosmic web filaments. We use the luminosity density field constructed using 8 h^{-1} Mpc smoothing to characterize the large-scale environments. We use the Bisous model to extract the filamentary structures in different large-scale environments. We study the properties of galaxy groups as a function of their dynamical mass in different large-scale environments. We find differences in the properties of central galaxies and their groups in and outside of filaments at fixed halo and large-scale environments. In high-density environments, the group mass function has higher number densities in filaments compared to that outside of filaments towards the massive end. The relation is the opposite in low-density environments. At fixed group mass and large-scale luminosity density, mass-to-light ratios show that groups in filaments are slightly more luminous than those outside of filaments. At fixed group mass and large-scale luminosity density, central galaxies in filaments have redder colors, higher stellar masses, and lower specific star formation rates than those outside of filaments. However, the differences in central galaxy and group properties in and outside of filaments are not clear in some group mass bins. We show that the differences in central galaxy properties are due to the higher abundances of elliptical galaxies in filaments. Filamentary structures in the cosmic web are not simply visual associations of galaxies, but rather play an important role in shaping the properties of groups and their central galaxies. The differences in central galaxy and group properties in and outside of cosmic web filaments are not simple effects related to large-scale environmental density. The results point towards an efficient mechanism in cosmic web filaments which quench star formation and transform central galaxy morphology from late to early types.

Cohen et al. (2017) analysed the relationship between star formation (SF), substructure, and supercluster environment in a sample of 107 nearby galaxy clusters using data from the Sloan Digital Sky Survey. Previous works have investigated the relationships between SF and cluster substructure, and cluster substructure and supercluster environment, but definitive conclusions relating all three of these variables has remained elusive. We find an inverse relationship between cluster SF fraction (fSF) and supercluster environment density, calculated using the Galaxy luminosity density field at a smoothing length of 8 h^{-1} Mpc (D8). The slope of fSF versus D8 is -0.008 ± 0.002. The fSF of clusters located in low-density large-scale environments, 0.244 ± 0.011, is higher than for clusters located in high-density supercluster cores, 0.202 ± 0.014. We also divide superclusters, according to their morphology, into filament- and spider-type systems. The inverse relationship between cluster fSF and large-scale density is dominated by filament- rather than spider-type superclusters. In high-density cores of superclusters, we find a higher fSF in spider-type superclusters, 0.229 ± 0.016, than in filament-type superclusters, 0.166 ± 0.019. Using principal component analysis, we confirm these results and the direct correlation between cluster substructure and SF. These results indicate that cluster SF is affected by both the dynamical age of the cluster (younger systems exhibit higher amounts of SF); the large-scale density of the supercluster environment (high-density core regions exhibit lower amounts of SF); and supercluster morphology (spider-type superclusters exhibit higher amounts of SF at high densities).

Hirv et al. (2017) studied the alignment of galaxies relative to their local environment in SDSS-DR8 and, using these data, we discuss evolution scenarios for different types of galaxies. Methods: We defined a vector field of the direction of anisotropy of the local environment of galaxies. We summed the unit direction vectors of all close neighbours of a given galaxy in a particular way to estimate this field. We found the alignment angles between the spin axes of disc galaxies, or the minor axes of elliptical galaxies, and the direction of anisotropy. The distributions of cosines of these angles are compared to the random distributions to analyse the alignment of galaxies. Sab galaxies show perpendicular alignment relative to the direction of anisotropy in a sparse environment, for single galaxies and galaxies of low luminosity. Most of the parallel alignment of Scd galaxies comes from dense regions, from 2...3 member groups and from galaxies with low luminosity. The perpendicular alignment of S0 galaxies does not depend strongly on environmental density nor luminosity; it is detected for single and 2...3 member group galaxies, and for main galaxies of 4...10 member groups. The perpendicular alignment of elliptical galaxies is clearly detected for single galaxies and for members of ≤ 10 member groups; the alignment increases with environmental density and luminosity. We confirm the existence of fossil tidally induced alignment of Sab galaxies at low z. The alignment of Scd galaxies can be explained via the infall of matter to filaments. S0 galaxies may have encountered relatively massive mergers along the direction of anisotropy. Major mergers along this direction can explain the alignment of elliptical galaxies. Less massive, but repeated mergers are possibly responsible for the formation of elliptical galaxies in sparser areas and for less luminous elliptical galaxies.

Einasto et al. (2017b) studied the morphology of the superclusters from the BOSS Great Wall (BGW), a recently discovered very rich supercluster complex at the redshift $z = 0.47$. We have employed the Minkowski functionals to quantify supercluster morphology. We calculate supercluster luminosities and masses using two methods. Firstly, we used data about the luminosities and stellar masses of high stellar mass galaxies with $\log(M/h^{-1}M\odot) \geq 11.3$. Secondly, we applied a scaling relation that combines morphological and physical parameters of superclusters to obtain supercluster luminosities, and obtained supercluster masses using the mass-to-light ratios found for local rich superclusters. The BGW superclusters are very elongated systems, with shape parameter values of less than 0.2. This value is lower than that found for the most elongated local superclusters. The values of the fourth Minkowski functional V3 for the richer BGW superclusters (V3 = 7 and 10) show that they have a complicated and rich inner structure. We identify two Planck SZ clusters in the BGW superclusters, one in the richest BGW supercluster, and another in one of the poor BGW superclusters. The luminosities of the BGW superclusters are in the range of $1 - 8 \times 10^{13} h^{-2} L\odot$, and masses in the range of $0.4 - 2.1 \times 10^{16} h^{-1} M\odot$. Supercluster luminosities and masses obtained with two methods agree well.

Deshev et al. (2017b,a) investigated mergers of galaxy clusters as the most energetic events in the universe after the Big Bang. With the increased availability of multi-object spectroscopy and X-ray data an ever increasing fraction of local clusters are recognised as exhibiting signs of recent or past merging events on various scales. Our goal is to probe how these mergers affect the evolution and content of their member galaxies. We specifically aim to answer the following questions: Is the quenching of star formation in merging clusters enhanced when compared with relaxed clusters? Is the quenching preceded by a (short lived) burst of star formation? We obtained optical spectroscopy of > 400 galaxies in the field of the merging cluster Abell520. We combine these observations with archival data to get a comprehensive picture of the state of star formation in the members of this merging cluster. Finally, we compare these observations with a control sample of 10 non-merging clusters at the same redshift from The Arizona Cluster Redshift Survey (ACReS). We split the member galaxies in passive, star forming or recently quenched depending on their spectra. The core of the merger shows a decreased fraction of star forming galaxies compared to clusters in the non-merging sample. This region, dominated by passive galaxies, is extended along the axis of the merger. We find evidence of rapid quenching of the galaxies during the core passage with no signs of a star burst on the time scales of the merger (~ 0.4Gyr). Additionally, we report the tentative discovery of an infalling group along the main filament feeding the merger, currently at ~ 2.5 Mpc from the merger centre. This group contains a high fraction of star forming galaxies as well as ~2/3 of all the recently quenched galaxies in our survey.

Järvelä et al. (2017) studied the large-scale environments of narrow-line Seyfert 1 (NLS1) galaxies to get a new perspective on their properties, particularly their radio loudness. The large-scale environment is believed to have an impact on the evolution and intrinsic properties of galaxies, however, NLS1 sources have not been studied in this context before. We have a large and diverse sample of 1341 NLS1 galaxies and three separate environment data sets constructed using Sloan Digital Sky Survey. We use various statistical methods to investigate how the properties of NLS1 galaxies are connected to the large-scale environment, and compare the large-scale environments of NLS1 galaxies with other active galactic nuclei (AGN) classes, for example, other jetted AGN and broad-line Seyfert 1 (BLS1) galaxies, to study how they are related. NLS1 galaxies reside in less dense environments than any of the comparison samples, thus confirming their young age. The average large-scale environment density and environmental distribution of NLS1 sources is clearly different compared to BLS1 galaxies, thus it is improbable that they could be the parent population of NLS1 galaxies and unified by orientation. Within the NLS1 class there is a trend of increasing radio loudness with increasing large-scale environment density, indicating that the large-scale environment affects their intrinsic properties. Our results suggest that the NLS1 class of sources is not homogeneous, and furthermore, that a considerable fraction of them are misclassified. We further support a published proposal to replace the traditional classification to radio-loud, and radio-quiet or radio-silent sources with a division into jetted and non-jetted sources.

López-Sanjuan et al. (2017) studied the evolution of the B-band luminosity function (LF) since $z = 1$ using ALHAMBRA data. We present a robust methodology to compute LFs using multi-filter photometric data. The application to ALHAMBRA shows a factor 2.55 ± 0.14 decrease in the luminosity density jB of star-forming galaxies, and a factor 1.25 ± 0.16 increase in the jB of quiescent ones since $z = 1$, confirming the continuous build-up of the quiescent population with cosmic time. The contribution of the faint quiescent population to jB increases from 3% at $z = 1$ to 6% at $z = 0$. The developed methodology will be applied to future multi-filter surveys such as J-PAS.

Viaene et al. (2017) find that the dust in M 31 is mainly (91% of the absorbed luminosity) heated by the evolved stellar populations. The bright bulge produces a strong radiation field and induces non-local heating up to the main star-forming ring at 10 kpc. The relative contribution of unevolved stellar populations to the dust heating varies strongly with wavelength and with galactocentric distance. The dust heating fraction of unevolved stellar populations correlates strongly with NUV-r colour and specific star formation rate. These two related parameters are promising probes for the dust heating sources at a local scale.

Tenjes et al. (2017) investigated spiral arms and the stability of the Andromeda galaxy. No systematic offsets between the observed UV and CO/far-IR emission across the spiral segments are detected. The calculated effective stability parameter has a lowest value of $Q_{eff} \approx 1.8$ at galacto-centric distances of $12 - 13$ kpc. The least stable wavelengths are rather long, with the lowest values starting from 3 kpc at distances $R > 11$ kpc. The classical density wave theory is not a realistic explanation for the spiral structure of M 31. Instead, external causes should be considered, such as interactions with massive gas clouds or dwarf companions of M 31.

Kuutma et al. (2017) investigated the impact of filament and void environments on galaxies. After the normalisation with respect to environment density and redshift, several residual dependencies of galaxy properties still remain. Most notable is the trend of morphology transformations, resulting in a higher elliptical-to-spiral ratio while moving from voids towards filament spines, bringing along a corresponding increase in the g-i colour index and a decrease in star formation rate. After separating elliptical and spiral subsamples, some of the colour index and star formation rate evolution still remains. The mentioned trends are characteristic only for galaxies brighter than about $M_r = -20$ mag. Unlike some other recent studies, we do not witness an increase in the galaxy stellar mass while approaching filaments. The detected transformations can be explained by an increase in the galaxy-galaxy merger rate and/or the cut-off of extragalactic gas supplies (starvation) near and inside filaments. Unlike voids, large-scale galaxy filaments are not a mere density enhancement, but have their own specific impact on the constituent galaxies, reducing the star formation rate and raising the chances of elliptical morphology also at a fixed environment density level.

Tempel et al. (2017b,a) analysed the catalogue of 88 662 galaxy groups with at least two members. Among them are 6873 systems with at least six members which we consider to be more reliable groups. We find 498 group mergers with up to six groups. We performed a brief comparison with some known clusters in the nearby Universe, including the Coma cluster and Abell 1750. The Coma cluster in our catalogue is a merging system with six distinguishable subcomponents. In the case of Abell 1750 we find a clear sign of filamentary infall toward this cluster. Our analysis of mass-to-light ratio (M/L) of galaxy groups reveals that M/L slightly increases with group richness.

Sorce & Tempel (2017) applied Wiener Filter reconstruction technique to galaxy radial peculiar velocity catalogues to understand how the Hubble constant (H0) value and the grouping scheme affect the reconstructions.

Bonamente et al. (2017) analysed all available archival XMM-Newton observations of X Comae, a bright X-ray quasar behind the Coma cluster, to study the properties of the warm-hot intergalactic medium (WHIM) in the vicinity of the nearest massive galaxy cluster. We conclude that the putative warm-hot medium towards Coma is consistent with expected properties, with a baryon overdensity $\delta_b \geq 10$ and a sightline extent of order of tens of Mpc.

Kipper et al. (2018) devised a method to calculate the stationary gravitational potential distribution perpendicular to the Galactic plane by comparing the vertical probability density distribution of a sample of observed stars with the theoretical probability density distribution computed from their vertical coordinates and velocities. Our results show no firm evidence for significant amount of dark matter in the Solar neighbourhood.

Old et al. (2017) examine the effects of an important source of systematic uncertainty in galaxy-based cluster mass estimation techniques: the presence of significant dynamical substructure. Dynamical substructure manifests as dynamically distinct subgroups in phase-space, indicating an 'unrelaxed' state. we find a systematic bias for all methods, such that clusters with significant substructure have higher measured masses than their relaxed counterparts.

Kalberla et al. (2017) used the Galactic portion of the Effelsberg-Bonn H I Survey (EBHIS) to continue our study of such anisotropies in the H I distribution in direction of two WSRT fields, Horologium and Auriga Radio-polarimetric depolarization canals are associated with filamentary H I structures that belong to the cold neutral medium (CNM). Anisotropies in the CNM are in this case linked to a steepening of the power-spectrum spectral index, indicating that phase transitions in a turbulent medium occur on all scales. Filamentary H I structures, driven by thermal instabilities, and radio-polarimetric filaments are associated with each other. The magneto-ionic medium that causes the radio-polarimetric filaments is probably wrapped around the H I.

The Planck survey has quantified polarized Galactic foregrounds and established that they are a main limiting factor in the quest for the cosmic microwave background B-mode signal induced by primordial gravitational waves during cosmic inflation. By adjusting the parameters of the dust model, we were able to reproduce the Planck dust observations at 353GHz in the selected region. Realistic simulations of the polarized dust emission enabled by such a dust model are useful for testing the accuracy of component separation methods, studying non-Gaussianity, and constraining the amount of decorrelation with frequency (Ghosh et al., 2017).

Motivated by the recent detection of the gravitational wave signal emitted by a binary neutron star merger, we analyse the possible impact of dark matter on such signals (Ellis et al., 2017). We show that dark matter cores in merging neutron stars may yield an observable supplementary peak in the gravitational wave power spectral density following the merger, which could be distinguished from the features produced by the neutron components.

Kolodzig et al. (2017b) studied surface brightness fluctuations of the cosmic X-ray background (CXB) using Chandra data of XBOOTES. We show that the power spectrum shape is sensitive to the ICM structure all the way to the outskirts, out to $\sim$ few $\times R_{500}$. We also look for possible contribution of the warm-hot intergalactic medium (WHIM) to the observed CXB fluctuations. Our results underline the significant diagnostics potential of the CXB fluctuation analysis in studying the ICM structure in clusters.

Kolodzig et al. (2017a) demonstrated that the detected LSS signal is produced by unresolved clusters and groups of galaxies. For the flux limit of the XBOOTES survey, their flux-weighted mean redshift equals $< z >\sim 0.3$, and the mean temperature of their intracluster medium (ICM), $< T >\approx 1.4$ keV, corresponds to the mass of M500 $\sim 10^{13.5}\ M_{\odot}$. The power spectrum of CXB fluctuations carries information about the redshift distribution of these objects and the spatial structure of their ICM on the linear scales of up to Mpc, i.e. of the order of the virial radius.

Kolodzig et al. (2018) studied surface brightness fluctuations of the cosmic X-ray background (CXB) using Chandra data of XBOOTES. After masking out resolved sources we compute the power spectrum of fluctuations of the unresolved CXB for angular scales from ≈ 2 arcsec to 3. The non-trivial large-scale structure (LSS) signal dominates over the shot noise of unresolved point sources on angular scales above ~ 1 arcmin and is produced mainly by the intracluster medium (ICM) of unresolved clusters and groups of galaxies,

Vennik & Hopp (2017) studied the distribution, kinematics and star-formation properties of satellite galaxies in five nearby groups, which were observed spectroscopically with the Hobby-Eberly Telescope. We compare our results with those of two other samples of nearby groups. We studied the morphology of two brightest members of the nearby NGC 697 group of galaxies, and found evidence of satellite accretion onto the primary galaxy NGC 697 of the group as well as outer and inner irregularities of the only early-type galaxy NGC 680 of the group, which are probably shaped by recent dry merging event(s) (Vennik, 2017).

Cohen et al. (2017) analysed the relationship between star formation (SF), substructure, and supercluster environment in a sample of 107 nearby galaxy clusters using data from the Sloan Digital Sky Survey. Previous works have investigated the relationships between SF and cluster substructure, and cluster substructure and supercluster environment, but definitive conclusions relating all three of these variables has remained elusive. We find an inverse relationship between cluster SF fraction (fSF) and supercluster environment density, calculated using the Galaxy luminosity density field at a smoothing length of 8 h^{-1} Mpc (D8).

Far-ultraviolet (FUV) observations have revealed transition temperature gas (TTG; $\log T(K) = 5$), located in the lower Galactic halo and in high-velocity clouds. However, the corresponding X-ray absorption has so far remained mostly undetected. In order to make an improvement in this respect in Galactic X-ray absorption studies, we accumulated very deep (3 Ms) spectra of the blazar PKS 2155-304 obtained with the spectrometers RGS1, RGS2, LETG/HRC, and LETG/ACIS-S and studied the absorption lines due to the intervening Galactic components (Nevalainen et al., 2017; Nevalainen, 2017). Forster et al. (2017) summarised the outcome of the 12th meeting of the International Astronomical Consortium for High Energy Calibration (IACHEC), held at the UCLA conference center in Lake Arrowhead (California) in March 2017.

6 List of collaborators

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References

Bonamente, M., Ahoranta, J., Tilton, E., Tempel, E., & Morandi, A. 2017, *Characterization of the warm-hot intergalactic medium near the Coma cluster through high-resolution spectroscopy of X Comae*, MNRAS, 469, 3984

Cohen, S. A., Hickox, R. C., Wegner, G. A., Einasto, M., & Vennik, J. 2017, *Star Formation and Supercluster Environment of 107 nearby Galaxy Clusters*, ApJ, 835, 56

Deshev, B., Finoguenov, A., Verdugo, M., Ziegler, B., Park, C., Hwang, H. S., Haines, C., Kamphuis, P., Tamm, A., Einasto, M., Hwang, N., & Park, B.-G. 2017a, *Galaxy evolution in merging clusters: The passive core of the "Train Wreck" cluster of galaxies, A520*, ArXiv e-prints 707.03208

Deshev, B., Finoguenov, A., Verdugo, M., Ziegler, B., Park, C., Seong, H. H., Haines, C., Kamphuis, P., Tamm, A., Einasto, M., Hwang, N., & Park, B.-G. 2017b, *VizieR Online Data Catalog: Abell 520 galaxies redshifts (Deshev+, 2017)*, VizieR Online Data Catalog, 360

Einasto, J. 2017, *Evolution of the Cosmic Web*, in Astronomical Society of the Pacific Conference Series, Vol. 511, Astronomical Society of the Pacific Conference Series, ed. A. M. Mickaelian, H. A. Harutyunian, & E. H. Nikoghosyan, 141

Einasto, J. 2018, *Cosmology paradigm changes.*, Annual Review of Astronomy and Astrophysics, 56

Einasto, J., Suhhonenko, I., Liivamägi, L. J., & Einasto, M. 2018, *Percolation analysis of the cosmic web*, A&A, (In preparation)

Einasto, M., Deshev, B., Lietzen, H., Kipper, R., Tempel, E., Park, C., Gramann, M., Heinämäki, P., Saar, E., & Einasto, J. 2017a, *Infalling groups and galaxy transformations in the cluster A2142*, ArXiv e-prints 1711.07806

Einasto, M., Lietzen, H., Gramann, M., Saar, E., Tempel, E., Liivamägi, L. J., Montero-Dorta, A. D., Streblyanska, A., Maraston, C., & Rubiño-Martín, J. A. 2017b, *BOSS Great Wall: morphology, luminosity, and mass*, A&A, 603, A5

Ellis, J., Hektor, A., Hütsi, G., Kannike, K., Marzola, L., Raidal, M., & Vaskonen, V. 2017, *Search for Dark Matter Effects on Gravitational Signals from Neutron Star Mergers*, ArXiv e-prints 1710.05540

Forster, K., Grant, C. E., Guainazzi, M., Kashyap, V., Marshall, H. L., Miller, E. D., Natalucci, L., Nevalainen, J., Plucinsky, P. P., & Terada, Y. 2017, *Summary of the 12th IACHEC Meeting*, ArXiv e-prints 1708.01446

Ghosh, T., Boulanger, F., Martin, P. G., Bracco, A., Vansyngel, F., Aumont, J., Bock, J. J., Doré, O., Haud, U., Kalberla, P. M. W., & Serra, P. 2017, *Modelling and simulation of large-scale polarized dust emission over the southern Galactic cap using the GASS Hi data*, A&A, 601, A71

Hirv, A., Pelt, J., Saar, E., Tago, E., Tamm, A., Tempel, E., & Einasto, M. 2017, *Alignment of galaxies relative to their local environment in SDSS-DR8*, A&A, 599, A31

Järvelä, E., Lähteenmäki, A., Lietzen, H., Poudel, A., Heinämäki, P., & Einasto, M. 2017, *Large-scale environments of narrow-line Seyfert 1 galaxies*, A&A, 606, A9

Kalberla, P. M. W., Kerp, J., Haud, U., & Haverkorn, M. 2017, *H I anisotropies associated with radio-polarimetric filaments . Steep power spectra associated with cold gas*, A&A, 607, A15

Kipper, R., Tempel, E., & Tenjes, P. 2018, *A method to calculate the local density distribution of the Galaxy from the Tycho-Gaia Astrometric Solution data*, MNRAS, ArXiv 1709.06744, 473, 2188

Kolodzig, A., Gilfanov, M., Hütsi, G., & Sunyaev, R. 2017a, *Can AGN and galaxy clusters explain the surface brightness fluctuations of the cosmic X-ray background?*, MNRAS, 466, 3035

Kolodzig, A., Gilfanov, M., Hütsi, G., & Sunyaev, R. 2017b, *Studying the ICM in clusters of galaxies via surface brightness fluctuations of the cosmic X-ray background*, ArXiv e-prints 1708.00820

Kolodzig, A., Gilfanov, M., Hütsi, G., & Sunyaev, R. 2018, *Studying the ICM in clusters of galaxies via surface brightness fluctuations of the cosmic X-ray background*, MNRAS, 473, 4653

Kuutma, T., Tamm, A., & Tempel, E. 2017, *From voids to filaments: environmental transformations of galaxies in the SDSS*, A&A, 600, L6

Libeskind, N. I., van de Weygaert, R., Cautun, M., Falck, B., Tempel, E., Abel, T., Alpaslan, M., Aragón-Calvo, M. A., Forero-Romero, J. E., Gonzalez, R., Gottlöber, S., Hahn, O., Hellwing, W. A., et al. 2018, *Tracing the cosmic web*, MNRAS, 473, 1195

López-Sanjuan, C., Tempel, E., Benítez, N., Molino, A., Viironen, K., Díaz-García, L. A., Fernández-Soto, A., Santos, W. A., Varela, J., Cenarro, A. J., Moles, M., Arnalte-Mur, P., Ascaso, B., et al. 2017, *The ALHAMBRA survey: B-band luminosity function of quiescent and star-forming galaxies by PDF analysis*, A&A, 599, A62

Nevalainen, J. 2017, *Discovery of Galactic OIV and OV X-ray absorption due to transition temperature gas in the PKS 2155-304 spectrum*, in The X-ray Universe 2017, ed. J.-U. Ness & S. Migliari, 158

Nevalainen, J., Wakker, B., Kaastra, J., Bonamente, M., Snowden, S., Paerels, F., & de Vries, C. 2017, *Discovery of Galactic O iv and O v X-ray absorption due to transition temperature gas in the PKS 2155-304 spectrum*, A&A, 605, A47

Old, L., Wojtak, R., Pearce, F. R., Gray, M. E., Mamon, G. A., Sifón, C., Tempel, E., Biviano, A., Yee, H. K. C., de Carvalho, R., Müller, V., Sepp, T., Skibba, R. A., et al. 2017, *Galaxy Cluster Mass Reconstruction Project: III. The impact of dynamical substructure on cluster mass estimates*, ArXiv e-prints 1709.10108

Poudel, A., Heinämäki, P., Tempel, E., Einasto, M., Lietzen, H., & Nurmi, P. 2017, *The effect of cosmic web filaments on the properties of groups and their central galaxies*, A&A, 597, A86

Sorce, J. G. & Tempel, E. 2017, *How does the grouping scheme affect the Wiener Filter reconstruction of the local Universe?*, MNRAS, 469, 2859

Tempel, E., Tuvikene, T., Kipper, R., & Libeskind, N. I. 2017a, *Merging groups and clusters of galaxies from the SDSS data. The catalogue of groups and potentially merging systems*, A&A, 602, A100

Tempel, E., Tuvikene, T., Kipper, R., & Libeskind, N. I. 2017b, *VizieR Online Data Catalog: Merging groups and clusters from the SDSS data (Tempel+, 2017)*, VizieR Online Data Catalog, 360

Tenjes, P., Tuvikene, T., Tamm, A., Kipper, R., & Tempel, E. 2017, *Spiral arms and disc stability in the Andromeda galaxy*, A&A, 600, A34

Vennik, J. 2017, *Interacting galaxies in the NGC 697 group of galaxies*, in IAU Symposium, Vol. 321, Formation and Evolution of Galaxy Outskirts, ed. A. Gil de Paz, J. H. Knapen, & J. C. Lee, 300

Vennik, J. & Hopp, U. 2017, *Satellite Galaxies In Nearby Groups: Distribution, Kinematics And Star-Forming Properties*, in Galaxy Evolution Across Time, Proceedings of a conference held 12-16 June, 2017 in Paris., 94

Viaene, S., Baes, M., Tamm, A., Tempel, E., Bendo, G., Blommaert, J. A. D. L., Boquien, M., Boselli, A., Camps, P., Cooray, A., De Looze, I., De Vis, P., Fernández-Ontiveros, J. A., et al. 2017, *The Herschel Exploitation of Local Galaxy Andromeda (HELGA). VII. A SKIRT radiative transfer model and insights on dust heating*, A&A, 599, A64

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